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technology

investing in technology:

the Learning Return

Investments in education technology can pose major dilemmas for policymakers. Most agree that in today's world, technology is not a frill but an important part of any modern curriculum. Equally clear, however, is its expense. Computers alone are big-ticket items, and educators are buying more of them. Over the last decade, K-12 spending on technology in the United States tripled, now totaling more than $6 billion. Given these realities, policymakers at state and local levels are asking the predictable question: Does this level of spending on technology make a difference in student learning?

The answer from research is similarly unsurprising: It depends. Schools are using an array of technologies in differing ways, for varying purposes. Wide disparity exists in teacher knowledge and skills as well as in organizational capability to plan and implement technology use in a comprehensive, results-oriented way. Often, the very ways that schools use — or misuse — technology make evaluation of its impact challenging. (If achievement gain is absent, is the problem the technology or lack of student access to it?) Where technology is used as a tool to support standards-based teaching of complex thinking and problem solving, and appropriate assessments measure student gains, those gains can be impressive indeed.

The real question, then, is not *whether* technology can make a difference in instruction and learning, but how and under what circumstances it does. This brief examines that question. It reports on key research findings, setting aside decisions about hardware and software purchases in favor of focusing on larger policy and pedagogical issues. How does learning "from" computers differ from learning "with" them? What kinds of technology use have what effects on how teachers teach and students learn? The brief then summarizes lessons learned about conditions for effective technology use. Finally, it offers policy implications.

This brief draws from The Learning Return on Our Educational Technology Investment: A Review of Findings from Research, *by Cathy Ringstaff and Loretta Kelley, published in 2002 by WestEd. The paper draws on a selection of research studies, choosing those most methodologically sound and favoring longitudinal studies that examined changes over time. Not a comprehensive literature review, it looks instead at what we've learned from the best research. Available from WestEd.org.*

What the Research Says

The overriding message from most current research on computer-based technology in K-12 education is that technology is a means, not an end; a tool for achieving learning goals, not a goal in itself. Yet many schools and districts make their investments before establishing clear plans for technology use.

A key issue in implementing a plan for technology use is determining purpose. Will students be learning "from" computers or "with" them? In other words, will computers essentially be tutors, used to increase basic skills and knowledge? Or will technology be a resource helping students develop such abilities as higher-order thinking, creativity, and research skills?

Computers as tutors. Common uses of computers to build basic skills include computer-based and computer-assisted instruction, integrated and intelligent learning systems, drill-and-practice software, and computer tutorials. Research is mixed. One prominent study finds that computers used purely for drill and practice in mathematics had a negative impact on achievement.[1] But two large-scale, longitudinal studies that spanned the 1990s along with findings from several meta-analyses between 1985 and 2000 show impressive student gains resulting from drill-and-practice software use.[2] Such findings have bolstered the case

for computer-assisted instruction, preschool through higher education, especially given the rising stakes attached to test scores. Some researchers also argue that skill-building uses of technology are cost-effective because they require minimal teacher training and can often be accomplished with low-end technology.

Computers as tools for problem solving, conceptual development, and critical thinking. To use computers only as basic-skills tutors, however, is shortsighted. Technology is most powerful when students and teachers take advantage of its sophistication and versatility to support higher-order thinking and conceptualizing. For example, various applications can show real-world uses of mathematical concepts or provide tools for research, data analysis, or writing.

The most dramatic illustrations of harnessing technology in these ways come from classrooms organized around projects — that is, where student teams grapple with real-life, complex problems such as the effect of acid rain on their water supply or saving a local endangered species. In the process, they learn and apply disciplines ranging from mathematics and writing to social studies, science, and the arts. Project teams use email and the Internet to gain up-to-date content knowledge; spreadsheets and chart- and graph-making tools to organize and analyze data and map solutions; PowerPoint and camcorders to create stakeholder presentations — which, in turn, give students practice in communications skills and often make them valued community contributors.

Measuring student thinking and problem-solving gains from such approaches is challenging. Though research remains inconclusive, several longitudinal studies — some using specially designed, performance-based assessments — have shown that under the right conditions (see Lessons Learned, below), students using sophisticated technologies as everyday learning tools show marked growth in essential workplace skills (see box). Moreover, such gains do not come at the expense of basic skills.[3] Research reviews also show increased student motivation, engagement, and self-esteem as well as improved school attendance and fewer dropouts.[4]

Impact of technology on classrooms, schools, and districts. Used well, technology can have a transformative effect on education systems because it tends to redefine teacher and student roles and beliefs about teaching and learning. The teacher becomes a coach and collaborator (with students and other teachers) rather than dispenser of knowledge. Students intrigued by a project take charge of their learning and gain responsibility for and control over their work; they construct, rather than just receive, knowledge. Such changes strongly support reform goals that aim to shift school culture from isolated classroom practice to team-oriented learning community.

Lessons Learned

Whether it's simple computer-based tutoring or more advanced technology suited to student exploration, the research consistently points to certain conditions that favor productive outcomes. These include:

Technology is best used as one component in a broad-based reform effort. To effectively improve student achievement, technology needs to be interwoven with other, systematic reforms. In one school-business partnership, for example, standardized test scores showed marked gains after students were given home access to email. Simultaneously, however, the reading curriculum changed, the school switched to block scheduling, and teachers got extensive professional development.[5]

Teachers must be adequately trained to use technology. Virtually every major study of successful technology use finds that teacher professional development is key.[6] Teachers trained in how to use technology use it more often and in ways that result in student gains. Conversely, lack of training is a significant barrier to success.[7] For technology to become a core component of teachers' instructional repertoire, they not only need familiarity with equipment, but — more important — they need to see and practice the most productive ways of using it to support learning. They need time to explore, reflect, collaborate with peers, and engage in hands-on learning.[8] Experts suggest a 30/70 rule: Spend 30 percent of the technology budget on equipment and 70 percent on the supportive "human infrastructure."[9] By contrast, most school districts spend less than 10 percent on training.[10]

Teachers may need to change their beliefs about teaching and learning. Rather than lecture, recitation, and seat work, technology use pushes toward an instructional mode of supporting student collaboration, inquiry, problem solving, and interactive learning. The transition to such a different way of teaching requires much time and effort. Research shows that providing teachers with a vision of what's possible — via opportunities to spend time in technology-rich classrooms and observe for themselves the impact on teaching and learning — can strongly bolster their motivation to take on the challenge themselves.

Technology resources must be sufficient and accessible. Success depends on students and teachers having enough computers as well as convenient, consistent, and frequent access to them. Research suggests that near-universal access is possible with one computer for every five students — a ratio far exceeding that found in most classrooms, especially those serving poor and minority students.[11] Often, computers are in labs rather than classrooms, a situation that impedes access (including student and teacher access to the Internet) and limits achievement impact.[12]

Rising numbers of schools are joining programs that explore the use of handheld computing devices, in part because their lower cost may help narrow the gap between digital "haves" and "have nots." The portability of these devices — and/or the use of laptop computers — can enable every student to use computers, including the Internet, for homework. That, in turn, can boost achievement.[13] The key to this result is for teachers to give meaningful, engaging assignments, rather than busywork.

Technology should be integrated into the curricular and instructional framework. Again, technology should not be an add-on but an everyday tool supporting curricular goals — something teachers need to be clear about (i.e., they are not "teaching technology"). Similarly, the best courseware (software designed for educational program use) is research-based, reflects curricular standards, and promotes understanding of concepts and content.[14]

Policy Implications

LONG-TERM PLANNING

States. Rather than setting up categorical programs, states need to incorporate technology policies into their overall strategic direction and make funding contingent on school districts doing the same.

Districts. Technology spending decisions need to be based on up-front planning that integrates technology use into a cohesive strategy aimed at supporting learning goals. Equipment and use decisions need to be goal-oriented (What student skills, capabilities are you striving to develop? Will this technology help bring home and school closer together?), research-based (What evidence supports using this technology thus?), and realistically funded (Have you budgeted for ongoing maintenance, replacement? For teacher training and at-the-ready technical support?).

TEACHER TRAINING

States. Technology skills should be explicit within teaching standards that articulate what teachers need to know and be able to do. Preservice, inservice, and ongoing professional development policies, then, should incorporate the needed training.

Districts. Since teacher knowledge is key for success, professional development should account for the lion's share of the technology budget (i.e., follow the 30/70 rule). A key part of teacher training should be access to models: exemplary classrooms where teachers can see the innovations of their more tech-savvy colleagues who fully integrate technology into their curricula.

ACCESS

States. Technology funding should be contingent on districts' demonstrating that an adequate student-to-computer ratio is part of their plan. State policy should address the digital divide, ensuring adequate technology resources for all students, including after-school access to computers for students who don't have them at home.

Districts. Plans should include sufficient resources for new equipment or, if donated equipment must be used, should outline minimum standards for it. Computers should be in classrooms rather than labs so that they are routine learning tools. Internet connectivity is essential.

EVALUATION

States and districts. Evaluating the progress of technology integration in schools and classrooms should be a standard feature in all grant applications and awards.

APPLE CLASSROOMS OF TOMORROW

The Apple Classrooms of Tomorrow project (ACOT), launched in 1985, equipped five schools around the nation with top-of-the-line hardware and software. Teachers got in-depth training in telecommunications, troubleshooting, and using software tools. Coordinators at each site served as technical and instructional guides. Project-based, interdisciplinary strategies, as well as team teaching, were the norm. Students used word processing, databases, spreadsheets, hypermedia, and multimedia as part of everyday learning.

A 10-year, longitudinal study of the high school involved showed that, when compared with non-ACOT peers, project students routinely employed inquiry, collaborative, technological, and problem-solving skills — skills the U.S. Department of Labor has identified as fundamental for workplace readiness.[15]

The study also found that technology had an enduring, positive impact on student engagement when used as a learning tool (rather than for drill and practice) and integrated into other aspects of student experience. Teachers changed beliefs about classroom management, learning, teacher-student roles, and instructional practices. ACOT classrooms later became sites for teacher professional development, allowing visiting teachers to observe and work in them.[16]

Conclusion

There is no magic formula that policymakers can use to determine if the return on technology use is worth the investment. Rather than asking, "is technology worth the cost?" the better question is, "under what conditions does technology offer the most benefit for students?" With solid planning to ensure that technology is integrated into comprehensive reform, that teachers are trained and provided adequate technical support in its use, and that all students and teachers have routine access to high-tech tools, states and districts can fully tap technology's promise.

ENDNOTES

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