Research Paper & Strategic Briefing

Tipping Point: The Rise and Rise of One-to-One Computing in Schools

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VITAL WAVE CONSULTING™

Contents

Executive Summary

Once considered a leading-edge idea and a possible panacea for all that ills contemporary education, one-to-one computing in K-12 education has evolved significantly in recent years. No longer simply an idealistic concept, providing each student with their own laptop is now a rapidly growing practice with a track record of improving educational outcomes. Even more importantly, one-to-one computing is widely recognized as an essential component of preparing the workforce of the 21st century, and a crucial means of ensuring that the opportunities of the digital age are extended broadly and equitably across socio-economic groups and geographic regions.

While one-to-one computing is not without its detractors, a confluence of factors is driving the market to a tipping point. Policymakers, educators and leading information and communication technology (ICT) companies now approach one-to-one programs in a mature and pragmatic manner. The benefits are well-documented, as are the challenges of deployment and methods of overcoming these challenges to create benefits for students. With a critical mass of successful deployments underway and national governments in the United Kingdom (UK), Australia, Singapore and Uruguay announcing comprehensive policies, the question is not *if* one-to-one is going to happen, but when.

This paper provides guidance into the questions of precisely when one-to-one computing will enter the mainstream, how this will come about, and how this should best be accomplished. First it examines the key forces driving one-to-one computing and forecasts demand. The paper then presents potential challenges, along with the tools and frameworks available for gaining the maximum benefit from integrating ICT into education. Finally, evidence of the lessons learned and benefits gained by early adopters of one-to-one are illustrated through case studies from early adopters.

Introduction

Behind the paradigm shift in education that is driving adoption of one-to-one computing are massive societal shifts requiring that the workforce of the 21st century use fundamentally different skills from those of the 20th century industrial age. These shifts include globalization, rapid technological change, and the evolution toward an information-based economy. Thriving in this new environment requires skills such as flexibility, self-directed learning, and cross-cultural savvy on the part of workers. In the educational arena, this implies teaching technical skills (i.e., programming, software literacy), as well as broader capabilities such as research, critical thinking and collaboration.

This paper adopts the definition of one-to-one computing articulated by the One to One Institute: "One-to-one learning [computing] provides each and every student access to his or her own personal portable technology in a wireless environment allowing students to learn at their own pace and ability levels." [i] A growing body of evidence demonstrates that giving students personal access to a laptop computer promotes the development of these higher-level skills, while also improving academic fundamentals such as improved reading skills and improved attendance levels. A crucial reason for the success of the one-to-one computing paradigm is that today's K-12 students are "digital natives" who use technology in their everyday lives for communication, collaboration and personal expression, be it through text messaging, blogging or video cameras.

Finally, the effect of the MIT Media Lab's "One Laptop per Child" (OLPC), which has brought the benefits (and limitations) of one-to-one computing to widespread public attention as a tool for addressing equity issues between the developed and developing worlds cannot be overlooked. Subsequent to this high-profile campaign, the concept of one-to-one has become well-known throughout the developed world, with OLPC pilots now being conducted in U.S. schools with low-income populations. The topic is now frequently covered in national media outlets.

National Public Radio's "All Things Considered" aired a series June 24-25, 2008, covering the initial stages of an OLPC pilot in Immokalee, Florida. The school's assistant superintendent defended the investment in laptops for children who lacked books at home by emphasizing the value of the programming abilities the students are learning. She used the analogy of a Trojan horse for the laptops and stated that "it's what's inside the horse that matters."[ii] The story emphasized how quickly the students took to learning basic programming, emphasizing the point that today's youth are "digital natives."

Developing world countries and rural and less-affluent urban school districts are taking the one-to-one computing paradigm seriously as evidence mounts that digital "haves" and "have-nots" accelerate already existing social divides. The power of one-to-one computing is that it turns the digital divide on its head. In this scenario, one-to-one becomes a digital opportunity that helps address a learning divide, potentially closing the gap between the life chances of the less affluent and affluent. The rapid pace of technological change and increased globalization mean that certain countries have the opportunity to leapfrog the industrial age, transforming themselves into information age tigers. Countries such as China, India, Ireland and Korea are on this path. Other countries have the opportunity to do this in the near future.

The Shift to One-to-One Computing

One may ask: Are the digital and learning divide issues too long-term and visionary to impact one-to-one computing in the near-to-medium term? Increasingly the answer is no. Rapid technological and social change raises the stakes for national policymakers and individual schools alike, bringing home the point that they could be left behind at an ever more rapid rate, and with more far-reaching consequences. These educational outcomes in turn contribute to long-term economic and social outcomes. For the developed world, this makes the consequences of poorly preparing students for the workplace of tomorrow more severe than ever. If a large portion of their workforce is not prepared for the information age economy, these jobs will move offshore. For this reason, countries in the developed world are taking steps towards decreasing the ratio of computers per student in the classroom. Successful pilot cases of one-to-one computing deployments are encouraging further deployment. In addition, countries such as the U.K. and Australia have recently established funding programs to decrease the ratio of computers per student in schools. These programs are a clear step toward one-to-one computing. While this process will take several years, it is well underway, and is gathering momentum.

United States

The United States, with its decentralized school administration structure, blazed a trail by introducing some of the first one-to-one computing solutions. One of the most notable cases is the state of Maine, where in 2001 governor Angus King announced plans to equip each K-12 student with a laptop in an effort to make his state more economically competitive in the future. This successful initiative was followed by Henrico County,

One-to-One Computing Programs in the US

California est. 6,000 • Colorado 380 • Connecticut est. 750 • Florida est. 8,500 • Georgia 210 • Illinois est. 1,500 • Indiana 673 • Kansas 6,385 • Kentucky 2,950 • Massachusetts 717 • Maryland est. 650 • Maine est. 1,500, Michigan est. 1,500, Missouri 790, North Carolina 2,050, Nebraska 95 • New Jersey est. 2,505 • Nevada 157 • Ohio est. 2,265 • Oklahoma 132 • Pennsylvania est. 1,392 • Tennessee est. 2,000 • Texas est. 14,850 • Virginia 27,125 • Washington est. 7,227

Michigan's Freedom to Learn Initiative

The state of Michigan's Department of Education launched the Freedom to Learn initiative in 2003 in conjunction with Ferris State University. Focusing on under-performing middle schools in one-fifth of the state's 500 districts, the program distributed wireless-capable HP laptops running Microsoft XP and Office to thousands of students and teachers and launched innovative teaching models organized around project-based individual and group learning. Funding for the initiative came from state education budgets as well as from each participating school district. To date, the program has achievement impressive accomplishments, including:

- After seeing the engagement of the students and communities involved in the pilot, FTL managers expanded the program to sixth graders across the entire state, recognizing middle school as a time in which many students begin to lose interest in traditional schooling.
- Initially developed by then-Michigan Governor Jennifer Granholm, the program's most notable achievement has been that its success in implementing one-to-one computing programs led to the creation of the One-to-One Institute (one-to-oneinstitute.org), a national non-profit organization dedicated to assisting other schools and districts looking to make the leap.

Virginia, shortly thereafter. Since that time, countless other school-district one-to-one computing programs have been launched. Across the U.S., at least 28 states have implemented successful student one-to-one learning programs.

These one-to-one computing initiatives are generally taking place on the school-district level. Statewide initiatives have been less common, and thus far full-scale programs have been limited to smaller states such as North Dakota and Maine.

United Kingdom

In the 2005-06 academic year the British government committed £3 billion (approximately US$6 billion) to the largest-ever school investment program, Building Schools for the Future (BSF). The program is a component of the national government's educational reform agenda. In its first year, £2.2 billion (US$4.4 billion) went to local authorities around the country to rebuild and remodel all secondary schools and prepare them to be "21st century facilities"[iii] with significant investments in ICTs as well as in buildings and infrastructure. Investment contracts spread out over 15 separate waves of invitation ensure ongoing evaluation and meaningful participation by local authorities.

County Kent State Schools, England

County Kent in England's Southeast region provides a key example of BSF in action. Although Kent houses the 2nd wealthiest population in the country, it has also seen a rise of immigrants and a sizable proportion of the residents fall within the lowest 15% of socioeconomic indicators. In recent years Kent has experienced a brain drain of educated graduates leaving the County for larger cities elsewhere in England. Two goals of the local government are thus to reach out to disenfranchised populations and provide them with a nurturing, empowering educational environment as well as to prepare the County for 21st century jobs. With over 104 secondary schools serving diverse populations, Kent has looked to the U.S. as a model, hoping to adopt the best parts of the American educational system (valuing creativity) while taking advantage of the great governmental investment in the region. Under Kent's "Putting Learners First" project, schools such as Hugh Christie Technology College provide tablet PCs for over 200 students, laptops for each teacher, and opportunities to participate in both Microsoft and Cisco Academies.

Prior to the BSF infrastructure initiative, the British government launched Laptops for Teachers (LFT) in 2002, which many consider a pilot for BSF. If the overall goal is to transform traditional learning, then a logical first step would be to interface with teachers themselves; LFT aimed to increase teachers' access to and comprehension of computers by providing £120 million (US$240 million) to local authorities for the purchase of laptops.[iv] Successful evaluations of the program led to increased government investment for teachers and then students.

A key component of BSF is to create ICT-rich environments in all secondary schools. BSF states that it will pay for "passive network infrastructure, active network equipment, hardware (computers and peripherals), software and setting up an area-wide managed network."[v] With an average expenditure of £1,675 (US$3,350) per student, it is the discretion of each local authority to determine the specifics of the schools' digital learning initiatives, provided they respond to BSF's ICT Output Specification Template. **In numerous cases this funding is being directed towards one-to-one computing programs**. County Kent and Leeds are key examples of this movement.

Implementation of the national program has been carried out by Partnerships for Schools, an organization created in 2004 by the governing Department for Children, Schools and families, specifically to manage the BSF program. Managing the technology component of BSF is Becta (formerly known as the British Educational Communications and Technology Agency), the British government's lead agency for ICT in education. A key strategic objective of Becta is "To put education and skills system on the way towards universal access to learning through technology." For the 2007-08 year, this objective is broken down into specific measurable goals, including "3,000 (88 percent) secondary schools and 8,700 (50 percent) secondary schools providing access to a personal online learning space."[vi] This objective reflects a strong commitment to one-to-one computing as an integral component of an ambitious national education initiative.

Australia

In November 2007, the **Australian national government committed $1.2 billion (US$1.15 billion) over five years (starting in 2008) to provide laptops to senior high students**. This program has launched a national public debate about how to best achieve one-to-one computing in the schools such that students are prepared for the workplace of the 21st Century. While the initial phases of the program target a one computer per two students ratio, the government has publicly communicated a final goal of providing each K-12 student with their own personal laptop. Dubbed the "Digital Education Revolution" the program is a component of a larger overhaul of the nation's educational system, aiming for a large-scale improvement in the country's education and training to world class standards.[vii] In the first round of funding, the Ministry of Education identified the neediest schools across the country, all eligible for funding. Over 95 percent of these schools (902) applied for support and 896 were successful in their proposals. Round two begins in July 2008 and will be used to ensure that every secondary school across Australia reaches the 1:2 computer-to-student ratio in the near future, as a first step toward providing each and every student with a personal laptop.

The program is administered through two related initiatives:

- *National Secondary School Computer Fund* – provides grants of up to $1 million (US$956,000) to secondary schools for their new or updated technology plans (including computers and networking devices)

- *Fiber Connections to Schools initiative* – funds up to $100 million (US$95 million) to support the development of a school-based broadband connection program

Recognizing that the initial purchase of computers and networks is only one component of a successful plan for technology integration in education, the Australian government has also committed $32.6 million (US$31 million) over two years to be used for online curriculum tools and resources. Training and resources will be available to educators at both the state and territory level, as well as with religious and private school systems, in order to ensure a nationwide sustainable commitment to Australia's schools.

Queensland

Even before the announcement of the Digital Education Revolution, Australia's states and territories had already been working towards a more technologically advanced classroom. Notably, starting in 2007, the Department of Education, Training and the Arts in Queensland deployed a number of ICT initiatives, each laying the groundwork for successful one-to-one computing. Such initiatives include:

- *Computers for Teachers* – Over 10,000 Lenovo/IBM ThinkPads were distributed to teachers across the State, all with the standard installation of the Smart Classrooms "Managed Operating Environment" consisting of Windows Servers, Windows XP Service Pack 2 and Macintosh OS 10.x, integrated remote management tools, accredited technical training and support. From July 2007 through July 2010, over $70 million ($67 million US) in laptops and training will be disbursed to teachers across Queensland;

- *OneSchool* – A student-focused software application to manage learning, resources, reporting and analysis will only be released to schools that have upgraded to the Managed Operating Environment. This first release of OneSchool will also allow administrators to create and use electronic student records.

- *Intranets in Schools* – A customized intranet, based on Microsoft SharePoint server, will improve communication within schools and centralize all administration and digital learning materials. It will also be rolled out to all schools once they have upgraded to the newest Minister of Education (MOE) version.

While teachers across Queensland receive either Lenovo/IBM ThinkPads or Apple MacBooks, the populations involved in the nationwide program are so much larger that the government has received bids from Asus, Dell, HP and Intel to purchase their sub-$500 laptops in bulk. The only specifications regarding computer purchase require wireless connectivity and portability – no desktop computers will be funded through Digital Education Revolution. By equipping increasing numbers of students and teachers with laptops, the government of Queensland is laying a foundation for one-to-one computing.

Top Drivers of One-to-One Computing

Educational Outcome Drivers

The prospect of improving student performance and motivation is perhaps the most important driver motivating governments and school districts to embark on one-to-one computer initiatives. Several research studies provide evidence of this. For example, a 2005 study published by the Journal of Educational Computing and cited by Brains Consulting entitled *Learning With Technology: The Impact of Laptop Use on Student Achievement* revealed the following key findings:

- Laptops lead to more student writing and writing of a higher quality
- Laptops increase access to information and improve research analysis skills
- Students spend more time engaging in collaborative work and participate in more project-based instruction
- Students direct their own learning, readily engage in problem-solving and critical thinking
- Students consistently show deeper and more flexible uses of technology
- Students spend more time doing homework on computers[viii]

Additionally, the pioneering one-to-one computing initiatives in the state of Maine and Henrico Country, Virginia, have been in place for a sufficient amount of time to provide documented proof of educational benefits. A 2007 study by the University of Southern Maine showed that middle school students in Maine have displayed improved progress in their writing skills.[ix] Teachers, meanwhile, have benefited from greater collaboration with colleagues and a wider range of resources available to them, while improving their own technological skills and training.

Enhancing Education

School districts in Maine and Arizona saw results including a drop in absenteeism, an improved performance in grades in multiple subjects, and a marked decrease in school dropout rates.[x] Students are able to direct their own learning with laptops, and the 70% of students who are "non-auditory learners" can learn in a more visual and interactive environment.

Continued success in Maine and Virginia has inspired similar one-to-one computing initiatives in states such as Washington and Nebraska, which have seen benefits such as improved academic achievement and motivation and a transformation in the quality and innovation of teachers' instruction. These successes have in turn influenced numerous additional initiatives, including the Australian government's commitment of more than 1 billion dollars to launch the aforementioned "Digital Education Revolution."

It is important to keep in mind that one-to-one computing is not a quick fix to resolve all educational challenges. For example, evidence that having access to a personal laptop improves student performance on standardized tests is mixed. However, many educational experts cite benefits beyond those captured by testing. For example, Mark Warschauer, education professor at the University of California at Irvine and author of "Laptops and Literacy: Learning the Wireless Classroom," stated in a recent New York Times article, "Where laptops and Internet use make a difference are in innovation, creativity, autonomy and independent research… if the goal is to get kids up to basic standard levels,

then maybe laptops are not the tool. But if the goal is to create the George Lucas and Steve Jobs of the future, then laptops are extremely useful." [xi]

Economic Drivers

Economic growth and development is repeatedly cited by local and state governments as a major driver and benefit of their one-to-one computing initiatives. This factor has accelerated in importance in recent years as both manufacturing industries and white collar jobs have declined across the industrialized world. These jobs are either replaced by information-age jobs or outsourced to the developing world. Just as former Maine Governor King cited the opportunity to reverse his state's status as an economic laggard when he unveiled a one-to-one computing initiative at the beginning of the decade, so **officials ranging from district superintendents to governors have also identified economic development as a major reason for investing in their own one-to-one computing programs**.

> "We live in a technology-driven age where computers are essential tools in most industries and workplaces. But computers can also be valuable tools as part of the learning process. With this pilot program, we'll give students another resource for learning and, at the same time, help them develop technology skills that will help them compete when they're finished with school and ready to enter the workforce."[xii]
>
> *—Illinois Governor Rod Blagojevich in his announcement of the selection of seven school districts to receive grants for one-to-one computing programs in September 2006*

While most one-to-one computing initiatives are too new to have shown their impact on long-term economic development, **there is mounting evidence that corporate executives make investment decisions at least partially on the basis of the technological training of local workforces**. One of the factors of the Irish economic "miracle" of the last fifteen years is the attractiveness of the country's technology-oriented educational system and the workforce it has produced, which has been noted by leaders of Intel and Dell as key reasons in their multi-billion dollar investments in Irish manufacturing and research facilities.[xiii] Companies have an increasing number of options when making investment decisions and workforce development is cited as one of the key differentiators in the competition between communities for the opportunities of tomorrow. Both the Australian and the British governments have cited the need to prepare every member of their society for the workforce of the 21st century as major factors in launching national initiatives.

In addition to competing with other countries and localities for jobs and development, towns and school districts also compete with each other for students and families. Educational decision makers are acutely aware of the possibility of gaining or losing families and the tax base they provide and cite such concerns in one-to-one computing initiatives. The Northern Cass School District in North Dakota mentioned the economic impact of its one-to-one computing initiative when it said in unveiling the program that "parents will want to move to our district to give their children an opportunity to enhance learning through technology."[xiv]

Social Goal Drivers

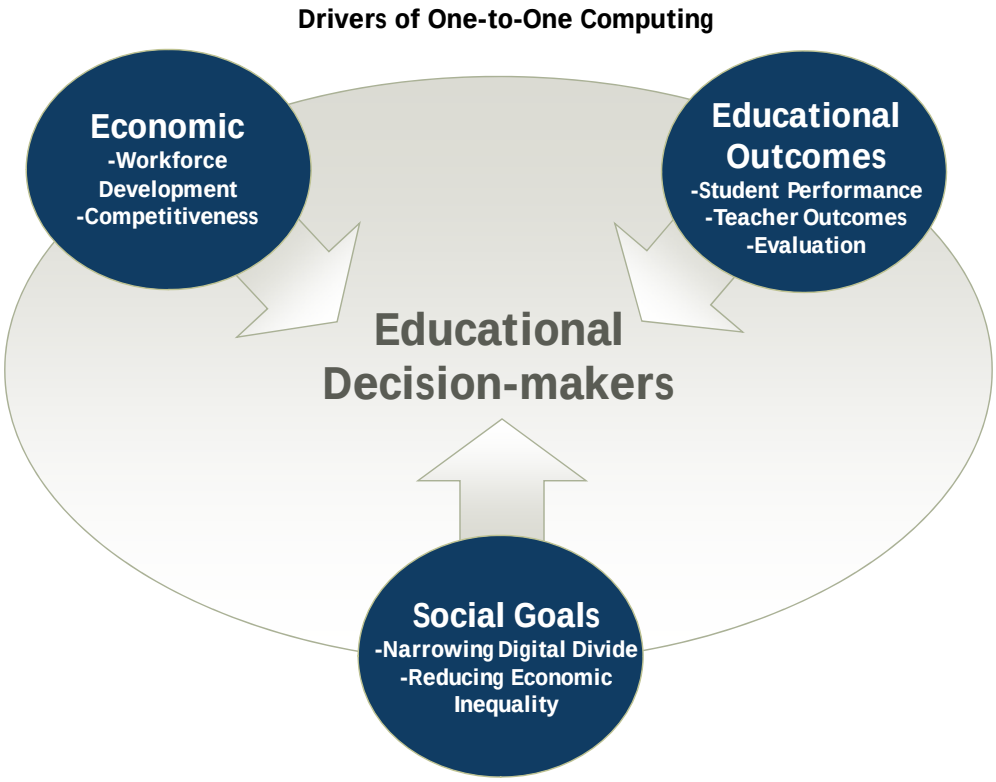
As important to many policymakers as long-term economic goals and short-term educational outcomes is the goal of reducing socioeconomic inequality between different demographic and geographic groups. A key part of achieving this aim is reducing the "digital divide" between wealthy, urban areas

and poorer rural and inner city areas. Many policymakers and elected officials have begun to see this as not only good policy but increasingly as a moral imperative in addressing equity. Increasingly, policymakers recognize that the digital revolution can cut two ways: it can be a force accelerating existing social advantage and disadvantage, or it can be a force for economic inclusion by empowering all socio-economic and ethnic groups, regardless of their geographic location.

In **Australia, where a large percentage of students live in rural environments, educators and policymakers have viewed one-to-one computing as an equalizer,** not only within the country but for Australian youth traditionally on the fringes of the global economy. For nearly twenty years, the notion of a 21st Century Classroom, replete with appropriate technology for every student, has caught on as a way to achieve the national schooling goals set out by the Australian Educational Council. In Britain, the notion of closing the achievement gap between white and minority students, as well as between richer parts of the nation such as southeast England and poorer areas such as Wales, is also a hot topic among educators. Many educational decision makers believe that one-to-one computing programs can close a gap between rich and poor students that results from wealthier students having home access to technology while poor students do not.

Gaps in access between racial groups are also a concern in the United States. As of 2005, there was a 20 point difference in rates of PC ownership and Internet access between white and black households. A 2008 study by the Public Policy Institute of California found that only 40 percent of the state's Hispanic residents have Internet access, compared to 86 percent of whites, 84 percent of Asians and 79 percent of African Americans.[xv] One-to-one laptop programs help to level that playing field by equalizing access across socio-economic groups.

The figure below outlines the key drivers of one-to-one computing programs.



Challenges Confronting One-to-One Computing

While there are powerful drivers accelerating the shift to one-to-one computing in education, the obstacles educators face in reaching that goal are considerable. Financial/budgetary obstacles, stakeholder resistance, teacher training requirements and inadequate tactical planning can all inhibit one-to-one computing efforts.

Financial / Budgetary Obstacles

Financial / Budgetary Obstacles

The upfront and ongoing investment required to implement one-to-one computing initiatives is perhaps the most significant obstacle today. While many one-to-one computing programs have received backing from corporate and philanthropic donors, universal implementation will require significant expenditures at a time of strained education budgets. Investments in technology compete with imperatives to reduce class sizes, increase teacher salaries, and upgrade physical infrastructure. Some one-to-one computing initiatives have reported difficulties due to larger-than-expected maintenance and replacement costs. The issue of sharing costs with families also threatens to become more problematic, as the greater ability of parents and families in affluent areas to pay for a part of computer costs could widen rather than narrow the digital divide.

Potential Solutions:

While funding is likely to remain a primary barrier to the expansion of one-to-one computing programs around the world, schools and administrators are coming up with a variety of ways that one-to-one computing deployments can be financed. School lease, school purchase, and "hybrid" financing options that can be tailored to the needs of individual communities or families allow schools to choose one-to-one computing options that best suit their economic or fiscal situation. Successful financing of one-to-one computing programs will also require commitments at the highest levels of government and dedicated revenue streams to ensure long-term operation and continuation of these programs. Identifying and tapping private sector actors such as corporations and foundations is also an option to fill gaps left by public funding.

Resistance from Stakeholders

Stakeholder Resistance

Since one-to-one computing initiatives entail both large financial outlays and significant reorientation of teacher training and techniques, advocates may have to overcome resistance from key stakeholders such as teachers and parents. Some one-to-one computing initiatives have been hampered by student viewing of inappropriate material on the Internet and the use of laptops to cheat on tests or engage in "chatting" with friends during class.[xvi] Such issues pose new challenges for teachers and threaten to undermine parental and community support for one-to-one computing programs. Teachers may fear the diversion of funds from other areas to computers and a shift away from the "basics" of learning. All of these issues must be addressed for successful implementations to occur.

Cases such as the Liverpool Central School District in New York State illustrate the need to ensure parental and community support for the initiative is strong. In a May 4, 2007, article, *The New York Times* reported that the school district decided to phase out its laptop program beginning in the fall of 2008. One reason cited for ending the program was parents' resistance, particularly to its expense. The article reports that "parents have long criticized the cost of the laptop program: about $300K from the

state plus individual student leases of $25 a month or $900 from 10th to 12th grades for take-home privileges."[xvii]

Potential Solutions:

Advocates are advised to engage educational leaders (state governments and school superintendents) in articulating the pedagogical benefits of one-to-one computing; working at the grassroots level (with IT departments and teachers) will have a more limited impact, and is less likely to lead to systemic change. Such leaders are also crucial in driving the program to successful execution.

In addition, workshops should be held with parents prior to implementation of a one-to-one program clearly laying out the mission, objectives and benefits. By learning from the examples of prior implementations, it is now possible to obtain buy-in from key stake-holders based upon a realistic assessment of the advantages of one-to-one computing from a short, medium and long-term perspective.

Deploying adequate filtering technology solutions—to prevent inappropriate use of the Internet—is also critical to the success of one-to-one computing projects. Internet filters can largely mitigate the concerns of families and school officials.

Teacher Training Requirements

An important goal for many educators is the reorientation of the basic paradigm of learning that can take place in a one-to-one computing context, thereby imparting skills required in the 21st Century. Pamela Livingston, in her article "The One-to-One Tsunami," describes the possibilities for greater self-directed learning, higher order thinking, and the possibility of instantaneous research during projects.[xviii] Where in conventional science classes students observe teachers performing dissections and physics experiments, with one-to-one computing initiatives each student can simulate these tasks at their desk, transforming learning from a passive act into an interactive one. Students can even lead learning and devise lessons for their classmates. This shift can only take place in the context of a major change in the way teachers themselves are taught and trained, and portends a shift in education toward student-centered learning.

At the same time, school districts implementing one-to-one computing must often work within the existing educational paradigm. This means that, at a minimum, teachers need to be supported in integrating one-to-one learning into the curriculum. It is essential that teachers receive their laptops prior to the students and receive specialized training on how to integrate laptops into the curriculum. Teachers may also require assurances that adequate technical support will be made available, such that classroom activities are not disrupted due to hardware and software issues.

Potential Solutions:

Support programs such as the Microsoft Innovative Schools and the Anytime, Anywhere Learning Foundation have emerged to provide frameworks, tools and guidance in the transition to teaching the skills required for the 21st Century. Specific steps such as providing teachers with their own laptops at least three to 12 months before their

students is one step towards empowering teachers. Furthermore, careful planning such that students are encouraged to take responsibility for teaching and learning from each other in collaborative environments can advance the development of independent learning skills.

Inadequate Tactical Planning

Problems related to financing maintenance and support arise when the total cost of ownership (TCO) of computers is not accurately determined prior to procurement and deployment. Shortcomings in planning can lead to failures in execution, which in turn undermine support. In particular, some of the earliest adopters of one-to-one computing in the United States failed to take into account the total cost of maintaining computer hardware, software upgrades, repairs and network maintenance. Higher-than-expected costs have undermined support for one-to-one computing.[xix]

Potential Solution:

Administrators must perform a thorough assessment of the costs involved in one-to-one computing deployments including a full TCO analysis to fully understand and budget for all anticipated costs. Assessing student, family and community needs and perceptions is also crucial in ensuring that the appropriate solution is chosen for each school. Planning programs such as the Anytime, Anywhere Learning Foundation's "21 Steps to 21st Century Learning Institute, and the Microsoft Solution Blueprint Workshops for Education Ministries provide detailed road maps and action steps to ensure all components of a one-to-one computing implementation are properly planned.

Market Forecast

In the past two years, the outlook for the one-to-one educational computing market has been buoyed by a number of trends favorable to the rapid growth of this segment over the short- and medium-term future. These trends are occurring on both the demand side and the supply side of the market. **On the demand side,** the increasing number of national, state/provincial, and local one-to-one computing initiatives that have gathered steam, along with a growing number of local school districts that are embarking on one-to-one computing pilot programs, is beginning to create a self-sustaining momentum behind the idea of one-to-one computing. As more initiatives are announced, educational decision makers at all levels begin to fear that their school systems are falling behind neighboring areas, or other countries, and feel obliged to at least begin small-scale deployments of one-to-one computers. **On the supply front**, a host of low-cost, compact devices is stoking interest in new capabilities while allowing education officials to stretch their budgets further. These developments are mitigated, however, by the economic slowdown now hitting North America and the British Isles, which is beginning to take its toll on education budgets and which may last through 2009. Building the political will for increasing technology budgets and devising creative ways of financing one-to-one computing programs may be the key to crossing the tipping point. In this respect, Australia and the U.K. may advance further than the United States in the short-to-medium term.

Growth in One-to-One Computing Initiatives

According to the Anywhere Anytime Learning Foundation, in late 2006 there were over 500,000 children in the U.S. enrolled in one-to-one computing programs, out of a total K-12 population of nearly 55 million. The growth in this number exceeds 15 percent per year in the U.S., and other developed countries have seen similar rates of growth. Since mid-2006, several major programs have been launched, including:

- The new government of Australia announced a plan in late 2007 to invest AUS $1 billion over four years to equip each Australian student in grades 9-12 with his or her own computer.
- In the 2005-06 academic year the British government committed £3 billion (approximately US$6 billion) to the largest-ever school investment program, Building Schools for the Future (BSF), opening the pathway for numerous schools to transition to one-to-one computing. Becta, an implementing partner of BSF, targets one-to-one computing.
- In September 2006, the state of Illinois announced the Technology Immersion Pilot Program (TIPP), part of its broader I-Connect one-to-one computing initiative, to give laptops to 2,200 students in 17 schools throughout the state.
- In January 2007, Pennsylvania unveiled its Classrooms for the Future one-to-one laptop program with technology company CDW as its partner. The program has since delivered over 80,000 new laptops at 257 schools across Pennsylvania.
- Dozens of individual schools and school districts in the U.S. and Canada have announced one-to-one computing initiatives of their own.

Several other states, such as South Dakota, have launched their own programs and states with longstanding programs such as Maine and Michigan have undertaken further expansion in the last several years. The U.S. federal government has contributed grant money to fund pilot programs at the state and local level. Larger states such as California, New York, and Texas have lagged at starting new programs, but their entrance into the market could further swell growth rates in the educational

computing market. With a penetration rate of only 1 percent of the U.S. market, one-to-one computing constitutes a huge, untapped market.

Technological Stimuli

As interest in one-to-one computing has soared, the array of devices available to educators to meet their program needs has grown, and this has in turn further fueled the growth of the one-to-one computing market. The **explosion of mobile computing devices has been particularly important**, as consumers continue to shift away from traditional desktop computers. The launch of the One Laptop per Child project represented a psychological quantum leap; the idea of an ultra low-cost (if not quite $100) laptop for every child in the world suddenly began to seem like a tantalizingly close prospect. Countries such as Uruguay have taken the plunge with plans to provide all of the country's schoolchildren with their own low-cost laptop computer.

"Take off" Stage Reached

The 2008 America's Digital Schools Report confirms that one-to-one computing programs may indeed have reached the "take off" stage. According to the report, which is based on surveys of over 400 administrators, the percentage of schools reporting improvement in their one-to-one computing programs increased from 30% in 2006 to 78.7% in 2007. Forty-one percent of pilot programs now include over 1,000 students each and a further 10% include more than 5,000 students.

The OLPC's XO laptop debut has spurred competition in the form of the Intel Classmate PC and the Asus Eee, among others. Estimates on the sales of low-cost computing devices (priced under $500) vary widely, but all observers agree that they are booming. JP Morgan analyst Alvin Kwock predicts that 10 million to 15 million low-cost computing devices will be sold around the world in 2008, and Acer CEO Gianfranco Lanci predicts that 40 million to 45 million low-cost computers will be sold in 2009. Intel projections call for the sale of over 50 million Classmate PC units in 2011. Other observers are less optimistic, with IDC predicting total low-cost computer sales of $3.5 million in 2008, rising to $9 million in 2012. Projected worldwide growth in the overall notebook market remains robust, with sales rising 35 percent in 2008 to 145 million units and another 25 percent in 2009 to 181 million units.[xx]

The low prices of these new computing devices, typically $200-$500, are allowing education decision makers to reorient their thinking away from desktop computers in computer labs toward the concept of a device in the hands of every student, for use at school, home and in between. Technology budgets in the U.S. are expected to remain fairly stable through 2010, but falling prices for hardware are increasing purchasing power and letting educators imagine the possibility of equipping each student with a personal device.

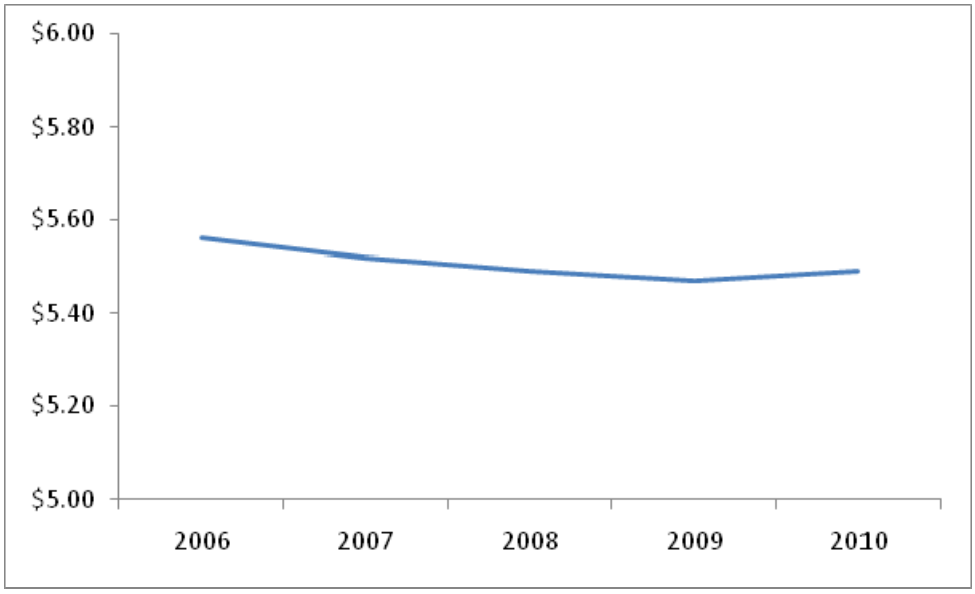
The rise of devices specifically tailored to classroom computing is also feeding the growth of the one-to-one computing market. Innovations in tablet PCs in particular are leading to increasing adoption of such devices in classroom computing. Microsoft's integration first of its Windows XP operating system and later of Windows Vista with tablet functionality has allowed for quieter, smoother student note taking.[xxi] Sales of other devices such as PDAs, MP3 players, and game players that can be used in different capacities in one-to-one computing programs are also growing at double-digit rates.

The natural consequence of such a rapidly growing market is the rise in competition. Furthermore, an ever-greater number of technology providers are building comprehensive one-to-one computing solutions for schools and teachers. Apple, Dell, Gateway, HP and Microsoft have all created information portals for one-to-one computing programs. In Apple's case, the Maine initiative has reversed a diminishing share of the educational market and given the company implementation expertise from which it can learn and improve. Thus, while opportunities increase with the size of the one-to-one computing market, competition gets hotter and already tight margins may shrink further.

Budget Obstacles

While falling computer prices and greater private sector involvement in educational technology bode well for the expansion of one-to-one computing initiatives, financial constraints still represent a formidable obstacle to more widespread adoption in many countries and environments. As the table below illustrates, technology budgets in the United States are projected to stagnate for the next several years despite rising enrollment, particularly as the subprime mortgage crisis, falling property values and soaring energy costs take their toll on federal, state and local budgets. School districts will be hard pressed to avoid budget cuts.

U.S. K-12 Technology Budgets in Billions



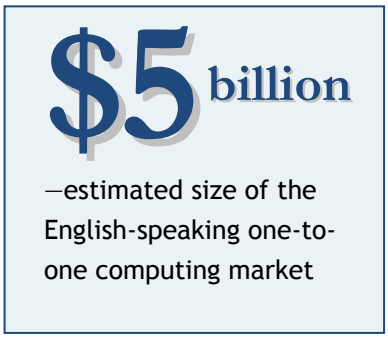
Already, states such as Michigan that have committed to expansions of one-to-one computing programs have had to shelve them in the face of budget constraints. The likelihood that this will continue to occur will force schools to look at alternatives to government funding. Private sector partners such as foundations and corporations have long been involved in subsidizing the cost of one-to-one computing initiatives and will no doubt continue to play a role, but companies in particular are limited by their need to make profits in this market. School systems in a number of one-to-one computing initiatives require parents or families to contribute to the cost of computers, but doing so on a large scale will require finding solutions for families without the financial means to contribute. And since the total cost of ownership for computers is several times the initial hardware expenditure, school officials will have to budget for large expansions in human and physical costs if pilot one-to-one computing programs are to be grown in a sustainable manner. Countries with more centralized control

over education may be at an advantage due to the potential for volume discounts and economies of scale, a point accentuated by the Australian national one-to-one computing initiative.

Market Size

With one-to-one computing programs proliferating and new, lower-cost devices entering the market, but education budgets under strain, what will the market for one-to-one computing devices look like over the next several years?

It has been estimated that the total cost of equipping each child and teacher in the U.S. with their own laptop computer (using a COSN / Gartner total cost of ownership estimate of $2,000) is $107 billion.[xxii] Initial hardware costs are estimated to be only a quarter to a third of total costs, which would be a total expenditure of approximately $30 billion. If only 10 percent of U.S. students and teachers were enrolled in one-to-one computing programs by 2012, that would constitute a market of approximately $3 billion, with billions more spent on software, support and maintenance. Add to this the nearly $1 billion Australia will spend on its "Digital Education Revolution" and the initiatives being announced in Britain and Canada, and **a more than $5 billion market in the English-speaking developed world alone begins to take shape.** Hardware prices are predicted to continue to fall over the next several years, and the field of devices is likely to continue shifting toward more mobile computing functionality.



On the software front, growth is also likely to be robust. Continued innovation in adapting operating systems to new device types means that many of the devices that will be deployed in one-to-one computing solutions will use Window or Mac operating systems, which is itself a significant opportunity. The rush to create appropriate content will also give a boost to the market for educational software, which has seen diminished sales growth as free online content competes vigorously for market share. The extent to which off-the-shelf software application sales increases may depend on the uncertain success of wireless Internet initiatives in cities and schools, since extensive Internet coverage might allow schools to bypass off-the-shelf packages and access free or low-cost content online.

Software sales to schools totaled $1.9 billion in 2006 and have been increasing at a nearly 5 percent annual clip.[xxiii] **An acceleration in the growth of one-to-one computing could result in an educational software market of almost $3 billion by 2012**.

Expanding Device Options

A further factor fueling growth of the one-to-one computing market is the expansion in device types on the market, ranging from MP3 players to smartphones, to PDAs, to low cost laptops, to the tablet. Each of these options expands the range of price-points and functions available to schools embarking upon a one-to-one computing initiative. This, combined with the rapid expansion of wireless connectivity and falling price points for hardware and software, brings one-to-one computing within the reach of an increasing number of schools. In this section, we first review laptop options, as the majority of one-to-one initiatives will opt to use this type of device, and then provide an analysis of each device type, with a view toward its appropriateness in the educational arena.

Laptops, rather than desktop computers, are the standard device for one-to-one computing initiatives, due to the combination of functionality and portability. One of the one-to-one computing program's greatest strengths, in fact, is that by allowing students to bring the laptops home for "anytime, anywhere" learning, it extends the learning community to students' parents and siblings. Experts feel that laptops' ability to support more memory-intensive programs like audio, video and mapping production in addition to standard word processing and Internet software, make them the most robust option for one-to-one computing. As ultra low-cost (e.g., OLPC's XO and Intel's Classmate PC) laptops become more advanced and are able to run more robust versions of Windows and other advanced configurations, they are poised to challenge the dominance of standard laptops in this sector.

1. Ultra Low-cost PCs (e.g., OLPC XO, Intel Classmate PC, Asus Eee)

Positioning

- Ultra low-cost computers, or those priced under $300, have largely spurred the conversations on one-to-one computing in developing countries and around the world. They are traditionally laptop computers. The OLPC announced the XO Computer to much fanfare in 2005, but has fallen short on nearly all of its goals. The price has risen to $188 and only 370,000 laptops were shipping by end-of-year 2007, when the original mark had been 150 million by the end of 2008. Agreement to create a version that runs Windows is widely touted as being key to boosting sales.
- The Classmate PC has fared a bit better as it is supported by Intel, which has the distribution and marketing required for scale. Asus Eee, which was based on the Intel Classmate PC reference design, has become the most popular ultra low-cost model, with sales projected to hit 10 million in 2009, approximately a half to a third of total ultra low-cost computer sales.

What is possible

- Full-functioning, lightweight computers boast wireless connectivity, word processing and other software programs built-in, along with a user interface that appeals to children;
- Prices are competitive with most handhelds and smartphones;
- Multiple USB ports allow for the use of peripherals and external storage;
- Some XO models have hand cranks to generate power and both the XO and the Classmate PC have been "ruggedized" to withstand the harsh environments of developing countries.

What is not possible

- Low-powered processors limit the number and variety of software applications that can run on these devices;
- Small keyboard may be difficult, if not impossible, for older students and teachers to work with;
- XO maintenance model (students fixing their own computers) is untested and actual maintenance costs will likely be high;
- Internal problems and the loss of key players at OLPC organization (incorporated as a non-profit, not as a company) mean the future of the product is tenuous.

Impact on classroom

- Ultra low-cost PCs can do most things a full-powered laptop can do and its emphasis on wireless networking may encourage student-student and student-teacher collaboration.

Recommendations

For schools:

- Schools will have to evaluate the XO, Classmate PC and the Eee and compare them with the new crop of low-cost laptops. Analyzing the total cost of ownership of these models will also be essential, since support, maintenance, and training make up the bulk of costs and new devices may have higher costs in these areas.

For Microsoft:

- Continue to innovate with adaptable versions of Windows that match ultra low-cost specifications.

2. Ultra-Mobile PCs (UMPC) (i.e., Origami project)

Positioning

- A collaboration between Intel, Microsoft, Samsung and others, the ultra-mobile PC (UMPC) was initially developed as a competitor to Sony's PSP game device. It was then repositioned as a full-fledged PC, smaller and lighter than standard tablet PCs. Through the collaboration, pricing has come down and units are now expected to cost around $500.

What is possible

- Ultra portability improves students' mobility, and newer versions will be great options for field trips and other out-of-school activities as they will feature 8-hour battery life;
- Installing any software program that runs on Windows XP or Vista. Some are also now configured for various Linux flavors;
- Touch-sensitive screen allows for writing or drawing with a stylus, as with tablet computers;
- Wireless configuration allows for television/film viewing, GPS/navigation opportunities and everything else a laptop computer can do, due to its impressive processing power.

What is not possible

- UMPCs running Vista may not have much space left over for large software programs, due to the minimum specifications for Vista configuration;
- Most UMPCs do not have a physical keyboard but instead feature an on-screen digital keyboard. External keyboards can be attached via USB ports.

Impact on classroom

- The anticipated $500 price puts the UMPCs in a more expensive category than the ultra low-cost devices (OLPC's XO, Intel's Classmate PC or Asus' Eee) but they are still significantly less expensive than a standard laptop or tablet computer. This could be useful for cost-saving measures but unlike the tablets, the much smaller screen on the UMPC means that a student could not in all likelihood use it to compose an entire paper without utilizing external keyboards or monitors.

Recommendations

For schools:

- UMPCs offer great possibilities for extra-curricular activities and field trips but within school settings they may prove limiting without external monitors and keyboards. Schools need to consider pricing of a UMPC package as including these external peripherals, and then move ahead with UMPC as a pilot or first foray into one-to-one learning.

For Microsoft:

- Maintain and promote use of Windows mobile computing platforms (as opposed to XP or Vista) and continue to run pilot programs in schools—but simultaneously continue to invest in the OLPC, which is ultimately more of a rival to full-fledged laptops or tablets.

3. Laptop Computer Carts

Positioning

- Computer carts were originally considered an innovative way to introduce mobile computing into classroom settings, enabling one laptop to move handily between rooms. It is less a technology, and more a usage model—maintaining the computers at the schools, under school ownership. Although the computer-to-student ratio tends to be higher than one-to-one (more often 1:10 or 1:5, as clusters of student sign up for small-group time slots with a class' laptop), it could be seen as a first step for a school migrating toward a one-to-one computer learning program.

What is possible

- Laptops (see below) provide multiple options for both simple and advanced computing. The use of laptop carts in particular allows for structured group collaboration, with small numbers of students (usually 3 to 5) sharing in-class computer time.
- Studies show measurable student improvement with continued computer use, even if it is not with a personal device.

What is not possible

- Since the computers remain within the school at all times, students do not have the opportunity to bring the laptops home, restricting options for "anytime, anywhere" learning.
- Literally, mobility. Although the laptops are on carts many are configured for plug-in power and wired connectivity only, so they cannot be taken outdoors or maneuvered smoothly between classrooms.

Impact on classroom

- Although not an ideal option (or at least not one resembling true one-to-one learning), for many schools with limited funding, it may be a good first step.

Recommendations

For schools:

- Consider funding and financing options so as to leapfrog over the computer cart "stage" and move directly to a one-to-one computing scenario.

For Microsoft:

- Be aware that for many schools, this is still their only option. They will, of course, need relevant and useful software configurations so there is still an attractive market with this setup.

4. Tablet Computer

Positioning

- Tablet computers hold great potential for schools, whereas for businesses they still remain a niche product. More portable than even the ultra-light laptops, but with fewer features and often smaller screens and keyboards, the most unique features of many are the pivoting screen and stylus pen, which allows the user to write or draw directly on the screen and eliminate obtrusive typing noises.

What is possible

- Nearly everything that a full laptop can do—some even have built-in cameras and many employ flash memory instead of full hard drives, which means greater portability and increased sturdiness, which is optimal with teenage users traveling with the device to and from school each day;
- Tablets running mobile versions of Windows, Linux or even Mac operating systems allow for students to use familiar computer operating systems without worrying about memory-intensive systems to slow down the devices;
- More opportunities for graphics and artistic activities as students can render original artwork on the screen and capture it digitally;
- In addition to the touch-screen, many tablets also come equipped with physical keyboards, which facilitate in the writing of longer documents and reports;
- Tablets without keyboards are more rugged and without moving parts they are less likely to incur damage by student users;

- The swivel screen and notebook-like capability make it feel more comfortable and intuitive to newcomers to computers.

What is not possible

- Some models have less space for data storage and lower battery life than full-fledged laptops;
- Mobile operating systems (in some tablets) may limit functionality, and most cannot be used as multimedia devices like full laptops or even standalone DVD players;
- There is still a $200-$300 price premium for many tablet PCs, putting them at a disadvantage relative to new ultra low-cost PCs.

Impact on classroom

- Successful one-to-one computing pilots have already been launched with tablet computers; ultra portability, pared-down applications and recognizable (i.e., standard Windows) software fit well with students' needs. The increased emphasis on the "write-able" screen is suited to a classroom environment, as an upright screen may create a barrier between teacher and student.[xxiv]

Recommendations

For schools:

- Tablets are ideal for writing, math, graphing, diagramming and drawing. Schools must decide whether tablets' strongest features—light weight and the digital stylus—are worth the premiums they command.

Tablet Computers – Positioning & Advantages for the Classroom

If the greatest barrier to widespread adoption of one-to-one learning is convincing students and educators that technology need not be a distracting or foreign force, then it is logical to try and integrate appropriate, familiar technologies to seamlessly transition to computer-based work. The tablet PC is a logical solution to this dilemma, as its form factor and handwriting recognition software make for a comfortable stand-in for paper-based notebooks. Tablet PCs have finally emerged as more than just lighter laptop computers, and are now considered more user-friendly and intuitive for laptop neophytes.

Since the Windows XP Tablet Edition was introduced a few years ago, tablets have been able to employ both the touch screen and standard keyboard functionality, making them much more robust and multifaceted than tablet PCs in years past. Newer versions running Windows Vista also allow for installations of standard software.

Educators sing its praises as a tool with all of the features of a laptop, but the ability to hand-render mathematical formulas, drawings or anything one would do on a chalkboard, makes it exceptional. Tablets, say math instructors, allow students to figure out problems and show their work step-by-step, as they would with pencil and paper,[xxvi] while math work done on laptops reveals answers alone. Art teachers like the flexibility that tablet PCs and digital art afford, letting students experiment with their work and backtrack or erase with ease, rather than having to commit to any changes that they might have made had they worked with more traditional media.[xxvii]

Price is the only, and unfortunately a very significant, drawback. On average, tablet PCs tend to cost a few hundred dollars more than comparable laptops, making the choice to go for tablets a difficult one for budget-conscious schools. As demand grows, competition among manufacturers will also heat up—at present, Toshiba and Acer have led the pack but Lenovo/IBM, Samsung and even an after-market MacBook customized tablet[xxvii] have all been introduced in the last three years. More manufacturers are touting their involvements with schools[xxix] and negotiate bulk rate discounts for educational markets, undoubtedly the future for this device.

For Microsoft:

- Increased partnerships with manufacturers (see Toshiba's 10th anniversary of one-to-one computing[xxv]), along with repositioning of mobile O/S and OneNote note-taking software to appeal to student market.
- Emphasize tablets' great fit in learning settings—a "21st century notebook" in which students and teachers alike can access the internet for advanced research, take advantage of multimedia offerings and improve upon low-tech activities like note taking and artwork. There is great potential in highlighting features that allow tablets to fit naturally in classrooms, like their low horizontal orientation (no large monitor between student and teacher) and extreme portability.

Non-Laptop Options

1. MP3 Players

Positioning

- Most ubiquitous and accessible personal new media device;
- Low cost—as inexpensive as $20 per unit;
- Can also function as portable memory (particularly for images files), or as radio and sound recorders with appropriate add-on components.

What is possible

- Distributing pre-recorded lectures (podcasts) and other dynamic information;
- Capturing sound, which is useful for language classes;
- Newer models may have capability to view videos in addition to listen to sound, and/or wireless connectivity or beaming functions for interactivity with adjacent players or connections to the Internet;
- Large amounts of data storage (up to 160GB).

What is not possible

- Most do not have integrated keypads and cannot support external keyboards;
- Limited interactivity between user and device;
- Most cost-effective devices, which offer only the most basic of functions.

Impact on classroom

- Lessons can be recorded and replayed at any time, and outside of the school setting;
- Teachers can use lectures, audiobooks, data, images and other downloadable resources to standardize their lessons across schools or school districts.

Recommendations

For schools:

- Many have embraced podcasting and other pre-recorded lectures via online stores/websites or Open Courseware projects. Using standardized materials offers opportunity for all students across schools, counties or states to receive the same lectures. Standardizing usage of the same MP3 players (rather than letting each student use his/hers if they already own one) decreases schools' total cost of ownership and streamlines tech support/troubleshooting.

For Microsoft:

- Position the Zune as an educational alternative to the iPod as well as establish online store as a clearinghouse for educational materials (lectures, image files).

2. Smartphones/Mobile phones

Positioning

- Young adults continue to be a growing market for standard mobile phones; traditionally many have participated in family plans but higher-price multimedia plans are now the norm, at least in the U.S., for both mobile phones and smartphones, integrating SMS messaging, Internet access and multimedia downloads with calling plans;
- Mobile phone penetration in the youth market is even greater in Europe;
- Many schools in the U.S. have banned mobile phone usage by students while on campus.

What is possible

- The newest smartphones (AT&T/Apple iPhone, Verizon/LG Voyager, Sprint/Samsung Instinct, RIM Blackberry, Nokia N series) are essentially mini-computers, allowing for use of the Internet, email, phone, texting, calendars, cameras, calculators and more, all with considerable space for data storage (2GB-16GB);
- Use of Wi-Fi or Bluetooth for connectivity allows for less expensive connectivity;
- Most smartphones and mobile phones exhibit the sound and video replay features of MP3 devices;
- High portability factor allows for true anytime, anywhere learning;
- Increased interactivity among students (via phone, email, text, instant messaging) helps build learning community and uses students as resources.[xxx]

What is not possible

- Ability to view documents, many do not allow for manipulations or interactivity;
- Expensive usage—most devices rely on costly monthly charges in addition to initial purchase price;
- Advanced retooling is essential to ensure that students do not access inappropriate content or use the device for non-educational purposes (i.e., personal calls, e-mails, instant messages) while in the classroom.

Impact on classroom

- With devices even smaller than laptops but with high functionality, students are not limited to the classroom and have the ability to collect primary data in real-world settings;
- Dynamic, up-to-date learning opportunities;
- Limited application in creating or editing content;
- Great potential for rural or remote school settings to connect to the world at large.

Recommendations

For schools:

- Increased functionality of these devices means that system administrators have their work cut out for them to configure smart/mobile phones to limit students' activities to academics.

For Microsoft:

- The Windows Mobile O/S has already made its way onto some smartphones; the competition is getting stiffer with the newer, faster iPhone and the device-independent O/S Android, currently still in the R&D stage. Allowing for increased user development of mobile applications will help position Windows Mobile as a learning platform.

3. PDAs/Handhelds

Positioning

- On the decline; smartphones have usurped handhelds as the digital organizer of choice as they pair similar functions with phone capabilities.

What is possible

- PDAs allow for document editing and manipulation;
- Newer devices integrate Wi-Fi or Bluetooth for connectivity;
- Many include MP3 players, all include calendaring functions.

What is not possible

- Extensive use of the battery, these devices tend to have a short battery life, particularly when using wireless functionality;
- Future development or maintenance. Many developer-led initiatives have ended and the decline of the Palm and other handheld operating systems suggest a low likelihood for future development or maintenance to existing programs;
- Peripherals. Few, if any, peripherals are still developed and existing ones are nearing obsolescence.

Impact on classroom

- Ultra-portability allows for go-anywhere learning;
- Ability to read, create and edit content—although constrained by the very small keyboard size;
- Device is ideal for surveying/polling and seamless data uploading to desktop or laptop computer increases effectiveness.

Recommendations

For schools:

- These are rapidly becoming obsolete devices; although they may seem more attractive than smartphones or laptops because of their relatively low one-time price, schools will find that these devices are limited not only in their short-term functionality but in their shelf life.

For Microsoft:

- Probably not worth investing more resources or development into these devices. Better to focus on smartphones and their market prospects.

4. Game systems (e.g., Microsoft xBox, Nintendo Wii, Sony PlayStation Portable)

Positioning

- Video game consoles—both home-based systems and their portable counterparts—represent a growing product arena and fierce competition among vendors. Videogame sales (including educational and fitness-related software) regularly outpace revenues from the film industry and new players are entering the field all the time. Opportunities to employ the devices in educational have only just begun.

What is possible

- Engage students with a device traditionally known for pure entertainment activities;
- Portable players like the PSP can be used in one-to-one format with students working on individual educational games and simulations;
- Viewing images, movies and audio files—host of multimedia options;
- Accessing other computers on a network via wireless connectivity.

What is not possible

- Low interactivity—although students can play games and react or respond to these devices, they cannot manipulate the software as with software for more traditional operating systems;
- Most devices have a setup of one console/group of students; handheld/portable models are more expensive than handheld computers and smartphones but offer less functionality;
- Although most devices are Wi-Fi enabled, the browsers are more limited than those found on more robust devices and therefore restrict functional access to the Internet.

Impact on classroom

- Manufacturers have gone to great pains to demonstrate educational applications for these devices (see Sony's U.K.-based "PSP in Education" Launch[xxxi]). Many school principals and administrators, however, have banned them from school grounds;
- Using games as a teaching tool can prove successful for EST/language learning classes;[xxxii]
- Sites like Playing to Learn offer examples of successful game console application for educational use.

Recommendations

For schools:

- As pedagogies veer toward the nontraditional and more interactive, employing gaming devices in a learning setting is a logical and exciting development, provided school administrators can start to see them as tools and not as the distractions they have been in the past.

For Microsoft:

- This area offers a great avenue for opportunity—employing a fairly low-cost device with a built-in fan base among the youth market could be a win-win. Despite the fact that software is highly platform-specific, investment in and development for all types of devices continue and are likely to expand into the educational arena.

Elements of a Successful Implementation

Transforming Education: From Vision to Implementation

Once each and every student has access to their own personal digital device, the vision of anytime anywhere learning can be realized, enabling relevant, personalized student-centered learning. In short, **the shift to one-to-one computing entails a transformation in education to one that is more interactive and amenable to allowing students to follow their natural curiosity**. Allowing students access to the technologies they use to express themselves in their daily lives (i.e., wikis and blogs), provides the opportunity to personalize learning experiences and foster improved communication skills (oral, written and visual.) Laptops provide a completely different learning environment from standard hand-writing and paper notebooks—although with most work environments going all-electronic, this may actually be a better way of preparing our students for the workplace in the future. Additionally, laptops turn traditional teaching upside down, forcing educators to create a new pedagogy in which teachers are guides and learners themselves, rather than lecturers.

For a one-to-one vision to flower, a seed must first be planted. Advocates of the concept are advised to engage educational leaders (state governments and school superintendents) in articulating the pedagogical benefits of one-to-one computing. Working at the grassroots level (with IT departments and teachers) will have a more limited impact, and is less likely to lead to systemic change. Such leaders are also crucial in driving the program to successful execution. Creating a shared vision of the goals to be achieved through universal access is the first step in a successful implementation.

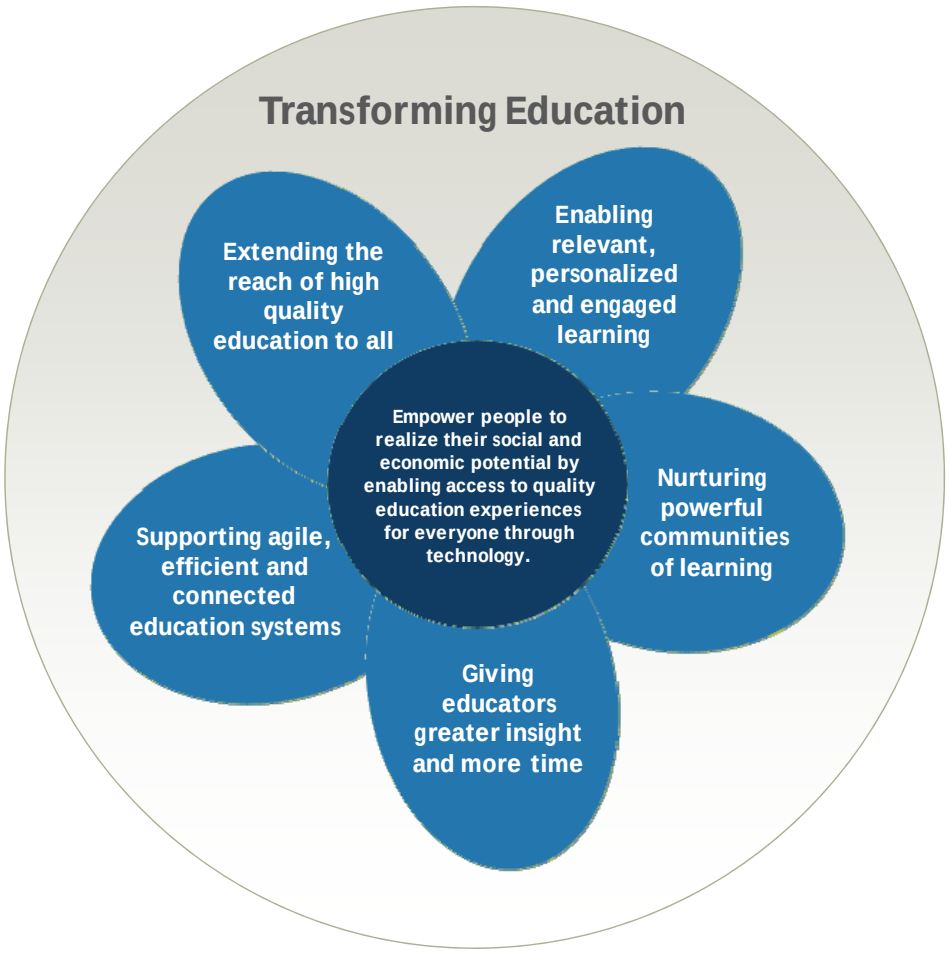
By articulating and aligning behind a shared vision for one-to-one computing, leaders can ensure the benefits of the program are well understood, and build a basis for long-term success. In the short-to-medium term, parents, students and teachers all reap benefits from well-planned student laptop initiatives. In the longer term, one-to-one computing ultimately helps build healthy economies by ensuring that no student is left behind in the information society. By ensuring that all K-12 students, regardless of economic background, have access to the skills and tools required in the information society, local and national governments ensure access to jobs and opportunities in the future.

This goal of economic inclusiveness is one of the cornerstones of the Microsoft Education Alliance. As the program literature states: "A strong technology infrastructure makes communities more appealing to local, regional and global businesses and investors, which in turn helps bolster economic growth and global competitiveness as well as stimulate jobs and personal achievement. In turn, it is vital that students have the necessary technology skills to thrive and grow within this environment. "

The mission of the Microsoft Education Alliance is to "empower people to realize their social and economic potential by enabling access to quality education experiences for everyone through technology." The five key goals of the Education Alliance are:

- Extending the reach of high-quality education to all:
- Enabling relevant, personalized and engaged learning
- Nurturing powerful communities of learning
- Giving educators greater insight and more time
- Supporting agile, efficient and connected education systems

The chart below depicts the five key goals of the Education Alliance:



Achieving the ambitious goal of preparing students for the 21st century requires more than simply giving laptops to students or building new schools. What is needed is a holistic approach that encompasses pedagogical vision, budgeting and technology planning. Policymakers and educators benefit greatly from gaining access to planning methodologies and frameworks that guide their implementation through the entire process, from vision setting to network set-up. Such a framework must be detailed enough to provide guidance, yet flexible enough to account for individual variation. It is essential that such programs provide guidance for envisioning and alignment, as well as tactical guidance and services enabling technology implementation. Microsoft provides such frameworks and resources for Ministries of Education, through the Envisioning Workshop and Solution Blueprint programs.

Microsoft provides such services for Ministries of Education through two programs:

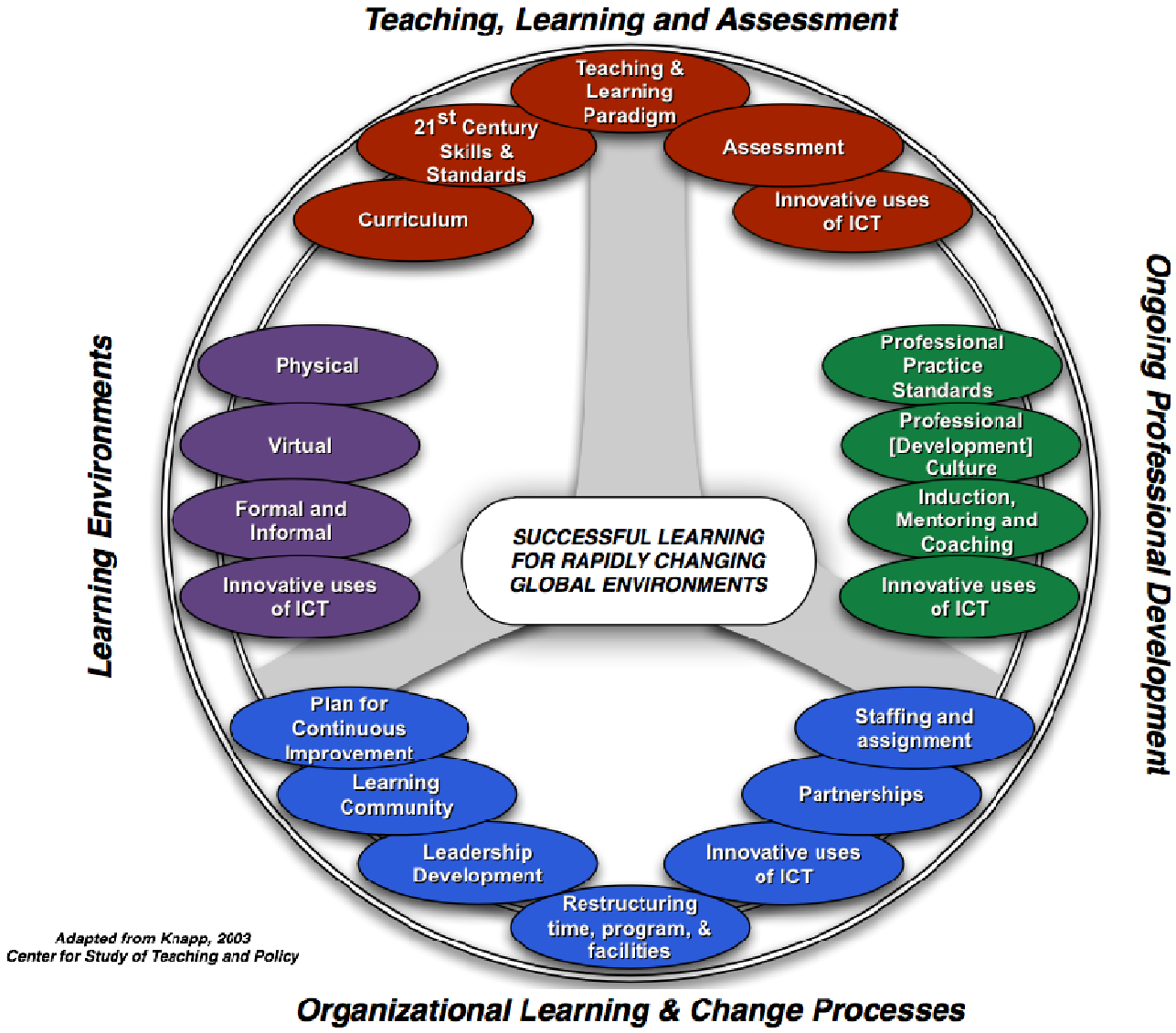
Envisioning Workshops	Solution Blueprints
A clear educational vision is critical and central to the entire program—from initial discussions with stakeholders, to the successful operation of the new schools. This 3- to 4-day workshop is facilitated by a 3rd-party group of education experts and provides a forum for deep discussion across key stakeholders to develop a strategy or validate an existing strategy for education. The participants Identify to what extent technology innovation impacts education innovation and outline the broad education priorities.	The proposed infrastructure model is based on five levels of maturity. Each level analyzes the impact of the IT infrastructure over the management efforts and resources available. It supports the improvement of the teaching and learning dynamics, and the accessibility to resources available in the Internet. Analysis shows that a planned and standardized infrastructure is the key that enables today's learning experience and paves the way for the upcoming technologies and pedagogies, such as 1:1 computing, distance learning environments and automated remote management. Expert consultants will conduct 10 to15 days of research and analysis of local solution requirements and current infrastructure.
Outcomes: Substantiated vision narrative or validated vision narrative, identified drivers for change. Description of what the future will look like, how the various ministries will be involved, a vision that all stakeholders have bought into.	**Outcomes:** Development of a deployment plan, success metrics and measurement recommendations for implementation of an ICT strategy.

Microsoft also provides schools with visioning tools for pedagogical transformation through the ***Innovative Schools*** **Program**:

The stated goal of the *Innovative Schools* program is to "work with schools to inspire transformational thinking and best practices programs." The program underscores that adoption of ICT in education, including one-to-one computing, must take place within a solid pedagogical framework. As part of Microsoft's Partners in Learning program, the Innovative Schools currently works with twelve schools from every world region—including Singapore's BackPack.Net Technology program, the Building Schools for the Future (BSF) program in the United Kingdom, and the School of the Future projects in Philadelphia and Taipei—and has plans to expand. In addition, several mentor schools form part of the worldwide network.

The *Wheel of Innovation* is a key tool for envisioning offered by the Innovative Schools program. Used as a self-assessment tool in workshops with education leaders, the wheel assists schools in charting pathways to reform. Adapted from the work of Mike Knapp and others at the Center for the Study of Teaching and Policy at the University of Washington, it allows schools to gauge their improvement along several measures over time.

The Wheel of Innovation



Specifically, the wheel allows schools to assess themselves along key elements of transforming education for the digital age.

Personalization is a key example of one such transformation. Providing students with their own computers allows for learning to be personalized, reflecting students' interests, motivations, preferences, knowledge and needs. This is facilitated by the broader range of media forms now available to students and by the student's ability to organize their documents on a personal device.

Further elements on the *Wheel of Innovation* are:

- Facilitating student-centered and student-led learning
- Using activities where students work collaboratively

This encourages schools to go beyond simply placing laptops in the hands of students to create a learning environment that leverages access to technology for maximum benefit, allowing for the development of 21st century skills, which include:

- Emotional literacy
- Problem solving
- Collaboration, communication
- Information gathering and analysis

Using the measures on the *Wheel of Innovation*, schools are able to gauge that a one-to-one computing program facilitates the acquisition of 21st century skills by:

- Use of activities where students work collaboratively
- Allowing students to access information and investigate concepts in ways infeasible otherwise (e.g., primary documents, simulations)
- Supporting anywhere, anytime learning

Providing such a tool to schools is a positive step, and one which Vital Wave Consulting expects to lead a transformation in learning within those schools that adopt this approach.

Implementation

Once the vision and goals of a one-to-one computing program are clearly established, the school is ready to plan for implementation. This phase is multi-faceted and involves a series of steps, from evaluating software to setting up networks, to involving parents in the process.

Ultimately schools will blend together people, process and technology components to create a cohesive plan. The Anytime, Anywhere Learning Foundation's "21 Steps to the 21st Century" process is one tool for achieving this.

A sample of the planning steps, sourced from the Anytime, Anywhere Learning Foundation and the Microsoft Innovative Schools program, are summarized below:[xxxiii]

1 Build a Team

First, it is recommended that schools build a team that gains the support of parents and community, and ensures that plans for integrating the laptops align with educational goals. This team creates a detailed set of policies, guiding action steps and phases, all based upon the vision for what the one-to-one computing program is to achieve. This team also works with teachers to create training opportunities and raises funds.

#2 Choose a Technology Solution

Students require software that is easy to use, maximizes their learning experiences and is widely used in the workplace. It is also essential that these applications support communication, collaboration, research and teamwork.

For the network, a series of questions need to be asked, including: What level of security do you need to regulate student browsing of the Internet? Do you want to create a network over which students can

communicate with teachers? If so, how will you establish a secure environment for the teachers' laptops?

#3 Prepare a Budget

The budget must be complete and include all expenses such as:

- Hardware
- Software
- Infrastructure improvements
- System maintenance and upgrading
- Telecommunications power and storage
- Ongoing technical support for teachers and administrators
- Professional development
- Insurance and security costs

It is advisable to consider a range of options for receiving supplemental funds including:

- Parental contributions
- Government grants for off-off infrastructure costs
- Corporate sponsorships
- Foundations

4 Create a Plan for Equal Access

As bridging the digital divide is a key goal for many one-to-one computing programs, it is important to create a plan for equal access. Part of this involves deciding whether the program will be mandatory or not, what the funding sources will be, and what the parental contribution will be.

#5 Ensure Teachers Have Their Own

Teachers are able to incorporate laptops most successfully if they have access to their own three to 12 months before laptops are distributed to students. It is also essential that teachers have access to training. Hence, the first step in any one-to-one computing program is to provide teachers with laptops and training in advance of the students.

6 Start with a Pilot, then Implement Broadly

Beginning with a pilot program allows the school the opportunity to test the one-to-one computing concept and reveal the issues and implications of running a broader program. The pilot program may consist of a single classroom that tries out the new technology for a semester or a year, or two grades participating concurrently.

7 Gain Insights Through Evaluation and Communication

Formal evaluation gives credible feedback to provide to sponsors, program supporters, critics and parents. It provides convincing evidence to support continuing and expanding a program. And it helps

identify any missteps that may have occurred during the initial implementation and implement corrective courses of action.

Products

Microsoft offers various products, services and support partners for the one-to-one computing market:

- Traditional Microsoft products allow for productivity: Windows Vista, the Microsoft Office Suite and Microsoft Student offer the advantage of easy-to-use products that allow students to extend their skills to the workplace.

- Multimedia products allow for collaboration: Microsoft OneNote allows students to collate their notes, pictures, audio and video recordings in one place. Students are offered a media rich environment into which they can drag links, text or images from Web pages into their notes and use handwriting if and when required.

These products are highly attractive to schools for various reasons, including attractive price points, the ability to operate across multiple platforms, and the ability to easily translate skills into the workplace. When deployed with proper support and planning and in collaboration with strategic technology partners, these products have allowed schools to achieve superior results. A small sampling of these cases is detailed below.

Partner Components

A number of different partner types may play critical roles in enabling Anytime, Anywhere Learning solutions. Depending on the scope and complexity of the solution, some or all of the partner types listed may be needed:

- Hardware Client, mobile devices, servers, peripherals, storage, network equipment, learning devices, software content management, media authoring, ERP, student information systems, systems infrastructure, security, accountability & assessment, networking services, systems integration, licensing providers, NGOs, IS outsourcing, deployment & support

- Content: publisher digital materials, instructional content, student social networking, education resources

Resources for Partners

When education partners become members of the Microsoft Partner Program, they gain access to the Partner Portal through which they can learn about and access the benefits of membership, including partner-ready resources and links specifically related to building a business in the education industry (https://partner.microsoft.com/40065089?msp_id=education).

- The Microsoft Education Community at www.mseducommunity.com provides a forum for education partners to communicate and collaborate with each other and with Microsoft, to share best practices, and find relevant information about education initiatives, training and enablement opportunities. Partners for School of the Future.

Philadelphia School of the Future

The Philadelphia School of the Future (SOF) opened its doors in 2006 to 750 students from across the city, half of whom hail from the working class neighborhood of West Philadelphia, where the school is situated. Lauded as an innovative public-private partnership between Microsoft and the Philadelphia School District, the seventh largest in the nation, the $50 million school is only one of 10 new public high schools built as part of the District's $1.5 billion capital plan. Providing each student with a personal Gateway laptop is only one part of the technological investment; wireless classrooms, complete digital administration, smart cards, and even extension of the broadband network to students' homes all contribute to the public school's advancements. Administrators anticipate that the digital streamlining of grading, reporting, procurement and teacher-parent communication will not only make for a more efficient school, but will prove cost-effective over time as well.

The primary focus of the school's mission, however, is not technology for technology's sake but to nurture the desire to implement advanced research and development methods into daily curricula and processes so that the entire school's population will constantly aim to improve student achievement. By taking advantage of the resources that the city of Philadelphia has to offer, the School of the Future will collaborate with such venerable institutions as the Philadelphia Museum of Art to expand the concept of a learning setting. The District's academic program manager Mary Cullinane cites the school's effort to "break down the dependency on time and place" as a progressive step in involving the entire community in public education. An equally pioneering step stems from the building's LEED Gold certification, allowing for an eco-friendly and sustainable learning environment, utilizing natural lighting, water conservation and recycling. Photoelectric glass will even generate a portion of the building's power supply and transmit real-time data for students to learn about the building's positive energy generation.

The facility's embodiment of innovation, technology and research has been made possible not only through the District and Microsoft's Partners in Learning initiative, but through a host of content, software, hardware and service providers. Organizations like The History Channel provide hours of digital content so as to obviate the need for clunky textbooks, and software firms VidiTalk and HunterStone enable the integration of streaming video content and other digital learning resources into the school's Microsoft SharePoint framework. Panasonic furnished SOF with audio/visual equipment and, in consultation with the school's planners, ensured that there were no static "computer lab" rooms, but that minimal fixed assets allow for flexible learning with multiple configuration options for student-led learning groups.

Innovative Case Studies

With the benefit of the guidelines articulated above, a growing number of schools are building a vision for one-to-one computing and successfully executing their strategy.

The examples below illustrate the benefits of proper planning and alignment of people, process and technology to produce concrete improvements. Both in terms of promoting social equity and in terms of transforming education to meet the needs of the 21st century workplace, one-to-one computing initiatives reap positive outcomes.

United States

Tahoma Senior High School, Maple Valley, Wash.

Maple Valley, a moderately sized town southeast of Seattle located in the Tahoma School District, is known for its "aggressive pursuit of new opportunities"[xxxiv] and consistently produces students ranking in the state of Washington's top 10 percent. In order to continue producing superior results, the following program was initiated in the 2007-08 academic year.

- Dozens of high school sophomores were assigned individual laptops running Microsoft Windows XP and Microsoft Office for use throughout the year, a program subsequently expanded to the entire grade.[xxxv]
- Innovative programs have been put into place, such as those conducted by social studies teacher Barry Fountain who runs class laptop lessons, such as one involving stem cell research in which scientists at the University of Washington talk to the class online or by videoconference.[xxxvi]

Cincinnati Country Day School, Cincinnati, Ohio

Cincinnati Country Day School in Ohio pioneered the integration of technology in secondary education, adopting a one-to-one computing pilot program sponsored by Microsoft and Toshiba.

- According to the schools instructors, Tablet PCs "give kids choices in education," "level out their abilities" and brought "electricity" into the kids, exciting many of them to do extra homework that hadn't even been assigned. Teachers cite the tablet's innovative design as being "no more divisive than a pad of paper," as there are no barriers between teacher and student, and handwriting recognition allows for all of the benefits of paper with the advantages of underlying technology.
- Each student was matched with his or her own laptop until 2002. The school subsequently migrated to Toshiba tablet PCs running the Windows XP Tablet PC Edition.
- The school has a strong humanities as well as technological innovation, and the tablet assists in accelerating this trend.

Auburn City Schools, Auburn, Ala.

Auburn City Schools in Auburn, Alabama, have been a beacon of educational innovation in the state for decades, so it was a logical site for a two-year pilot of one-to-one computing with the 21st Century Learning Initiative. Starting in October 2006, all of the junior high schools and high schools have been

wirelessly networked and every classroom in the lower schools has several computers, Internet access and an interactive whiteboard.

- Before students could receive their laptops, at least one parent had to attend a mandatory information session, a move that administrators believe "leaves no parent behind" and gets them involved in the entire one-to-one process, from curriculum development to hardware selection.[xxxvii]
- The pilot has paid off: Grade school students create Microsoft PowerPoint presentations including images from science experiments, the school lunch program is automated, and the per-pupil expenditure of $9,000 per year (for 5,669 students) suggests that more high-tech investments are still to be made for students of all ages.

Ariño-Alloza Rural School, Aragón, Spain

Ariño-Alloza, a small mining town in Spain, has become known as an innovator through its use of technologies in education. A full 20 percent of the town's population is comprised of immigrants, economically motivated by the mining opportunities, yet the school's administrators saw the student population as cohesive enough to be able to undertake a pilot one-to-one computing initiative. In 2003, the Ariño-Alloza Rural School not only purchased tablet PCs for every 5th and 6th year primary school student, but also gave up all pens, paper, textbooks and other traditional school implements. Since the program's launch in 2003, 9,924 students representing 253 schools have been studying with a tablet PC with €14 million (US$21.70 million) invested in technologies and training.

Paired with multimedia-ready classrooms outfitted with interactive digital blackboards, video projectors and players and Internet access, the Microsoft Office-equipped tablet PCs helped to create a high-tech learning community previously unknown in the region. School officials report that the pedagogical effects have been striking.

- Not only have students' tech skills been brought up to 21st century standards, but the students themselves have become more self-reliant and taken the initiative with their education.
- Students now create or co-create lessons with teachers using educational websites and other digital resources and interact with their classmates operating under the belief that they all have something to teach each other.
- Teachers' roles have evolved into that of managers of learning, assisting and guiding students' self-directed research and exploration, as opposed to more traditional models of education in which teachers are the sole information conduits.
- Students seek out virtual tours of foreign cities and museums, all on their Tablet PCs and often without teachers prompting them to work more.
- The students from the pilot program all found themselves better prepared for secondary school and earned higher grades for their work than their peers who had studied in more traditional settings.

Additional state-run schools are now following suit and with staggered benchmarks each year, by the 2009-10 academic year, 100 percent of all 5th and 6th year primary school students throughout Aragón will be allocated their own tablet PC for use in school and at home.

Nashwaaksis Middle School, Fredericton, New Brunswick, Canada

The Province of New Brunswick has much in common with Maine, its U.S. neighbor to the south. In addition to being a fairly rural, sparsely populated region, both state and provincial governments found

enough evidence and belief in the positive impacts of one-to-one computing initiatives on their students' ability to succeed in the global economy.[xxxviii] In 2004, New Brunswick's Ministry of Education, Microsoft and HP partnered to provide laptops and support to more than 600 students, launching the Dedicated Notebook Computer Research Project. Results included:

- Teachers remark on a decrease in discipline issues for participating students.
- The school's Technology Mentor noted that particularly among boys, using the notebook computers regularly improved student writing and research skills.
- Teacher professional development was conducted so that they could undertake professional development training, resulting in teacher buy-in and enthusiasm, and a trend toward more student-centered teaching and learning.

Based on the success of the Nashwaaksis pilot, New Brunswick committed an additional $10 million the following year and is researching equipping all students and teachers across the province, understanding that the cost of such a program may call for $50 million a year.

Learning2Go Wolverhampton, U.K.

The city of Wolverhampton in England's West Midlands region boasts an ethnically and socioeconomically diverse population of approximately 250,000. In 2002, an enterprising teacher participated in a mobile device pilot program sponsored by Becta, the British Educational Communications and Technology Agency. After local authorities determined that it had been a worthwhile undertaking, the city council initiated a partnership with Microsoft, Toshiba and Espresso software to deploy Pocket PCs to classes in four of Wolverhampton's schools. Results include:

- Entitled *Learning2Go*, the program emphasized the portability of the PocketPCs and encouraged students to access information around the clock, and from any location—in school or at home, or even en route on the bus.
- Teachers report that the PDA devices empower students, increase confidence, catalyze peer coaching and improve students' speaking, listening and overall collaborative learning abilities. *Learning2Go* calls upon students to be active learners and calls "learner voice," or student input into their own education, as a key to the success of the project.
- Over the past five years, new phases of rollout have introduced thousands more devices to schoolchildren across Wolverhampton, and the National Education authority is looking to the program as a model for the rest of the U.K.

Bristol CLC Hand e-Learning, Bristol, U.K.

Bristol, the sixth-largest city in England, had been using handheld wireless devices (PDAs) in primary schools and in September 2006 decided to expand the program into a one-to-one computing program for secondary schools. To ensure success, the following steps were taken:

- The CLCs (City Learning Centers) built a team of partners including students' parents, Becta representatives, consultants with experience in the Wolverhampton Learning2Go program and the eLearning Foundation.
- Upon the first wave of distribution of PDAs, authorities discovered that for many households, the handheld device was the only computer in the home.

- Monthly evaluations from the consultant ensured that both teachers and students remained on top of the software and devices, and that the administration and community maintained their commitment to the project.
- Over time, the authorities determined that the first device was prone to damage too easily, and for the expansion of the program (a fourth school was added in January 2008, meaning that over 1,000 devices are now in place throughout Bristol), the HTC Ameo, with a 3G wireless contract with T-Mobile, was selected for its durability and dependability.[xxxix]
- The new device more resembles a mini-computer than a handheld, but the "hand e-learning" name still remains in place. In addition to creating how-to guides for teachers and students, the Bristol CLCs also maintain a portal with ideas for including the handheld computers in diverse curricula, including history (using digitized historical records and images), geography (with online mapping programs), foreign languages, art and science.
- Teachers encouraged the students to take notes using Microsoft OneNote, use the embedded camera and voice recorders and to view video files and eBooks on the devices.

Frankston High School, Victoria, Australia

South of Melbourne, the residential suburb of Frankston implemented Australia's first public school notebook computer program in 1995. Additional investments in technology came in 2001, with the installation of the school's first wireless network, the subsequent equipment of a number of classrooms with data projectors and the conversion of much of the school's curriculum to electronic files. In 2006, the administration decided that the absence of pen functionality detracted from the quality of the education delivered, and sought opportunities with integrating tablet PCs into the classroom.

- The objectives for using tablets were clearly identified. The goal was to increase student engagement, particularly in math, art and Japanese lessons, all of which rely heavily on handwritten notes.
- At present, more than 650 students between the ages of 12 and 16 bring computers to and from class every day, with 350 of them using tablet PCs Running Microsoft Windows XP Tablet PC Edition 2005 and other Microsoft technology.[xl]
- The school has been cautious about using technology for the sake of it, and has aimed to have the computers enhance, rather than detract from, the lessons themselves.
- The assistant principal marvels at the students' ability to not overwhelm themselves with all of the new tools and data, noting that they "are by no means intimidated by the information to which they now have access."

Conclusion

As this paper has shown, adoption of one-to-one computing is accelerating. Policy-makers, educators, and even the general public are increasingly aware that educational outcomes can be maximized by providing students with access to personal wirelessly-enabled devices such that "anytime, anywhere" learning is made possible. At the same time, the one-to-one computing concept has matured, and educators understand that it is about far more than technology. Instead, a one-to-one computing initiative requires vision, planning and careful execution. In short, it requires alignment between people, process and technology. This entails preparation on the part of the entire school community, as well as the support of capable technology partners. With the right partner, schools benefit from access to affordable technology solutions, and gain support for planning, vision formulation and technical implementation.

Initially, what is required is a blueprint to guide the entire process to success. It is best that this blueprint be detailed and standardized, and based upon the lessons learned from prior one-to-one computing implementations, yet flexible enough to account for variations in different school environments. Once the blueprint has been agreed upon, schools require access to skilled technical support, and implementation services to ensure the program is executed efficiently and effectively. Equally important is the choice of hardware, software and content to facilitate the creation of a personalized learning environment that promotes independent learning, creativity and innovation.

For guidance in the visioning process, schools may look to the centers of excellence established through the Microsoft Partners in Learning and Innovative Schools programs. From Thailand, Mexico, Brazil, and Spain to Australia, the United States and the United Kingdom, these programs have worked with schools to ensure that ICT is effectively incorporated into the learning process in a way that builds basic skills (i.e., writing and research) and fosters higher-level abilities such as critical thinking and creativity. Providing students with an "Anywhere, Anytime" learning environment is crucial to achieving these goals, as this replicates the way learning is accomplished in the 21st century and enables students to make use of new information in a variety of contexts.

Yet, even the most compelling vision can flounder when not supported by solid execution. This is why programs such as the Microsoft Solution Blueprint are crucially important tools guiding successful technology implementation. By employing steps such as those contained within the "21 Steps to 21st Century" process to map out the policies and processes involved in coordinating the various people, process and technology components, the ability of one-to-one programs to maximize learning opportunities is increased.

Educators are advised to select a partner that offers the full array of tools and support programs to support the process of educational improvement, and ultimately transformation. By taking a holistic approach, schools are able to realize the end goal of maximizing educational outcomes, and bring the vision of preparing students across all socioeconomic groups and geographies to realize their full potential. In this way, the vision of one-to-one computing, allowing all students to benefit from the emerging opportunities of the information age, can be fully realized.

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