Technology

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In the Reggio Emelia class, children were working together to represent the idea of "city." They arranged recycled and new materials on a scanner, covered the arrangement with a large piece of white paper, closed the lid, and scanned the image. They evaluated the image on the computer screen collaboratively, returned to the scanner to revise their construction, and rescanned and reevaluated until they were satisfied. Then they printed their representation.

Episodes such as this have convinced many teachers that technology can play a significant, positive role in the lives of young children. Others believe that technology has overwhelmed a more "natural" childhood. We begin this article by addressing three questions.[134]

- How important is technology to young children — and how important should it be?
- What are constructive uses of educational technology?
- What are promising professional-development initiatives?

We conclude this article with visions of the future.

Importance of technology to young children

Technology will become increasingly important to young children, but not in the way many people think. Some believe that young children must be trained on computers to get high-paying jobs of the future. This is not a good reason to use technology with young children. Technology will change considerably by 2020, and even more by the time today's youngest children join the workforce. More importantly, early education should not be limited to job training! Use of computers should focus on realizing their potential across the many critical areas of development, including the cognitive and social-emotional domains. When technology contributes to this development, it should be used. When it does not, it should not be used. The following sections discuss how to use technology to positively contribute to children's development.

Social-emotional development.

Used wisely, computer technology actually promotes positive social interaction. In one example, children at a computer spent nine times as much time talking to their friends while on the computer than while doing puzzles. Children display positive emotions when using computers and show more positive affect and interest when they use computers together. Further, working on computers can promote new instances and forms of collaborative work, such as helping or instructing, and discussing and building upon each other's ideas. With the right software, they play cooperatively at the computer as much as in the block center. Indeed, the computer play can spill over into new, friendly, sustained interaction in other classroom centers, especially between boys and between children

with disabilities and their normally developing peers.

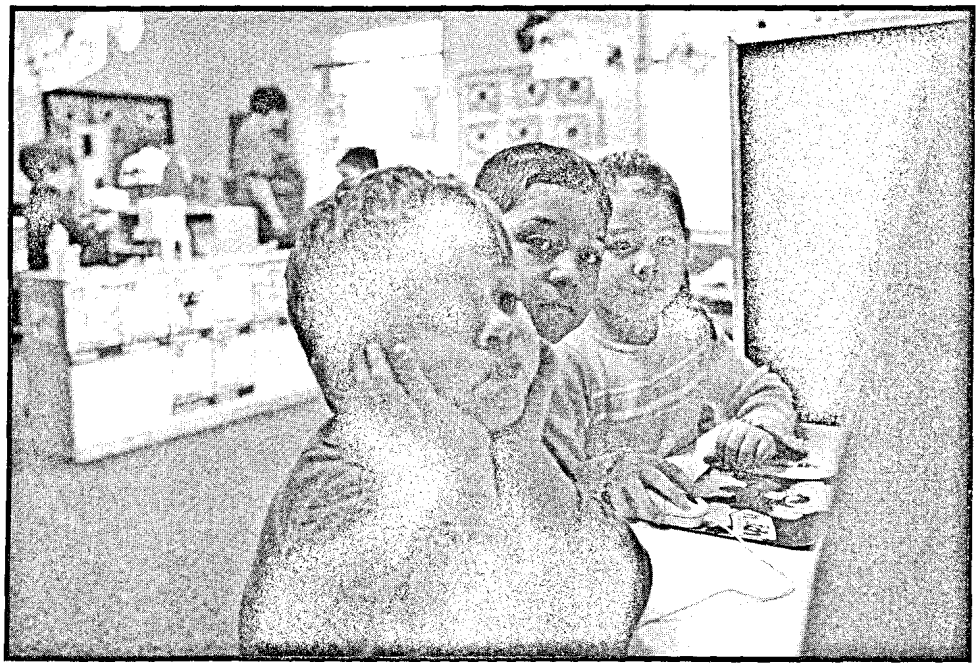
Of course, these benefits depend on high-quality technology environments. For example, open-ended educational programs and those designed for cooperative work or play are particularly useful in supporting collaboration. Unsurprisingly, violent video games can increase aggression and should be avoided.

Computers can also stimulate learning. Computers environments can, more so than other learning centers such as art or block centers, increase cognitive and social interactions, each to the benefit of the other. Using the right technology can increase creativity and learning in several content areas.

Creativity. Perhaps the most surprising positive effect of computers on young children is enhanced creativity. For example, using Logo to draw on the screen has been shown to increase children's creativity. Logo is a simple computer programming language in which children can command a pictured "turtle" to draw lines. In one study, preschoolers used simple key presses (pressing "f'" to make the turtle go "forward" and "r" to make it turn to the right) to make the turtle draw. These children learned to create more-elaborate pictures and later transferred these new ideas to artwork on paper. In a series of studies of our own, primary-grade children show increases on tests of creative thinking after working for a semester with Logo. We wondered, was it just that creating figures by directing the Logo turtle (forward 100, right 90, forward 50 right 90 . . .) enhanced the children's visual vocabulary? Further research of ours and that of others has shown that Logo experiences also *increase* verbal creativity. Originality has been consistently and positively affected in a string of Logo studies. Other studies have shown that using computers to read or write, or to acquire knowledge and insight into science, math, and other areas through design, can support the expression and development of creativity. High-quality computer experience enhances higher-order creative processes.

Language and literacy. Children use more language when social interaction increases due to using computers. Preschoolers' language activity is twice as high at the computer as at any of the other activities, including play dough, blocks, art, or games. Computers also help special populations.

Computer-assisted instruction drills and tutorials are not designed to increase creativity and conversations, but they help students develop prereading and reading skills. The computer's



visual displays, animated graphics, and speech, feedback, record-keeping, and individualization can make a unique contribution, from 4-year-olds through children in the primary grades. Computer-assisted instruction drills and tutorials can help children develop a wide variety of skills, including phonological awareness, letter and word recognition, listening, and abilities to predict, sequence, and make judgments.

Creativity and conversations in print can be facilitated with computers, especially using word processing or other applications to support "authentic" writing. For example, children plan, write, discuss, and revise. Even young children use more-descriptive phrases and create better plots with climaxes and character descriptions.

Math and reasoning. As with literacy skills, computer-assisted instruction drills and tutorials can help children practice math skills and foster deeper conceptual thinking. High-quality software can even promote valuable cognitive play. For example, children can break apart and put together shapes and sets in ways difficult or impossible to do with physical manipulatives. As another example, children doing Logo move their bodies and then command the Logo turtle to move in similar ways to create geometry paths, shapes, and complex, often surprising, designs. In this way, Logo encourages children to play and explore in a mathematical environment. It also develops children's explicit awareness of geometric motions, properties of shapes, and the meaning of measurements.

Conclusions

To the long lists of reported positive effects of computer use with children on literacy and math, one can add:

- Problem-solving skills.
- Decision-making ability.
- Understanding of cause and effect.
- Self-regulation and longer attention spans.
- For children with special needs, gains in the areas of social-emotional development, sharing, taking turns, focusing, and self-help skills; fine-motor and gross-motor abilities; and communication and cognition.

Promising professional practices

Used well, technology can make substantial contributions to early childhood educational settings. Too often, however, technology is not used well. Several recent initiatives help teachers use effective strategies that make all the difference.

Most teachers underuse technology for vague "enrichment" or "rewards." It is often a free-choice learning center without much guidance, which can become dominated by a small number of children, often boys.

In contrast, successful teachers integrate technology in their existing programs. Conceptual learning tools and games, integrated into the curriculum and mediated by teachers aware of their goals, will show the largest performance and achievement results.

Successful teachers also influence families. Parents overestimate the extent to which their children use the Internet for educational purposes and underestimate the extent to which they use it for entertainment. Educators need to find new ways to work with parents to change this pattern.

Successful use takes time. Some researchers estimate that it takes teachers three to six years to fully integrate information technologies into their teaching activities. (Start now: by 2020, you'll be guiding others!)

What professional-development initiatives have been promising? Research indicates that:

- Teachers need regular access to computers and professional development over years to experience significant changes in their instruction. Sometimes they need to confront deeply held beliefs about learning and teaching — for example, finding that children can construct significant

knowledge when guided to working in open-ended computer environments.

- Teachers need ongoing support regarding teaching and technology.
- Student teachers need supervising teachers who use technology well.
- Teachers of young children need concrete suggestions regarding how to put computers to work in classrooms and how to integrate them into other types of classroom activities.
- Professional-development staff should examine successful models for taking professional development and effective use of technology to large-scale use, such as the TICKIT, TRIAD, and ECCTS programs.

The future

Futurist and writer Arthur C. Clarke said, "Any sufficiently advanced technology is indistinguishable from magic."[135] We are certain to see amazing technology tools in the next 10 years. However, the future of high technology defies simple prognostication. These tools may include extensions of present-day software. In math and reading, for example, we will see better tools for understanding children's thinking and learning, and for using formative assessment in our teaching easily and effectively. Technological devices will become ever-more helpful teachers' assistants. Ever-more effective computer manipulatives and activities may invite children to explore these and other subjects, such as the scientific and social worlds. Electronic books will invite new ways of interacting that "grow" with children. The way children and adults interact with technology may be more natural and ubiquitous.

The futures of educational technology and of children can and should be designed and guided by those who care about children. What future might we strive to create?

Equity. The digital divide separating children from high- and lower-resource communities has been called mammoth. We need to work together to build a future that will provide all children fair access to all types of educational resources — especially community-based or school educational resources. Technology is a small but significant component of educational resources.

In another vein, technology offers critical benefits for children with certain disabilities. We expect the future to bring even greater benefits to children with a wider range of physical disabilities. Technology miracles are possible — if we demand them.

The positive path. Limit the total time children spend in front of screens. Commercial TV and inappropriate video games are the largest contributors to such time, with children ages 2 to 7 spending from two to three hours per day in front of a screen. We must work with families to decrease this time. Instead, positive uses such as those discussed and new ones to be created should be promoted. These, too, should be limited to no more than one to two hours a day, so children experience a wide range of learning situations. However, strict time limits in an early childhood classroom (for example, 5 or 10 minutes per child) are not wise. Such strict rules generate hostility and isolation instead of the usual positive effects of computers on social communication. The strict limits keep children from communicating and sharing. Child-centered control was again the more positive path.

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The future will bring technological toys that will interact with children without screens, and these may be useful. But they should not replace play with basic toys, from clay to wood to interactions with the nature world. And technological toys should invite, not suppress, creativity, exploration, and doing the work of good

play. In summary, promising practices include discouraging children's use of mind-numbing technologies, including junk TV, narcissistic ("Look at me") Web sites, technological toys that discourage creativity, and violent or noneducational video games. Also, promising practices encourage children to spend the time saved from not playing those noneducational games in building physical, mental, and social skills with and without electronic technology.

Invest wisely. When high-priority goals can be achieved well with specific computer applications, then detailed planning should precede any purchase. Determination of the type of technology-enhanced educational activity desired should precede any purchase of hardware. Further, extensive, high-quality professional development should be considered a necessary expense. Policymakers should realize that market forces alone will not provide high-quality content; funding for research and development is needed to fill noncommercial content and the needs of all members of our society.

Collaborate in conducting studies in teams of university-based researchers and teachers. We end with a prediction born in optimism: renewed emphasis on truly research-based education will help and encourage teachers to reject inappropriate and ineffective applications of technology and adopt, adapt, and help create those that benefit children. Some of these uses will support existing practices, but a small number for most teachers, and a large number for some teachers, will lead to innovative approaches not possible without the new technology. Children, teachers, and researchers all learn by designing educational strategies, computers programs, and other curricular tools. We need linked development and research to enable the vision, invention, and implementation of effective and appropriate educational technology.

To maximize the potential, and minimize misapplications, educators from the federal and state levels to the classroom level need to collaborate to use (and help produce) research guidelines as they design, test, and incorporate technology-enriched environments.

An observation attributed to many futurists is that people tend to overestimate the short-term effects of a new technology and underestimate its longer-term effects. Let's work together to create the best educational environments we can for young children, considering the profound transformations in technologies we shall see. ▶

Hope for the children of 2020

That the children of 2020 are provided the opportunities to engage with the natural world, as well as a range of technologies, to learn about their world, and to create new worlds for the future.

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Professional focus

Sarama and Clements conduct research in computer applications, the early development of mathematical ideas, and the effects of social interactions.