The Role of Technology in Early Childhood Learning

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If you ask, teachers will tell you about the advantages that they find in using computers. For example, writers have reported that four- and five-year-olds from an urban, economically disadvantaged population began making new friends as they asked others to join them in working at the computer. For the first time, they sought help from one another (Bowman 1985). An egocentric child learned cooperation and problem solving. Children's cooperative play paralleled the proportion of cooperative play in the block center and provided a context for initiating and sustaining interaction that could be transferred to play in other areas as well, especially for boys (Anderson 2000). Are these examples unique, or are such advantages widespread?

We know that computers are increasingly a part of preschoolers' lives. From 80 percent to 90 percent of early childhood educators attending the annual conference of the National Association for the Education of Young Children report using computers (Haugland 1997). Such use is no surprise—research on young children and technology indicates that we no longer need to ask whether the use of technology is "developmentally appropriate" (Clements and Nastasi 1993).

Unfortunately, not everyone reads the research! We were surprised and disappointed to find that some authors still disagree with current research about computer use by young children (Cordes and Miller 2000). This article presents a quick tour of research on the appropriateness of computer use with young children. What do we know about children's use of computers? How old should children be before computers can have a positive influence in their lives? How do children interact with computers? What is the empirical evidence about possible negative influences of such interaction? How do computers influence children's social and emotional development? How might computers affect their learning and thinking in mathematics? What are the implications for teachers?

Edited by **Julie Sarama,** *jsarama@buffalo.edu, and* **Douglas Clements,** *clements@buffalo.edu, State University of New York at Buffalo, Buffalo, NY 14260.* *This department addresses the early childhood teacher's need to support young children's emerging mathematics understandings and skills in a context that conforms with current knowledge about the way that children in prekindergarten and kindergarten learn mathematics. Readers are encouraged to send manuscripts for this section to "Early Childhood Corner," NCTM, 1906 Association Drive, Reston, VA 20191-9988.*

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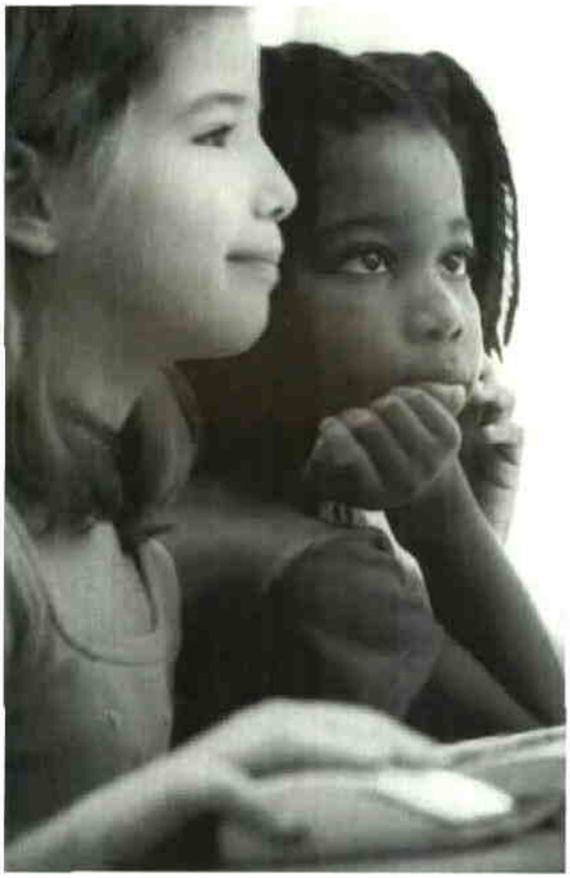
Developmental Appropriateness

Very young children have shown comfort and confidence in using software. They can follow pictorial directions and use situational and visual cues to understand and think about their activities (Clements and Nastasi 1993). Typing on the keyboard does not seem to cause them any trouble; if anything, the ability to type is a source of pride!

With the increasing availability of hardware and software adaptations, children with physical and emotional disabilities also can use computers with ease. In addition to enhancing their mobility and sense of control, computer use can also help



improve the self-esteem of disabled children. A four-year-old who was diagnosed with mental retardation and autism and who did not speak began to echo words for the first time while working at a computer (Schery and O'Connor 1992). Preschoolers' participation in computer activities facilitated social interaction among children who had disabilities and their peers who did not (Spiegel-McGill et al. 1989). A large-scale, multiyear study showed that every one of the study's 44 three- to five-year-olds who had special needs gained substantially and significantly in social-emotional development from their work with computers. On joining the program, children were making an average gain in social-emotional development of less than half a month per month. While participating in the program, children achieved an average rate of progress of 1.93 months per month (Hutinger and Johanson 2000).

Research has also moved beyond the simple question of whether computers can help young children learn—we know that they can. We now need to understand how best to use computers to aid learning and what types of learning we should facilitate with computers. Obviously, we do not believe that every use of technology is appropriate or beneficial. The design of the curriculum and that of the social setting are two of many important components in learning. The following paragraphs examine the social and classroom context.

Social Interaction

Research dismissed a serious and early concern that computers would isolate children. Computers serve as *catalysts* of social interaction. For example, children spent nine times as much time talking to peers while on the computer than while doing puzzles. Children prefer to work with friends rather than alone, and they display more positive emotion and interest when working together. They build new friendships in the computer's presence. They show increased collaborative work, including spontaneous helping and teaching, and they discuss and build on one another's ideas (Clements 1994). Even in the preschool classroom, a computer center fosters a positive climate characterized by praise and encouragement of peers (Klinzing and Hall 1985). Computer activity was more effective than toys in stimulating vocalization in a regular preschool environment and evoked higher levels of social play (McCormick 1987).

Children interact differently using different types of software. For example, open-ended programs, such as those that allow children to make shapes, foster collaboration. Drill-and-practice software, however, can encourage turn taking and competition.

The physical environment also affects children's interactions. Placing two seats in front of the computer and one at the side for the teacher can encourage positive social interaction. Placing computers close to one another can facilitate the sharing of ideas among children. Centrally located computers invite other children to pause and participate in the computer activity. Such an arrangement also helps keep teacher participation at an optimum level. Teachers remain nearby to provide supervision and assistance as needed but do not constantly stay so close that they inhibit the children.

Teaching and Learning Mathematics

The computer offers unique opportunities for learning through exploration, creative problem solving, and self-guided instruction. Again, children learn different things from different types of software. Drill-and-practice software leads to gains in certain rote skills but has not been as effective in improving children's development of mathematical ideas (Clements and Nastasi 1993). More valuable is software that asks children to solve problems. Discovery-based software that encourages and allows ample room for free exploration is also valuable. Research suggests, however, that the curriculum designed around such software should have children do more than merely engage in free exploration, which can lead to boredom (Lemerise 1993).

Children who are encouraged to do open-ended projects work longer and actively search for diverse ways to solve tasks.

Another initial fear was that computers would replace other early childhood activities. Research shows that computer activities yield the best results when coupled with suitable off-computer activities. For example, children who were exposed to developmental software alone showed gains in intelligence, nonverbal skills, long-term memory, and manual dexterity. Those who also worked with off-computer activities gained in all these areas and improved their scores in verbal, problem-solving, and conceptual skills (Haugland 1992). A control group used the computer to work with drill-and-practice software three times as often as the other groups but showed less than half the gains that the on- and off-computer groups did.

Such results do not mean that some practice software is not helpful. It can help children as young as three to five years old develop competence in counting and sorting. Most of children's time, however, should be spent developing ideas and solving problems. For example, using programs that allow pictures to be created with geometric shapes, children have demonstrated growing knowledge and competence in working with such concepts as symmetry, patterns, and spatial order. One child, Tammy, overlaid two overlapping triangles on one square and colored selected parts of this figure to create a third triangle that did not exist in the program! This preschooler not only exhibited an awareness of how she had made this shape but also realized that recreating the shape would be a challenge to others (Wright 1994).

Computer manipulatives can provide other unique advantages (Clements and Sarama 1998; Sarama, Clements, and Vukelic 1996). They allow children to save and retrieve work and, thus, work on projects over long periods. Computers offer flexible and manageable manipulatives that might "snap" into position. Computer manipulatives can also be resized or cut. Finally, computers can help bring mathematics to explicit awareness, for example, by asking children to choose what mathematical operations (turn, flip, or slide) to apply to manipulatives.

As an example, some kindergartners were working on a pattern with physical manipulatives and wanted to move the configuration slightly on the rug. Two girls tried to keep the design together but were unsuccessful. Marissa told Leah to fix the design. Leah tried, but in re-creating the design, she inserted two extra shapes and the pattern was not the same. The girls experienced considerable frustration at their inability to re-create their "old" design. Had the children been able to save their design or move it and keep the pieces together, their group project would have continued. Indeed, moving a design to another area of the screen was the most common reason for using the "glue" tool on the computer with these kindergartners (Sarama, Clements, and Vukelic 1996).

Final Words

We can use technology to teach the same old stuff in the same way, or we can capitalize on the benefits of technology by using integrated computer activities to increase achievement. Children who use practice software about ten minutes a day increase their scores on achievement tests. However,

> If the gadgets are computers, the same old teaching becomes incredibly more expensive and biased towards its dullest parts, namely the kind of rote learning in which measurable results can be obtained by treating the children like pigeons in a Skinner box. . . . I believe with Dewey, Montessori, and Piaget that children learn by doing and by thinking about what they do. And so the fundamental ingredients of educational innovation must be better things to do and better ways to think about oneself doing these things. (Papert 1980)

We believe, with Papert, that computers can be a rich source of these innovative ingredients. We believe that having children use computers in new ways, including to solve problems and manipulate mathematical objects, can be a catalyst for reform in early childhood mathematics classrooms.

As a final example, consider kindergartner Mitchell. He loved making hexagons. When he worked off the computer, he quickly manipulated the pattern-block pieces, making hexagons by trial and error but not responding to questions about his intent or strategies. When working on the computer, he seemed to be more aware of his actions; when asked how many times he turned a particular piece, he said, "Three," without hesitation. When building a hexagon out of triangles, he placed two, counted while pointing, and said, "I need four more."

He placed another triangle, turned it, and said, "Whoa! Now three more!"

He got three more triangles and finished his hexagon, proudly stating, "I did it!" The computer helped Mitchell be more deliberative and reflective.

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