ISTE Policy Brief

Technology and Student Achievement—The Indelible Link

iste International Society for Technology in Education

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June 2008

Dear Colleague:

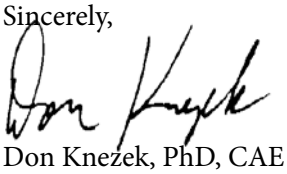
On behalf of the International Society for Technology in Education (ISTE®), I am pleased to release the first in a series of policy briefs focusing on the role of technology and learning. This first brief entitled, *Technology and Student Achievement—The Indelible Link,* will be a useful tool for ISTE members and other education technology supporters as we collectively advocate to ensure students are provided the technology and information skills and tools necessary for success in the 21st century.

ISTE members have monitored research on the effectiveness of education technology on student outcomes for more than 20 years, and one convincing trend has emerged: when implemented appropriately, the integration of technology into instruction has a strong positive impact on student achievement.

We encourage readers to use this document as a tool for their advocacy efforts. Feel free to excerpt the Executive Summary or the research findings or to share the entire report with policymakers and education leaders at the national, state, and local levels.

ISTE thanks Robert Kadel who was commissioned by ISTE as the lead researcher/ writer of this policy brief. ISTE appreciates all of the time and energy dedicated by the members of ISTE's Public Policy and Advocacy Committee as well as ISTE staff Mark Andrews, Talbot Bielefeldt, and Hilary Goldmann. A special thank you to COMPUTER EXPLORERS for their generous support of this policy brief. For more information about ISTE's public policy and advocacy efforts and about this policy brief, contact Hilary Goldmann, ISTE's Director of Government Affairs at hgoldmann@iste.org or 1.202.861.7777.

Sincerely,



Don Knezek, PhD, CAE
Chief Executive Officer

The International Society for Technology in Education (ISTE®) is the premier membership association for educators and education leaders engaged in improving teaching and learning by advancing the effective use of technology in PK–12 and teacher education. Home of the National Educational Technology Standards (NETS) and the National Educational Computing Conference (NECC), ISTE represents more than 100,000 education professionals worldwide. Learn more at http://www.iste.org.

Executive Summary

- **Education Technology has a positive effect on student achievement.** ISTE members have monitored research on the effectiveness of technology in education on student outcomes for more than 20 years, and one convincing trend has emerged: when implemented appropriately, the integration of technology into instruction has positive effects on student achievement.
- **Several states have emerged as leaders in integrating education technology.** Several state programs have involved the implementation of instructionally sound strategies in integrating education technology into instruction. Missouri's eMINTS program, Michigan's Freedom to Learn program, and Texas' Technology Immersion Pilot, just to name a few, have all shown statistically significant gains in elementary and middle grade reading, math, and science achievement when comparing participating students to their non-participating peers.
- **Published journal articles feature studies that have shown significant effects of education technology on student achievement.** In reviewing peer-reviewed journal articles on the effects of education technology integration on achievement, seven studies published since 2000 have shown significant effects in mathematics, and fourteen articles have shown significant effects in reading and literacy. This includes a number of interventions reviewed by the What Works Clearinghouse indicating that the interventions met high standards of scientific reliability.
- **Correct implementation of education technology is key.** The research demonstrates the need for the correct implementation and use of education technology. ISTE has identified seven factors for successful technology implementation:
    1. Effective professional development for teachers in the integration of technology into instruction is necessary to support student learning.
    2. Teachers' direct application of technology must be aligned to local and/or state curriculum standards.
    3. Technology must be incorporated into the daily learning schedule (i.e., not as a supplement or after-school tutorial).
    4. Programs and applications must provide individualized feedback to students and teachers and must have the ability to tailor lessons to individual student needs.
    5. Student collaboration in the use of technology is more effective in influencing student achievement than strictly individual use.
    6. Project-based learning and real-world simulations are more effective in changing student motivation and achievement than drill-and-practice applications.
    7. Effective technology integration requires leadership, support, and modeling from teachers, administrators, and the community/parents.
- **Research has shown that minority students, those from economically disadvantaged neighborhoods, and students who live in either inner-city or rural areas (but not suburban) tend to have less access to computers, the Internet, and educational software than their middle-class and more affluent peers.** In many cases, schools provide these students with their only access to computing devices and the Internet.

- **The integration of education technology provides students with 21st century skills.** In using technology for instruction and learning, students gain more than just knowledge in core subject areas — they also acquire skills necessary to be productive and competitive in the workplace, in higher education, and in military or community service. ISTE, the State Educational Technology Directors Association (SETDA), and the Partnership for 21st Century Skills have identified these as the abilities to "communicate, collaborate, analyze, create, innovate, and solve problems."
- **National policy recommendations:**
  - **ISTE recommends that national policy must be focused on providing the funding and resources necessary for the effective integration of technology into instruction.** Funding for Enhancing Education Through Technology (EETT, part of Title II-D) must be restored to its original levels as passed in 2001.
  - **ISTE recommends that Congress pass the Achievement Through Technology and Innovation Act (ATTAIN) Act as part of the next iteration of our nation's K–12 laws.** ATTAIN is designed to provide funds to meet the challenges faced by all schools and among those schools most in need. ATTAIN would not only renew funding for hardware and software in schools but also focus funds on continued professional development of teachers in integrating such technology into instruction. Additionally, ATTAIN would direct competitive grants to schools implementing school re-design initiatives with significant technology components. Finally, ATTAIN would provide all districts with a minimum of $3000 per year in formula funding, thereby providing some guaranteed support to districts that cannot prepare competitive grant proposals.
  - **ISTE recommends that E-Rate performance measures must set as a goal a connection speed of one gigabit per second so that administrators, teachers, and students have access to robust broadband networks to take advantage of current and future classroom technologies and services.**
- **State and local policy recommendations:**
  - **ISTE recommends that all states have a dedicated funding stream for educational technology that is tied to sustained high-quality professional development as well as investment in hardware, software, and infrastructure.** For those states that already have funding for this purpose, it must be sufficient to achieve targeted educational goals.
  - **ISTE recommends that administrators at the local level ensure that technology investments and professional development align to curriculum standards.** Data-driven decision making—among administrators and teachers—is key in this process. Useful data on student achievement can identify those gaps where students are not meeting curriculum standards. By identifying teachers' needs for classroom and building technologies and for professional development, administrators can ensure that funding is targeted where it will be most efficient and effective.

Introduction

There are many ways to measure student achievement. Grades, test scores, graduation rates, and the acquisition of skills are popular barometers of how well students are progressing in their formal learning. The Elementary and Secondary Education Act of 1965, as amended by the No Child Left Behind Act of 2001 (NCLB)[1] focuses almost exclusively on the use of standardized tests. Such tests can provide valuable information. Teachers and administrators can tailor curriculum and instruction to meet the needs of their students. Parents can gain an understanding of the areas in which their children need extra attention.

Yet in addition to NCLB's strong emphasis on standardized tests, it is necessary to measure achievement in broader terms: student portfolios; papers and reports; presentations; and formative assessments that gauge critical thinking and problem-solving skills alongside math, reading, and science. Likewise, it is essential to incorporate advances in the use of technology in teaching and learning and assess their effects on achievement measured through test scores and the acquisition of 21st century skills (i.e., the skills that are required for students to succeed beyond high school and thrive in the "Digital Age"). Such skills include: effective digital communication; the creation and use of multimedia documents, databases, and works of art; and the ability to make decisions based on the analysis of data, to name a few.

The research findings presented in this brief demonstrate that technology is being effectively integrated into teaching and learning and is having a positive impact on increasing student achievement through test scores and the acquisition of 21st century skills. This research presents convincing evidence that technology integration in teaching and learning is having a strong positive effect on student achievement across all segments of K–12 students, is helping to advance equity and access in historically high-need schools and communities, and is fortifying today's generation with a foundation of technology-based skills that fit within the larger picture of global competitiveness.

Current Research on Education Technology and Student Achievement

ISTE members have monitored research on the effectiveness of education technology on student outcomes for more than 20 years, and one convincing trend has emerged: when implemented appropriately, the integration of technology into instruction has a strong, positive impact on student achievement.

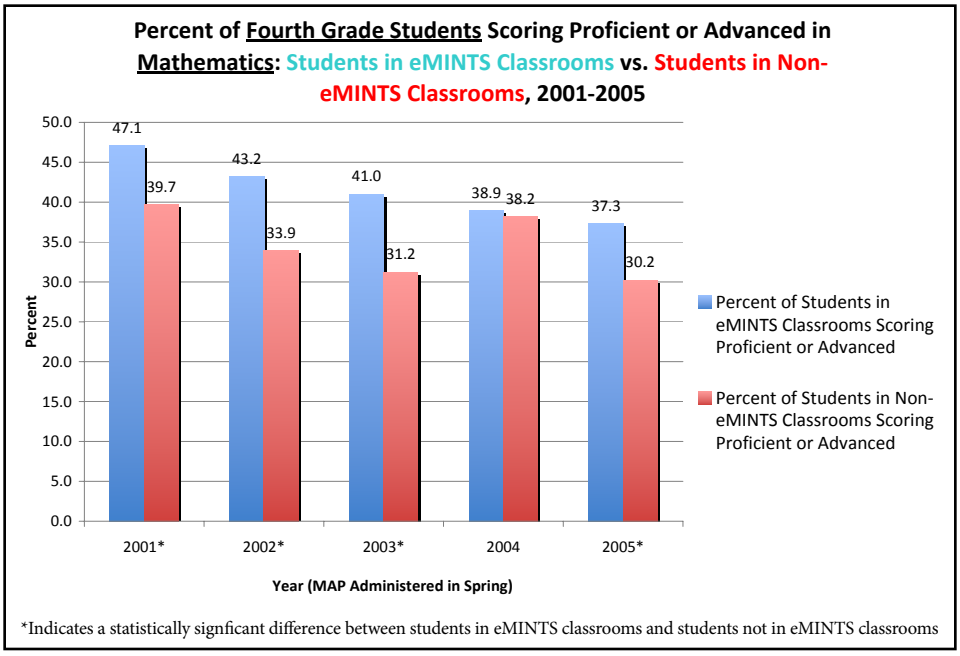
Several states are successfully utilizing instructionally sound strategies in their integration of technology into instruction. One of the most comprehensive examples is Missouri's eMINTS program[2]. eMINTS focuses on innovative instructional processes, and supporting elementary teachers to develop student-centered, inquiry-based instructional practices through multimedia and computer technology (eMINTS 2002, p. 2).

Evaluations of the program involved quasi-experimental studies[3] comparing students in eMINTS classrooms with those in non-eMINTS classrooms in the same grade at the same school. The results have revealed statistically significant differences in the performance of eMINTS students to non-eMINTS students across an array of subject areas. For example, students who participated in eMINTS classrooms have consistently outperformed their peers in statewide math assessments administered through the Missouri Assessment Program. The results are similar in communication arts, where students in eMINTS classrooms have outperformed their counterparts every year except 2002. Third graders in eMINTS classrooms scored significantly higher in science in 2001 and 2004, and fourth graders scored significantly higher in social studies from 2001 through 2003 (see page 6).

Results in other states are similar. Michigan's Freedom to Learn (FTL) program provides laptops for students in a number of the state's middle schools along with extensive teacher professional development around technology integration and curriculum enhancement. Evaluations show that students participating in FTL had significantly higher levels of engagement in their work and in using technology as a learning tool when compared with national averages (Lowther et al. 2005). The results are consistent for school years 2004–05 and 2005–06 (see also Lowther et al. 2007, Ross and Strahl 2005). In one notable FTL school, 8th grade math achievement doubled from 31 percent to 63 percent between 2004 and 2005, and science achievement jumped from 68 percent to 80 percent between 2003 and 2004.[4]

[1]ESEA was originally passed in 1965 and Congress reauthorizes it every five years. NCLB is the moniker given to the reauthorization of ESEA as passed in 2001.
[2]eMINTS is an acronym for enhancing Missouri's Instructional Networked Teaching Strategies.
[3]The studies are quasi-experimental because classrooms were not randomly assigned for participation in eMINTS. Rather, the schools were allowed to choose which classrooms would participate.
[4]From A Complete Guide to One-to-One Computing in the K-12 Environment, p. 24.

In Texas, the Technology Immersion Pilot (TIP) for middle schools yielded reductions in discipline problems and increases in student technology proficiency and use. As with FLT, these results were consistent across school years 2004–05 and 2005–06 (Shapley et al. 2006 and 2007). Students in one fully engaged TIP middle school saw their math achievement scores increase by 5 percent among 6th graders, 42 percent among 7th graders, and 24 percent among 8th graders. TIP evaluations pinpoint the critical importance of teacher professional development and engagement as key factors influencing these outcomes.[5]



Iowa's Department of Education, through a technical assistance program with the State Educational Technology Directors Association (SETDA), has implemented a new comprehensive, scientifically based and sustainable professional development system for elementary and middle school reading and math and the use of technology in those subjects. Preliminary results indicate that achievement scores of students participating in the program have increased by 14 points in 8th grade math, 16 points in 4th grade math, and 13 points in 4th grade reading, significantly higher than scores of students in the control group.

Looking at the effect of technology in raising achievement in specific subject areas, of 11 studies published since 2000 assessing technology integration and mathematics achievement, seven showed strong positive effects on scores among elementary and secondary students.[6] Three showed little discernible effects of education technology on math achievement.[7]

In literacy and reading achievement, 14 out of 19 studies reviewed showed strong positive effects of educational technology on reading achievement[8], nine showed little effect[9], and one showed a negative effect (What Works Clearinghouse August 2007).[10]

In science, three recent studies show generally positive effects of the use of educational technology on science achievement. Dunleavy and Heinecke (2007) found that ubiquitous, or 1:1, computing has a positive effect on science achievement among at-risk middle school students. Van Lehn et al. (2006) showed positive effects of computer mediated tutoring on physics test scores when students who had not taken a physics course before were introduced to intermediate material, but not when they studied material designed for novices (demonstrating the value of using technology to encourage higher-order thinking skills). In a meta-analysis of the effects of different teaching strategies on science achievement, Schroeder et al. (2007) showed that instructional technology had significant, positive effects on science test scores. Meanwhile, Taylor and Duran (2006), analyzing Detroit's MITTEN Program[11], found significant, positive effects on social studies learning by increasing student interest in the subject material.

Murphy (2007) conducted randomized control trials to test for the effect of the use of instructional technology in foreign language comprehension and found significant, positive effects. Moreover, he demonstrated that students who worked in pairs (as opposed to individually) and received elaborative feedback from instructors regarding their use of online comprehension exercises performed better than those who did not.

[5]Wolf, 2007, p.2
[6]Citations for these studies are as follows: Banerjee 2005, Penuel et al. 2002 and five intervention reports from the What Works Clearinghouse dated July 23, 2007; May 29, 2007; March 26, 2007; October 14, 2006; September 14, 2006.
[7]Citations for these studies are as follows: Dunleavy and Heinecke 2007, Yixin 2005, Din and Caleo 2000.
[8]Citations for these studies are as follows: Knezek and Christensen 2007; Tracey and Young 2006, Yip and Kwan 2006, Fasting and Lyster 2005, Jones et al. 2004, Blok et al. 2002, Penuel et al. 2002, Din and Caleo 2000 and six studies from the What Works Clearinghouse dated August 13, 2007a; August 13, 2007b; July 16, 2007a; July 2, 2007; April 23, 2007; and September 28, 2006.
[9]Citations for these studies are as follows: Tracey and Young 2006, Blok et al. 2002, Batchelder and Rachal 2000 and six studies from the What Works Clearinghouse dated August 13, 2007b; July 30, 2007; July 16, 2007a; July 16, 2007b; July 2, 2007; and March 12, 2007.
[10]This sums to greater than 19 studies because five studies showed mixed results, both positive effects and no statistically significant effects, depending on the implementation or student composition.
[11]Michigan Teachers' Technology Education Network

In a March 2007 study of the effectiveness of reading and math software on standardized test scores, Dynarski et al. (p. xiii) found no significant improvement in scores between treatment and control classrooms in either subject. However, Kadel (2007) identified two major problems in the study's design. First, teachers in the control group of schools were allowed to use technology in their classes, just not the specific software being tested in the study. In fact, 75 percent of teachers in the first-grade reading control group used a different reading software product. In other words, this was not so much a comparison of technology use versus no technology use. It was a comparison of the use of certain software programs in certain classrooms to classrooms where other software may or may not have been used. Second, the study's authors disclosed that the software products chosen for testing were suggested by educators and product developers; thus the "voluntary aspect of company participation in the study meant that products were *not a representative sampling of reading and math technology used in schools*" (p. xv, author's emphasis).

The research findings described in this section clearly demonstrate that the use of education technology in teaching and learning is having a strong, positive effect on student achievement. And while standardized test scores continue to be the measurement *du jour,* the use of technology is having an equally positive impact in helping students gain necessary 21st century skills that serve to advance learning engagement, and prepare students for life and work.

Seven Factors for Successfully Implementing Technology for Learning

As mentioned above, a handful of studies showed no statistically significant effect of educational technology on student achievement. Almost all of these studies have one thing in common: they illuminate the need for the correct implementation of technology into teaching and learning. Merely purchasing computers and practice software is not enough. Alignment of the software to curricular standards, effective school leadership, and professional development are equally as important.

In order to positively affect student achievement and to enhance 21st century skills, policy makers and practitioners should focus on seven key conditions:

1. **Effective professional development for teachers in the integration of technology into instruction is necessary to support student learning.** The use of technology for learning does not take place in a vacuum; practitioners must effectively apply technology in the curriculum and throughout the school day. Further, access to technology professional development must be consistent and ongoing in order to keep teachers up-to-date with changing programs, resources, and applications. ISTE's National Educational Technology Standards for Teachers (NETS•T) and the 10 Essential Conditions for Teacher Preparation provide additional guidance in this area. (See http://www.iste.org/nets.)
2. **Teachers' direct application of technology must be aligned to local and/or state curriculum standards.** Since curriculum standards have to align with local or state measures of achievement, classroom-based technology interventions must also mirror those standards. Moreover, any lesson plans designed to incorporate technology must be as rigorous and relevant in meeting local and state curriculum standards as non-technology-based plans.
3. **Technology must be incorporated into the daily learning schedule (i.e., not as a supplement or after-school tutorial).** Kulik (2003) found that computer simulations were effective when incorporated into "regular classroom instruction" and when teachers spend an adequate amount of time using it for core learning. Additionally, Middleton and Murray (1999) discovered that students whose teachers integrated technology into instruction more frequently and for a variety of purposes scored better in 4th and 5th grade mathematics than students whose teachers were low level users of technology.
4. **Programs and applications must provide individualized feedback to students and teachers and must have the ability to tailor lessons to individual student needs.** One major benefit of incorporating technology into instruction is to avoid a one-size-fits-all approach to learning. Instead, technology applications can be tailored to meet individual student needs, provide feedback on student progress, and assist them to reflect on their work. Teachers can use data-driven decision making tools to adapt instruction to students' specific needs. (See, e.g., Kulik 2003, White and Frederiksen 1998). Moreover, educational technology provides multiple avenues for assessing student learning and allowing students to communicate what they have learned to their teachers and parents.
5. **Technology use must be incorporated in a collaborative environment to be most effective.** Student collaboration with technology elevates student achievement more than individual use. Kulik (2003) and others found that student collaboration increased the information available to students through a process of sharing and

augmented critical-thinking skills as students worked to assimilate a range of ideas and information from online sources, software, and their peers.

6. **Project-based learning and real-world simulations must be the main focus of instructional technology utilization.** Adams and Hamm (2008), Cradler and Cradler (1999) and others reported that simulations, multimedia, and lessons based on problem-solving skills improve student motivation, a strong harbinger to increasing student achievement. Real-world simulations are also more effective than using computers for drill-and-practice.
7. **Effective technology integration requires leadership, support, and modeling from teachers, administrators, and the community/parents.** Educational planning that incorporates and models effective technology use has been positively related to increases in student achievement. When schools, community leaders, and families, demonstrate the effective use of technology for learning, communication, and project management, student motivation and interest in using technology in their own work is positively affected (e.g., Gysbers and Henderson 2002, Penuel et al. 20002, Honey 1999, and Mann et al. 1999.).

The Effects of Access and Equity on the Use of Technology to Improve Student Achievement

Inequities exist in both access to and in the use of technology. From the National Telecommunication & Information Administration's 2000 report *Falling Through the Net: Defining the Digital Divide* to the 2003 follow-up study, A Nation Online, to studies such as Judge et al. (2004) and Foss (2002), research has shown that minority students, those from poorer neighborhoods, and students who live in either inner-city or rural areas (but not suburban) tend to have less access to computers, the Internet, and educational software. Thus, they are reliant on schools, libraries, and community centers for their hardware, software, and internet access. Moreover, such students, who also tend to have lower grades and poorer test performance, receive computer-based instruction only for drill-and-practice and not for critical thinking skills or project-based learning. What hardware and software they do have available is still holding them back from achieving their potential.

ISTE's 2007 report, *A National Consideration of Digital Equity* (Davis et al. 2007), discusses four specific challenges that are central to the digital divide:

- Technology is not valued as an instructional tool
- Educators are receiving inadequate professional development
- There remains a significant number of students with limited access to technology outside of school
- Obtaining funding for technology continues to be difficult (pp. 2–4)

The report details five strategies for schools and districts to address these challenges:

- Legitimize the significant role culture plays in students' educational experience
- Continue to challenge perceptions about the role of technology in education
- Encourage others to recognize the critical link between technology professional development and classroom practice
- Create opportunities for students to access technology outside of the classroom
- Continue to seek funding for technology in spite of challenges (pp. 11–13)

ISTE invites the reader to review this report in more detail as part of the discussion of the mediating effects of digital equity in the link between technology and achievement. (Available from the ISTE Web site at http://www.iste.org/digitalequity/report)

How Does the Issue of the Effect of Technology on Student Achievement Fit into the Larger Picture of Global Competitiveness?

Education technology that best fits students' needs and is implemented with adequate professional development and support has strong, positive effects on student test scores. However, achievement as currently measured through standardized tests, does little to enhance and promote the teaching of 21st century skills necessary to be successful in a competitive workforce.

One major benefit of using technology in education is that students also acquire a wide array of technology-based skills. The report *Maximizing the Impact: The Pivotal Role of Technology in a 21st Century Education System* (ISTE, SETDA, and the Partnership for 21st Century Skills, 2007) addresses the impact of the integration of education technology into instruction on those skills American students will need to compete in the global economic market. Such skills include the ability to "communicate, collaborate, analyze, create, innovate, and solve problems" (p. 3). These activities are now only rarely addressed in a pencil-and-paper format in the public, private, and non-profit sectors; yet schools that do not routinely incorporate technology into core instruction continue to hinder students from learning and applying the tools that will be required of them beyond their formal education. Moreover, the Organisation for Economic Co-operation and Development reports that skills mastery in science, technology, and innovation are the keys to stronger economic growth. However, only a small percentage of American students receive rigorous training in and exposure to such skills (Business Roundtable, 2005).

Policy Recommendations

Based upon the research and considerations discussed above, ISTE makes the following recommendations regarding policy at the national, state, and local levels.

National Policy

ISTE believes that national policy, including Titles II-A and II-D of NCLB, must be focused on providing the funding and resources necessary for the effective integration of technology into instruction. Additionally, teachers and students must have access to robust broadband networks to gain access to and effectively use the latest educational technologies, services and applications.

ISTE Recommends: **Funding for the Enhancing Education Through Technology program (EETT, Title II-D) must be restored to its original funding level of $700.5 million as passed in 2001.**[12] Additionally, teachers and students must have access to robust broadband networks to gain access to and effectively use the latest educational technologies, services, and applications.

ISTE Recommends: **Congress must pass the Achievement Through Technology and Innovation Act (ATTAIN), successor legislation to EETT, to meet the challenges faced by all schools and among those schools most in need.** ATTAIN calls for not only renewed funding for hardware and software in schools but also focuses funds on continued professional development of teachers in integrating such technology into instruction. Additionally, ATTAIN would direct competitive grants to schools implementing school reform initiatives with significant technology components. Finally, ATTAIN would provide all districts with a minimum of $3,000 per year in formula funding, thereby providing some guaranteed support to districts that cannot prepare competitive grant proposals. ATTAIN will build on the success of EETT and, if fully funded, will help transform our nation's schools into productive, high performance 21st century learning environments.

ISTE Recommends: **E-Rate performance measures must set as a goal a connection speed of one gigabit per second so that administrators, teachers, and students have access to robust broadband networks to take advantage of the latest classroom technologies, services and applications.**

The one gigabit per second speed should be at the following three different connections:

- between Wide Area Networks (WANs) and the Internet,
- between WANs and district buildings,
- inside the building to the desktop computing device or wireless router.

State and Local Policy

The Education Counts Research Center, a project of Education Week (http://www.edweek.org/rc/edcounts), shows that states have a range of options for funding education technology (e.g., earmarked taxes or lotteries, bond sales, and partnerships with private foundations).

[12]EETT's appropriation levels have dropped from $700 million in 2002 to $272 million in 2007, having been cut substantially each successive year of the program. Source: http://www.ed.gov/programs/edtech/funding.html

ISTE Recommends: **Each state must have a dedicated funding stream that is tied to sustained high-quality professional development as well as investment in hardware, software, and infrastructure**. For those states that already have dedicated funding streams for this purpose, they must ensure that the funds are adequately targeted for investment in hardware, software, and professional development in educational technology and are sustained and expanded as learning innovations through technology increase.

ISTE Recommends: **Administrators at the local level ensure that technology investments and professional development align to curriculum standards set by their district and state. Data-driven decision making among administrators and teachers is key in this process.** Useful data on student achievement can identify those gaps where students are not meeting curriculum standards. By identifying teachers' needs for classroom and building technologies, administrators can ensure that funding is targeted where it will be most efficient and effective. Finally, ISTE's technology standards for administers, NETS•A, call on local leadership to "integrate strategic plans, technology plans, and other improvement plans and policies to align efforts and leverage resources." (See http://www.iste.org/nets/administrators.)

Conclusion

Given the overwhelming body of evidence showing an impact of the integration of technology into instruction on achievement and the acquisition of 21st century skills, it is clear that investing time and resources in education technology initiatives is paramount in local, state, and federal policy. ISTE urges its members, fellow practitioners and researchers, and policy makers to consider the long-term value of education technology and to enact policies and implement instructional strategies that use technology appropriately and prepare American students for the world they will face beyond school.

References

A nation online: entering the broadband age. (2004). Washington, DC: National Telecommunications and Information Administration.

Adams, D. & Hamm, M. (2008). *Helping students who struggle with math and science: Collaborative approach for elementary and middle schools*. Lanham, MD: Rowan & Littlefield.

Banerjee, A., Cole, S., Duflo, E., & Linden, L. (2005). Remedying education: Evidence from two randomized experiments in India. (Working paper.) Cambridge, MA: National Bureau of Economic Research.

Batchelder, J.S. & Rachal, J.R. (2000). Efficacy of a computer-assisted instruction program in a prison setting: An experimental study. *Adult Education Quarterly*: 50, 2.

Bickford, A. (2005). Analysis of 2004 MAP results for eMINTS students. http://www.emints.org/evaluation/reports/index.shtml

Blok, H., R., Oostdam, M.E., Otter, & Overmaat, M. (2002). Computer-assisted instruction in support of beginning reading instruction: A review. *Review of Educational Research*, 72, 101-30.

Business Roundtable. (2005). Tapping America's Potential: The education for innovation initiative. Retrieved May 2008 from http://www.businessroundtable.org/pdf/20050803001TAPfinalnb.pdf

A Complete Guide to One-to-One Computing in a K-12 Environment. (2008). Folsom, CA: eRepublic, Inc. Retrieved May 2008 from http://www.one-to-oneinstitute.org/files/CDE07_Book_MPC_K12.pdf

Din, F.S. & Caleo, J. (2000). Playing computer games versus better learning. Paper presented at the Annual Conference of the Eastern Educational Research Association, Clearwater, FL.

Dunleavy, M. & Heinecke, W.F. (2007). The impact of 1:1 laptop use on middle school math and science standardized test scores. *Computers in the Schools*, 24, 7-22.

Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N., Campuzano, L., Means, B., Murphy, R., Penuel, W., Javitz, H., Emery, D., & Sussex, W. (2007). *Effectiveness of reading and mathematics software products: findings from the first student cohort*. Washington, DC: Institute of Education Sciences, U.S. Department of Education.

eMINTS Evaluation Team. (2002). *Analysis of 2001 MAP results for eMINTS students*. http://www.emints.org/evaluation/reports/index.shtml

eMINTS Evaluation Team. (2003). *Analysis of 2002 MAP results for eMINTS students*. http://www.emints.org/evaluation/reports/index.shtml

eMINTS Evaluation Team. (2004). *Analysis of 2003 MAP results for eMINTS students*. http://www.emints.org/evaluation/reports/index.shtml

Falling through the net: Defining the digital divide. (2002). Washington, DC: National Telecommunications and Information Administration.

Fasting, R.B. & Lyster, S.H. (2005). The effects of computer technology in assisting the development of literacy in young struggling readers and spellers. *European Journal of Special Needs Education*, 20, 21-40.

Foss, J. (2002). The 'digital divide' goes to school. *Children's Advocate*, December: p.5.

Gysbers, N. & Henderson, P. Eds. (2002). *Implementing Comprehensive School Guidance Programs: Critical Leadership Issues and Successful Responses.* Austin, TX: CAPS Press (now Pro-Ed Incorporated).

Honey, M., Culp, K. M., & Carrigg, F. (1999). *Perspectives on technology and education research: Lessons from the past and present*. New York: Center for Children and Technology.

Huntley, L. & Greever-Rice, T. (2007). *Analysis of 2005 MAP results for eMINTS students*. http://www.emints.org/evaluation/reports/index.shtml

Jones, J.D., Staats, W.D., Bowling, N., Bickel, R.D., Cunningham, M.L., Cadle, C. (2004). An evaluation of the merit reading software program in the calhoun county (WV) middle/high school *Journal of Research on Technology in Education*, 37, 177-95.

Judge, S., Puckett, K., & Cabuk, B. (2004). Digital equity: New findings from the early childhood longitudinal study. *Journal of Research on Technology in Education*, 36, 383-96.

Kadel, R. (2007). The software report: Digging deeper. *Learning and Leading with Technology*, September: 22-23.

Knezek, G. & Christensen, R. (2007). Effect of technology-based programs on first- and second-grade reading achievement. *Computers in the Schools*, 24, 23-41.

Kulik, J. (2003). *Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say*. Arlington, VA: SRI International.

Larson, T.D. (2001). A comparison of fifth grade children receiving both a traditional and a technology based means of instruction in social studies. Master's thesis presented to Johnson Bible College, Knoxville, TN.

Lowther, D.L., Strahl, J.D., Inan, F.A., & Bates, J. (2007). *Freedom to learn program: Michigan 2005-2006 evaluation report*. Prepared for Freedom to Learn and the One-to-One Institute. Memphis, TN: Center for Research in Education Policy. Retrieved March 2008 from http://www.ftlwireless.org.

Lowther, D.L., Ross, S.M., Strahl, J.D., Inan, F.A., & Pollard, D. (2005). *Freedom to learn program: Michigan 2004-05 evaluation report*. Prepared for the Michigan Department of Education and Ferris State University. Memphis, TN: Center for Research in Education Policy. Retrieved March 2008 from http://www.ftlwireless.org.

Mann, D., Shakeshaft, C., Becker, J., & Kottkamp, R. (1998). *West Virginia story: Achievement gains from a statewide comprehensive instructional technology program*. Santa Monica, CA: Milken Exchange on Educational Technology.

Maximizing the Impact: The pivotal role of technology in a 21st century education system. (2007). Eugene, OR: International Society for Technology in Education; Glen Burnie, MD: State Educational Technology Directors Association; Tucson, AZ: Partnership for 21st Century Skills.

Murphy, P. (2007). Reading comprehension exercises online: The effects of feedback, proficiency and interaction. *Language Learning & Technology*, 11, 107-29.

OECD Science, Technology and Industry Scoreboard 2005: Briefing note for the United States. (2005). Paris: Organisation for Economic Co-operation and Development.

Penuel, W.R., Kim, D.Y., Michalchik, V., Lewis, S., Means, B., Murphy, R., Korbak, C., Whaley, A., & Allen, J.E. (2002). Using technology to enhance connections between home and school: A research synthesis. Washington, DC: Planning and Evaluation Service, U.S. Department of Education, DHHS Contract # 282-00-008-Task 1.

Ross, S.M. & Strahl, J.D. (2005). *Evaluation of Michigan's Freedom to Learn Program*. Memphis, TN: Center for Research in Education Policy. Retrieved March 2008 from http://www.ftlwireless.org.

Schroeder, C.M., Scott, T.P., Tolson, H., Huang, T. & Lee, Y. A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching*, 44, 1436-60.

SETDA Technical Assistance Partnership Program. (forthcoming). *Iowa: Year one progress report*. Retrieved March 2008 from http://www.setdatapp.org/content.cfm?sectionid=5&ResourceID=475.

Shapley, K., Sheehan, D., Sturges, K., Caranikas-Walker, F., Hunstberger, B., & Maloney, C. (2006). *Evaluation of the Texas technology immersion pilot: An analysis of baseline conditions and first-year implementation of technology immersion in middle schools*. Austin, TX: Texas Center for Educational Research. Retrieved March 2008 from http://www.etxtip.info.

Shapley, K., Sheehan, D., Maloney, C., Caranikas-Walker, F., Huntsberger, B., & Sturges, K. (2007). *Evaluation of the Texas technology immersion pilot: Findings from the second year*. Austin, TX: Texas Center for Educational Research. Retrieved March 2008 from http://www.etxtip.info.

Taylor, J.A. & Duran, M. (2006). Teaching social studies with technology: New research on collaborative approaches. *History Teacher*, 40, 9-25.

Tracey, D.H. & Young, J.W. (2006). Technology and early literacy: The impact of an integrated learning system on high-risk Kindergartners' achievement. ERIC # ED491554. Original publication information unavailable.

Van Lehn, K., Graesser, A.C., Jackson, G.T., Jordan, P., Olney, A., & Rosé, C.P. (2006). When are tutorial dialogues more effective than reading? *Cognitive Science*, 31, 3-62.

What Works Clearinghouse. (September 14, 2006). *Everyday Mathematics*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/elementary_math/eday_math/

What Works Clearinghouse. (September 28, 2006). *DaisyQuest*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/dq/

What Works Clearinghouse. (October 14, 2006). *The Expert Mathematician*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/middle_math/expert_math/

What Works Clearinghouse. (March 12, 2007). *Words and Concepts*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/early_ed/words/index.asp

What Works Clearinghouse. (April 23, 2007). *Accelerated Reader/Reading Renaissance*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/arrr/

What Works Clearinghouse. (March 26, 2007). *I CAN Learn® Pre-Algebra and Algebra*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/middle_math/iclprea/index.asp

What Works Clearinghouse. (May 29, 2007). *Cognitive Tutor® Algebra 1*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/middle_math/ct_algebra1/index.asp

What Works Clearinghouse. (July 2, 2007). *Failure Free Reading*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/failurefr/

What Works Clearinghouse. (July 16, 2007a). *Waterford Early Reading Program™*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/werp/index.asp

What Works Clearinghouse. (July 16, 2007b). *Read Naturally*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/read_naturally/

What Works Clearinghouse. (July 23, 2007). *SRA Real Math Building Blocks PreK*. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/early_ed/sra_prek/index.asp

What Works Clearinghouse. (July 30, 2007). *Waterford Early Reading Level One*™. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/werp/index.asp

What Works Clearinghouse. (August 13, 2007a). *Voyager Universal Literacy System*®. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/vuls/

What Works Clearinghouse. (August 13, 2007b). *Earobics*®. Washington, DC: Institute of Education Sciences. Retrieved May 2008 from http://ies.ed.gov/ncee/wwc/reports/beginning_reading/earobics/index.asp

White, B. Y., & Frederiksen, J. R. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition and Instruction*, 16(1), 3-188.

Wolf,M.A. (2007). "Systemic school reform: A guiding hand." *T.H.E. Journal*. Rtrieved May 2008 from http://www.thejournal.com/articles/20927

Yip, F.W.M. & Kwan, A.C.M. (2006). Online vocabulary games as a tool for teaching and learning english vocabulary. *Educational Media International*, 43, 233-49.

Yixin, Z. (2005). An experiment on mathematics pedagogy: Traditional method versus computer-assisted instruction. ERIC # ED490695. Original publication information unavailable.

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