The Condition of Technology in Arizona: 2005

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Background

Transitions in human history are marked by the development of different discoveries, inventions, or tools. The end of the Stone Age was marked by the development of bronze tools; the end of the Industrial Age was marked by the invention and availability of the Internet in 1983.[1] The ability to communicate almost instantaneously with others across the planet gave birth to virtual communities where differences of time and geographic location almost disappear, leading to what is today the early stages of the Information and Knowledge Age.

21st Century Skills

Among the results of the rapid evolution of technologies is the increase of the availability of cheap, digital storage. This, in turn, has allowed an exponential increase of accessible information.[2] Yet, while information has doubled in less than two years, our education system insists on teaching mainly memorization of facts to our students.[3] According to the *21st Century Literacy Summit*, "True learning [in the information society] requires being able to use new technologies, not simply to enhance the ability to memorize and repeat facts, but to gather, organize and evaluate information to solve problems and innovate practical ideas in real-world settings."[4] The document *enGauge®21st Century Skills: Literacy in the Digital Age* produced by The Metiri Group, a national consulting group that works with the North Central Regional

Educational Laboratory (NCREL), identified the following skills as necessary to success in this new era and notes that these skills must be accompanied by a solid knowledge base of reading, writing, mathematics, and science:[5]

- Digital Age Literacy: Basic, scientific, economic, and technological literacies; visual and information literacies; multicultural literacy and global awareness.
- Inventive Thinking: Adaptability and managing complexity; self-direction; curiosity, creativity, and risk taking; higher-order thinking and sound reasoning.
- Effective Communication: Teaming, collaboration, and interpersonal skills; personal, social, and civic responsibility; interactive communication.
- High Productivity: Prioritizing, planning, and managing for results; effective use of real-world tools; ability to produce relevant, high-quality products.

Schools face a big challenge to prepare the citizens that our society demands due to the extensive role that technology plays now and will play in the years to come. This report examines how Arizona schools are responding to this challenge.

Recent Policy Developments

No Child Left Behind Act and Technology

The No Child Left Behind Act (NCLB) was signed into law on January 8, 2002. Among other major changes in funding, NCLB consolidated two existing federal technology grant competitions into one state grant, the State and Local Technology Grant program. The activities funded with this money include training for educators (principals, vice principals, and teachers) to use and integrate technology into instruction.[6] This is important because, according to The Children Partnership:[7]

- An estimated 45 million Americans do not speak English at home versus 32 million in 2000. Many want information in languages other than English.

- An estimated 8.5 percent of Americans have at least one disability that requires special features on computers and access to the Internet to make these resources accessible.
- More Americans now (28.4 million versus 26 million in 2000) are foreign-born and look for information tailored to their unique cultural beliefs and practices.

Arizona schools educate almost one million students per year. Of these students, almost 145,000 are English Language Learners (ELL). This is nearly twice the number of ELL students enrolled in other states (80,000 on average).[8] Students in Arizona schools have a student-to-teacher ratio of almost 1:20, while the national average is 1:15. Finally, Arizona schools house almost 20 percent more American Indian students and almost 50 percent more Latino students than the average schools in the nation.[9] These statistics indicate the challenges Arizona's teachers face in providing equal education to all children. In terms of per student spending, which includes student instructional resources and teacher professional development, Arizona is 50th in the nation with only $5,197 dollars per student while the national average of per student spending is $7,875.[10] Whether through NCLB money or not, the resources available to Arizona teachers are scarce, adding to the difficulty of educating a diverse student population.

Importance of Professional Development

In 2003, Barton identified 14 variables that correlate to achievement. The achievement indicators that Pre-K-12 schools can influence are:

- Rigor of the curriculum.
- Teacher preparation.
- Teacher experience and attendance.
- Class size.
- Availability of appropriate technology-assisted instruction.[11]

Barton investigated the gaps on achievement between majority and minority students and, unsurprisingly, found such gaps in all indicators in schools with high minority enrollment. Among other things, he found that 61 percent of students in schools with lower minority enrollments were assigned to use the Internet to conduct research, while only 35 percent of students in high-minority-enrollment schools were similarly assigned. In the same way, Smerdon, *et al.*, found that students had greater access to computers and Internet-based education at schools where only 11 percent or less of the student population qualified for free or reduced price lunch.[12] By contrast, in schools where 71 percent or more of students qualified for free or reduced-price lunch, pupils were significantly less likely to have access to computers and Internet-based education (Table 1). As Barton points out, "It is not just a matter of hardware and connections to the Internet; it is also the kinds of assignments that students are asked to do."[13]

Table 1: Percent of Public School Teachers Reporting Varying Numbers of Computers Available in the Classroom, by Free/Reduced Price Lunch: 1999

School Characteristic	**Number of Computers in the Classroom with Internet**			
Percent of Students in School Eligible for Free or Reduced Price Lunch	**None**	**One**	**2 – 5**	**5 or More**
Less than 11%	34	47	14	5
11 to 30%	30	51	16	3
31 to 49%	29	51	15	5
50 to 70%	47	39	11	4
71% or more	49	39	9	3

Source: Table partially reproduced from Smerdon, *et al.* (2000). *Teachers' Tools for the 21st century: A report on teachers' use of technology* (NCES 2000-102), National Center for Education Statistics, p. 42.

For many economically disadvantaged students, their schools and public libraries are the main technology-access equalizers. Because poor students tend to be ethnic minorities who mostly attend schools with high percentages of students qualifying for free or reduced lunch, they can be expected to experience the achievement gaps that Barton identified.[14] The National Center for Education Statistics (NCES) Issue Brief, *Beyond School-Level Internet Access: Support for Instructional Use of Technology,* reports the results of two short surveys that used the Fast Response Survey System (FRSS) in 1999. [15] The surveys asked public school teachers how they were using technology in their classrooms, the availability of technology in the classroom and in the schools, the professional development in technology they had received, and the barriers they perceived to using such technology. The results, discussed in the NCES Issue Brief, found no statistical difference in achievement between high-poverty and/or high-minority enrollment schools and low-minority enrollment schools when teachers report having three key resources: classroom Internet access, on-site training, and assistance in the use of the Internet for instruction.[16] This finding has major implications for Arizona where schools educate many minority students.

In 1994, after the White House's National Information Infrastructure challenged the U.S. Department of Education and the nation to have Internet connectivity in all schools and classrooms, the NCES was charged with tracking the rate at which schools and classrooms received Internet access. The NCES, every academic year, surveys a sample of approximately 1,000 schools considered representative of schools across the nation to track Internet access and, after 1996, to track the types of Internet connections used. This report indicated that, at the national level, the most frequently cited barriers to the use of computers and the Internet for teaching were: insufficient numbers of computers (78 percent), lack of release time for teachers to learn how to use computers or the Internet (82 percent), and lack of time in the schedule for students to use computers in class (80 percent).[17] The repeated complaint about lack of time is understandable in a teaching context in which new demands and mandates are assigned to teachers on top of the many obligations in their work day.

Findings

In the Progressive Policy Institute's *2002 State New Economy Index,* Arizona ranked 16th while Illinois ranked 17th.[18] The comparison is noteworthy because Illinois, like Arizona, is a vibrant state with many high-tech industries; the Illinois State Senate Majority Leader considered the use of technology in schools an important enough topic to bring to the attention of the rest of the State Senate members.[19]

Arizona in the Numbers

Technology Counts 2004, the seventh edition of *Education Week*'s annual report on educational technology, reports that in Arizona, the state average ratio of students per instructional computer is 4.5:1, and 3.6:1 in schools with a high percentage of minority students. [20] Although the state has a more favorable ratio of students to computers than California, the state with the highest ratio (5.5:1), it still falls far behind North Dakota, where there are 1.4 students to 1 computer.

Technology Counts 2004 also reports that 89 percent of Arizona schools have Internet access for one or more computer classrooms, but only 68 percent of teachers used the Internet for instruction.[21] In the summer of 2003, the Arizona Department of Education (ADE) finished much of the work toward closing the gap in technology access among public schools by wiring and installing equipment in the final schools with "Students First" program funds. Having connectivity at most public schools allowed ADE to shift the focus from classroom technology to technology used for school data analysis and organization. The purpose of the Student Accountability Information System (SAIS), built mostly with state technology money, is to make schools more accountable for money expenditures and to track student progress. ADE has promised that "SAIS will dramatically improve both the exchange of school finance data between local education agencies (LEAs) and ADE and overall accountability in the K-12 system. SAIS will, for the first time, provide essential information to educators, legislators, and parents about the budgets, expenditures, and achievement levels of schools. In addition, this information will help our elected officials make better decisions about funding for schools and assist parents in making the right choices about their child's education."[22]

The state's approach thus far might be summarized as, "put computers in the classroom and teachers will use them." This strategy, however, overlooks two main factors: teacher training and teacher understanding of how to integrate technology to support vital student skills.

Teacher Technology Knowledge

Teacher technology knowledge substantially influences at least two important uses of technology in the classroom: How and how much technology is used by the students. Since teachers are the architects of students' learning experiences during the school day, they affect not only what students learn but also how they learn it, with what tools, and in which learning environments. When teachers are prepared to use technology to facilitate students' construction of knowledge through inquiry-based projects, technology becomes a tool of empowerment that gives students access to more resources and allows them to spend more time on problem solving, thinking, and reflection.[23] On the other hand, when teachers are poorly prepared to use technology, they are more likely to direct students to use drill-and-practice software, usually leaving out important skills such as those discussed above. Furthermore, NCES survey findings indicate that teachers who have more professional development hours (at least 32 hours) in the use of computers and the Internet are almost three times more likely to assign problem-solving activities that use technology than teachers with zero hours of professional development in technology.[24]

When comparing technology proficiency between the national averages and the Arizona teacher's average, the disparity is not wide. That does not mean, however, that Arizona's teachers are well prepared to use technology for teaching. Table 2 presents the results, in percentages, compiled from the same NCES survey and a 2,400 Arizona teacher sample.[25]

Table 2: Teacher Preparedness to Use Computers and Computer Software

Teachers Prepared to Use Computers			
Location	**Not Well Prepared**	**Moderately Prepared**	**Well Prepared**
National	13%	61%	26%
Arizona	12%	57%	31%
Teachers Prepared to Use Telecommunications			
	Not Well Prepared	**Moderately Prepared**	**Well Prepared**
National	35%	49%	16%
Arizona	30%	48%	22%
Teachers Prepared to Use Software to Teach Reading			
	Not Well Prepared	**Moderately Prepared**	**Well Prepared**
National	55%	36%	9%
Arizona	53%	34%	13%
Teachers Prepared to Use Software to Teach Writing			
	Not Well Prepared	**Moderately Prepared**	**Well Prepared**
National	43%	42%	15%
Arizona	43%	40%	17%

Source: National Assessment of Educational Progress. (1998). Information available on the National Center for Education Statistics website. Retrieved May 25, 2005, from http://nces.ed.gov/nationsreportcard/naepdata/search.asp
On the search page, select “Writing,” “Grade 8,” “National Pubic” or “Arizona,” and “Teacher Factors.” Then view survey questions “Prepared in the use of computers,” “Prepared in the use of Telecommunications,” “Prepared in using software for teaching reading,” and “Prepared in using software to teach writing.”

Although the majority of teachers appear to report feeling “moderately prepared” in the use of computers and computer software, not even one in four report feeling “well prepared” for those tasks. The issue worsens when teachers are asked to report on how prepared they are to teach reading and writing using computer software (data do not address other content areas), yet these two subjects are the core skills for a well-educated and capable workforce.

How much teachers used technology also depends on how technologically proficient they feel. In the NCES survey, teachers reported they used computers and the Internet more frequently to create instructional materials (88 percent) if they reported feeling “well or very well prepared” in its use. On the other hand, 50 percent of teachers who felt “not well prepared” used computers for the same purpose. For gathering information to create lesson plans, 71 percent of well-prepared teachers used the Internet, compared with 28 percent of the not-well-prepared teachers. The disparity between teachers’ Internet uses according to levels of technology proficiency is remarkably wide. Only 11 percent of low-technology-proficient teachers used the Internet to access research and best practices for teaching, while 52 percent of technology-proficient teachers used technology for the same purpose. When creating multimedia presentations for their classes, 55 percent of technology-proficient teachers used technologies, compared with only 12 percent of low technology-proficient teachers.[26] Obviously, teachers who use technology less in the least advanced ways are the ones who need it the most to access resources that may help them improve their teaching strategies to better prepare their students.

Under the terms of No Child Left Behind (NCLB), teachers need to demonstrate that they are “highly qualified” to teach their subject. “Highly qualified” teachers are defined as those who hold at least a bachelor’s degree from a four-year institution; hold full state certification; and demonstrate competence in their subject area.[27] Unfortunately, NCLB does not take into account technology use for instructional purposes. For instance, based on the National Report Card data from the NCES website,[28] it is clear that teachers minimally use technology to teach mathematics, as Table 3 shows.

Table 3: Use of Technology for Mathematics Instruction: 2000

Teachers Do Not Use Computers		
	4th Grade	8th Grade
National	24%	50%
Arizona	30%	66%
Teachers Use Computers for Drill and Practice		
	4th Grade	8th Grade
National	25%	17%
Arizona	26%	10%
Teachers Use Computers to Demonstrate New Topics		
	4th Grade	8th Grade
National	3%	8%
Arizona	2%	5%
Teachers Use Computers to Play Math Games		
	4th Grade	8th Grade
National	43%	14%
Arizona	35%	6%
Teachers Use Computers for Simulations and Applications		
	4th Grade	8th Grade
National	5%	12%
Arizona	7%	13%

Source: National Assessment of Educational Progress. (2000). Information available on the National Center for Education Statistics website. Retrieved May 25, 2005, from http://nces.ed.gov/nationsreportcard/naepdata/search.asp
On the search page, select "Mathematics," "Grade 4" or "Grade 8," "National" or "Arizona," and "Instructional Content and Practice," then view question "Primary use of computer for math."

Somewhat alarming is the difference between Arizona and the rest of the nation in the percentage of teachers who do not use computers to teach mathematics. While there is a six percent gap between the percentage of Arizona teachers and teachers nationwide who do not use computers to teach math in the fourth grade, the difference of 16 percent in the eighth grade between Arizona and the nation is unacceptable. Although the difference between the state and the national average in the rest of the above figures is not as wide, there is much room for improvement. Furthermore, when comparing state data from 1996 and 2000, the change in Arizona teachers' computer use is negative, with the exception of the year 2000 for fourth grade use of computers for simulations and applications and for eighth grade in the use of computers to demonstrate new topics, which had no change in those years. Surprisingly, teachers used less computer technology for mathematics instruction in 2000 than they did in 1996. Table 4 shows this comparison for fourth and eighth grade data.

Table 4: Arizona Teachers' Use of Technology for Mathematics Instruction: 1996 and 2000

Teachers Do Not Use Computers		
	4th Grade	8th Grade
2000	30%	66%
1996	26%	52%
Teachers Use Computers for Drill and Practice		
	4th Grade	8th Grade
2000	26%	10%
1996	30%	12%
Teachers Use Computers to Demonstrate New Topics		
	4th Grade	8th Grade
2000	2%	5%
1996	3%	5%
Teachers Use Computers to Play Math Games		
	4th Grade	8th Grade
2000	35%	6%
1996	36%	16%
Teachers Use Computers for Simulations and Applications		
	4th Grade	8th Grade
2000	7%	13%
1996	5%	15%

Source: National Assessment of Educational Progress. (1996 & 2000). Information available on the National Center for Education Statistics website. Retrieved May 25, 2005, from http://nces.ed.gov/nationsreportcard/naepdata/search.asp
On the search page, select "Mathematics," "Grade 8" or "Grade 4," "Arizona," and "Instructional Content and Practice," then view survey question "Primary use of computer for math."

In all fairness, this negative trend needs to be evaluated in terms of technology availability, technology professional development opportunities for teachers, and technology investment in general; these topics are out of the scope of this manuscript.

ADE offers teachers professional development opportunities and curriculum resources through ASSET (Arizona School Services through Education Technology). These opportunities, however, are not enough to bring the teachers to the level of technological proficiency required by the dawn of the Information and Knowledge Age.

Policy Implications

In times of tight budgets, policy makers face challenges to distribute the amount of money they have. Increasingly, government agencies and others are demanding scientific research to justify spending decisions and priorities in the name of accountability. This section outlines the major impacts teaching and learning with technology has on student learning outcomes. The findings are based on three meta-analysis studies reported in two different publications of available research. Meta-analysis is a type of systemic review where the results of many studies that deal with the same topic are abstracted, summarized, and analyzed statistically to find the effect that one variable has over another variable.

In 1999, Schahter conducted a meta-analysis of 500 research studies whose outcome was the presentation of several case studies to illustrate the positive and negative impact of technology on student achievement.[29] Shahter's study showed the following major impacts of the use of technology for instruction:

Positive Impacts:

- On average, students who used computer-based instruction scored 14 percent more than non-computer users in achievement tests.[30]
- Students learn more and faster when they receive computer-based instruction.
- Students develop more positive attitudes toward their classes with computer-based instruction.

Negative Impacts:

- Computers did not have a positive impact in every area in which they were studied.

Shahter's study included the review of work done by Sivin-Kachala.[31] Sivin-Kachala's meta-analysis included more than 200 studies and found consistent patterns of the impact of technology in student achievement:

- Technology-rich environments positively impact student achievement in all major subject areas.
- Technology-rich instructional environments help increase achievement of regular and special need students in preschool to higher education.
- Students' learning and self-concept attitudes consistently improved with computer-based instruction.

In addition, a meta-analysis, conducted by Waxman, Lin, and Michko, estimates the effects of teaching and learning with technology on students' cognitive, affective, and behavioral learning outcomes.[32] The analysis of 42 different studies found that the overall effect of teaching and learning with technology on student learning outcomes was far greater than previously thought—nearly twice as large as other such analyses had found. Waxman *et al.* found that using technology for teaching and learning improved cognitive and affective outcomes, although not at a significant level; it also found that technology had a slight, non-significant impact on student behavioral outcomes.[33] Although the results of this study did not find statistical significance, it confirms the impact that technology has on student learning outcomes.

The public policy implications of the meta-analysis studies findings are far reaching. If "intellectual capital" will be *the* natural resource of the information and knowledge economy, it should be a state priority to invest in developing intellectual capital by providing adequate technology resources, classroom connectivity in schools, training teachers to meaningfully use technology for instruction, and promoting technology-based learning and teaching at state teacher preparation programs. Due to the large number of American Indian and Latino students in Arizona schools, it is imperative to have adequate resources in schools where their enrollment is high. Ignoring these underserved populations, or avoiding provisions of equal education to develop their intellectual capital will leave the state economically uncompetitive, given that Latinos are the largest minority in the state.[34]

Recommendations

In light of the foregoing, it is recommended that:

1. The Arizona Department of Education (ADE) direct discretionary grants to schools to make up-to-date technology, fast connectivity, and teacher support on-site available for Pre-K-12 teachers.
2. Pre-K-16 schools, with the financial support of ADE, develop an in-house corps of highly-qualified teachers in technology integration issues across content areas and grade levels at each school building to coach other teachers in their technology use.
3. School principals, backed by school district superintendents, allow Pre-K-12 teachers time to learn how to use different technologies, including release time for training.
4. ADE identify representative schools across the state to fund a 1-to-1 student-to-computer ratio to model best practices for technology integration on a statewide basis.
5. The Arizona State Legislature and ADE plan for future state-level funding to build on lessons learned through technology use at model schools and at different technology initiatives to generalize the use of technology-rich environments in all public schools.
6. The Arizona State Legislature and ADE, through monetary incentives, support schools in forming alliances and partnerships between high schools and colleges, and/or high schools and businesses, particularly those in the knowledge industries, to provide a specialized workforce that will enable the state to attract more knowledge and information industries.

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