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Mathematics, Young Students, and Computers: Software, Teaching Strategies and Professional Development[1]

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Abstract: Technology can make substantial contributions to early childhood mathematics education, if used well (Sarama & Clements, 2002; Seng, 1999). Unfortunately, in the United States, reality often falls short of realizing this promise (Cuban, 2001; Healy, 1998). To be effective, teachers need to select appropriate software and practice successful teaching strategies. To learn to do this, they need to participate in high-quality professional development. Fortunately, research provides guidelines for each of these three areas. In this article, we draw implications from what we have learned from research regarding selecting software, using effective teaching strategies, and providing professional development. We also share concrete examples from two related projects, a software development project and a large-scale research project.

Selecting Software for Young Students

Young students can use computers and simple software for learning from at least the age of four years on (Clements & Nastasi, 1992; Sarama & Clements, 2002). The nature and extent of technology's contribution depends largely on what type of technology we use.

Computer Assisted Instruction (CAI)

Students can use CAI, in which the computer presents information or tasks and gives feedback, to develop skills and concepts. For example, drill-and-practice software can help young students develop competence in such skills as counting and sorting (Clements & Nastasi, 1993). Indeed, some reviewers claim that the largest gains in the use of CAI have been in mathematics for preschool (Fletcher-Flinn & Gravatt, 1995) or primary-grade students, especially in compensatory education programs (Lavin & Sanders, 1983; Niemiec & Walberg, 1984; Ragosta, Holland, & Jamison, 1981). About ten minutes a day proved sufficient time for significant

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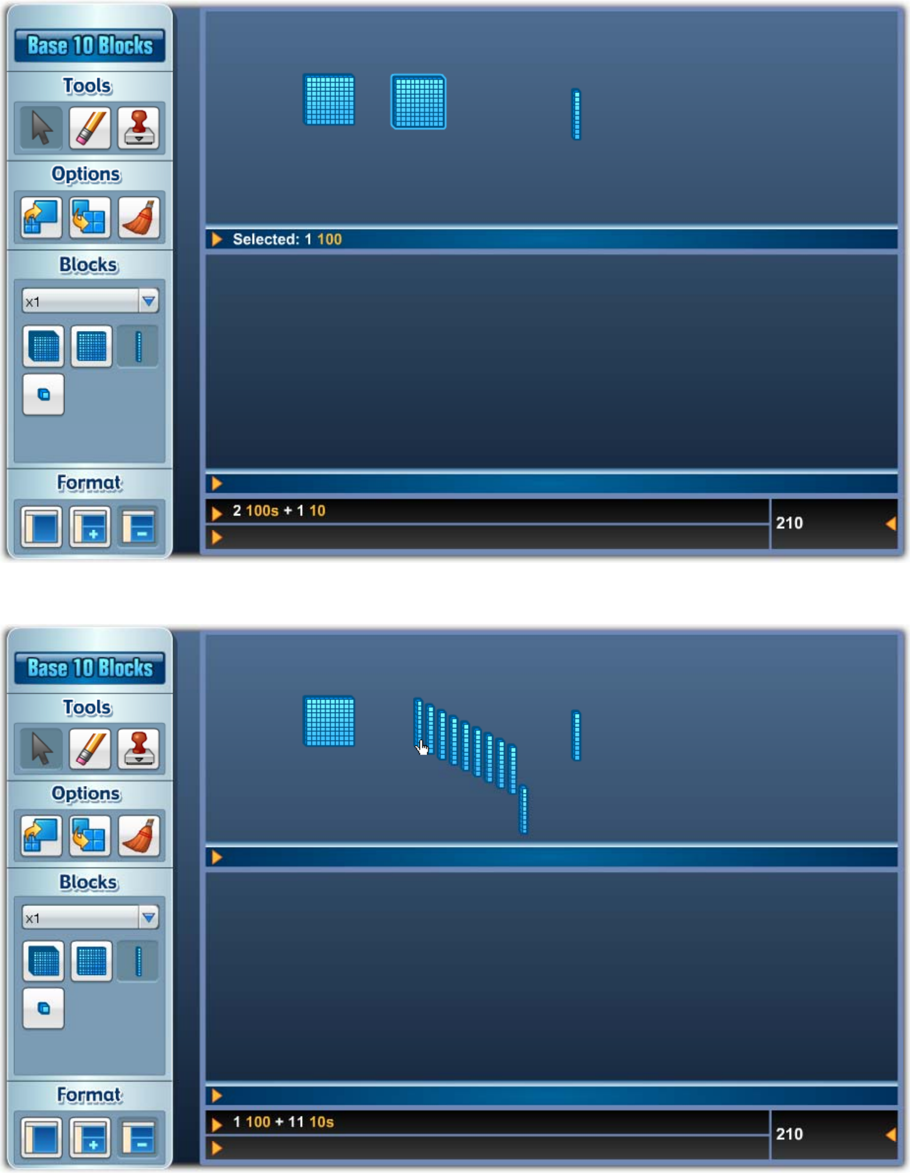
gains; twenty minutes was even better. This CAI approach may be as or more cost effective than traditional instruction (Fletcher, Hawley, & Piele, 1990) and other instructional interventions, such as peer tutoring and reducing class size (Niemiec & Walberg, 1987). However successful exclusively drill-oriented CAI work is, it should be used in moderation. Some students may be less motivated to perform academic work or less creative following a steady diet of only drill (Clements & Nastasi, 1985; Haugland, 1992). There are several complements to the CAI approach; one is the computer manipulative.

Computer Manipulatives

Most of us think of "manipulatives" as physical objects. Surprisingly, manipulating shapes and other mathematical objects on the computer can be just as or more effective in supporting learning (Clements & McMillen, 1996). For example, in one study, the first time students reflected on, and planned, putting together shapes to make new shapes, they were working on a computer, not with physical blocks (Sarama, Clements, & Vukelic, 1996). In a similar vein, students who explore shapes on the computer learn to understand and apply concepts such as symmetry, patterns, and spatial order (Wright, 1994). In a study comparing the use of physical bean sticks and on-screen bean sticks, students found the computer manipulative easier to use for learning (Char, 1989).

One of the reasons for this finding is that computer manipulatives allow students to perform specific mathematical transformations on objects on the screen. For example, whereas physical base-ten blocks must be "traded" (when subtracting, students may need to trade 1 ten for 10 ones), students can break a computer base-ten hundreds block directly into 10 tens (see Figures 1a and 1b). Such actions are more in line with the *mental actions* that we want students to carry out. The computer also *connects* the blocks to the symbols. For example, the number represented by the base-ten blocks is dynamically connected to the students' actions on the blocks, so that when the student changes the blocks, the number displayed is automatically changed as well. In Figure 1b, as the student breaks the hundreds block, the total amount 210 is, of course, the same. However, the display also shows the new number of blocks: 1 hundred block and 11 tens. Similarly, if the student removes 3 tens, the display automatically adjusts. Such features can help students make sense of their activity, the numbers, and the arithmetic.

Thus, computer manipulatives can offer unique advantages (Clements & Sarama, 1998; Sarama et al., 1996). They can allow students to save and retrieve work (and that work doesn't get "bumped" and "ruined" or "put away") and thus work on projects over a long period (Ishigaki, Chiba, & Matsuda, 1996). Computers can offer a flexible and manageable manipulative, one that, for example,



Figures 1a and 1b

might “snap” into position. They can provide extensible manipulatives that, for example, allow students to resize shapes. Computer manipulatives can also help connect concrete and symbolic representations by means of multiple, linked representations with feedback. In a similar vein, computers can help bring mathematics to explicit awareness, by asking students consciously to choose what mathematical operations (turn, flip, slide, scale) to apply (Sarama et al., 1996).

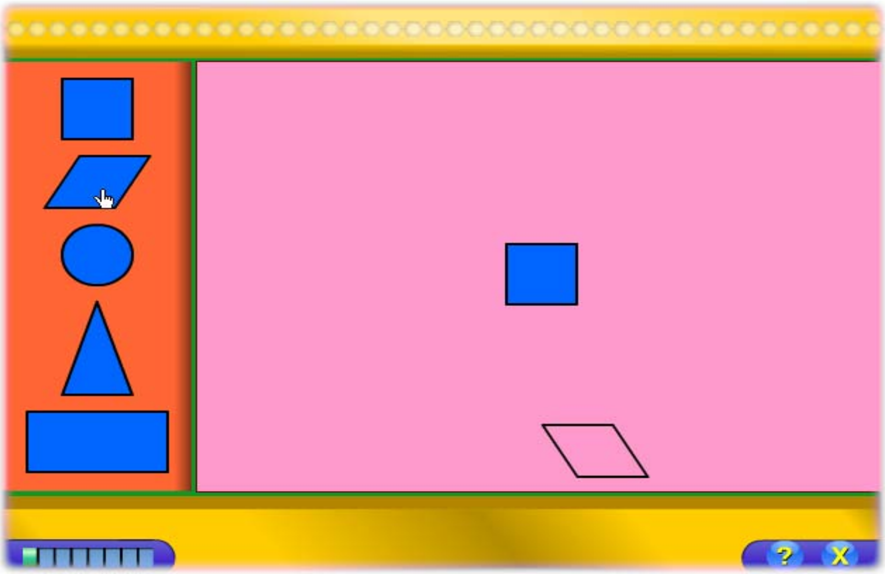
Finally, technology may also foster deeper conceptual thinking, including a valuable type of “cognitive play” (Steffe & Wiegel, 1994). For example, to develop length concepts, students were engaged in drawing on-screen sticks, marking a stick, breaking it along the marks, joining the parts back together, and cutting off pieces from a stick to establish equal lengths and pose and solve other problems. Students adopted a playful attitude as they repeatedly engaged in these activities, and they learned considerable mathematics.

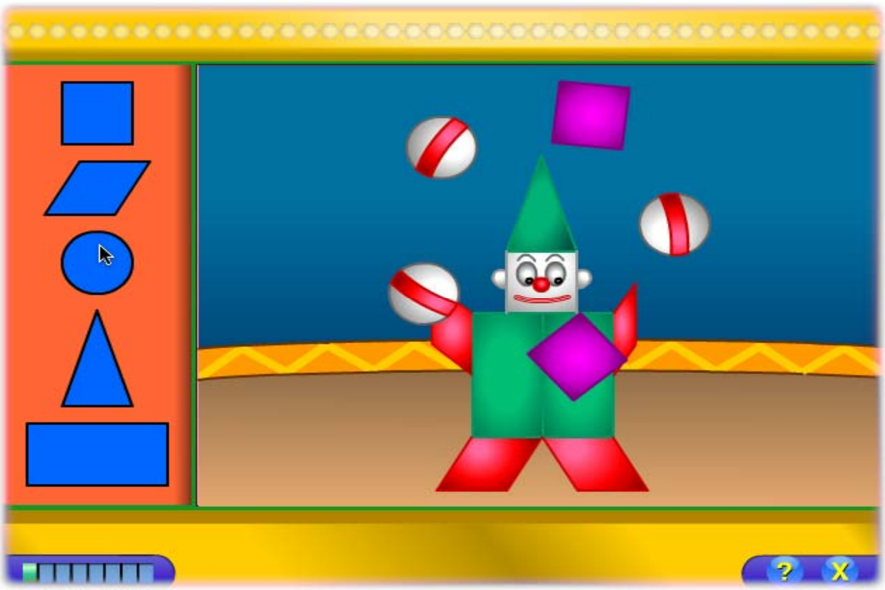
Combining CAI and Computer Manipulatives

The advantages of each of these two types of software can be combined. This is especially important because without computer manipulatives, learning from CAI can be limited. Students do not always learn to manipulate mathematical objects to solve problems independently. Without CAI, students often do not learn to use the features of computer manipulatives, or they explore their surface characteristics only in a trivial manner.

The *Building Blocks* project was designed to combine CAI and manipulative software. For example, one goal was to help children develop the ability to identify and apply various transformations to two-dimensional shapes. The *Building Blocks* activities follow a research-based learning trajectory for shape composition (Clements, Wilson, & Sarama, 2004). Students move through levels of thinking in developing the ability to compose two-dimensional figures. From lack of competence in composing geometric shapes, they gain abilities to combine shapes—initially through trial and error and gradually by attributes—into pictures, and finally synthesize combinations of shapes into new shapes (composite shapes).

In the first suite of activities, “Mystery Pictures,” students learn about shapes and see examples of how they can be combined to make pictures. The specific task for children is matching shapes to congruent outlines and hearing their names as they guess what the eventual picture will be (Figures 2a and 2b). The next level is similar, but students have to identify the shapes given their names, instead of a matching outline. Later, children have to solve actual composition problems. In a series of “Piece Puzzler” activities, students manipulate shapes to fill puzzles,





Figures 2a and 2b

learning to compose shapes themselves, first without, then with, the rigid motions of slide, flip, and turn. The puzzles follow the learning trajectory from simple, highly guided puzzles (Figure 3a) to those demanding significant composition competencies (Figure 3b). Then, students have to solve similar puzzles, but they only get one shape to use; thus, they must decompose that shape with transformations. One transformation, performed with the “axe tool,” decomposes shapes into their canonical components (e.g., symmetrical halves). In later problems in the in “Super Shape” suite, students use the scissors tool, which requires them to cut the shape from one vertex or midpoint to another. Thus, they have to create shapes they have not seen before.

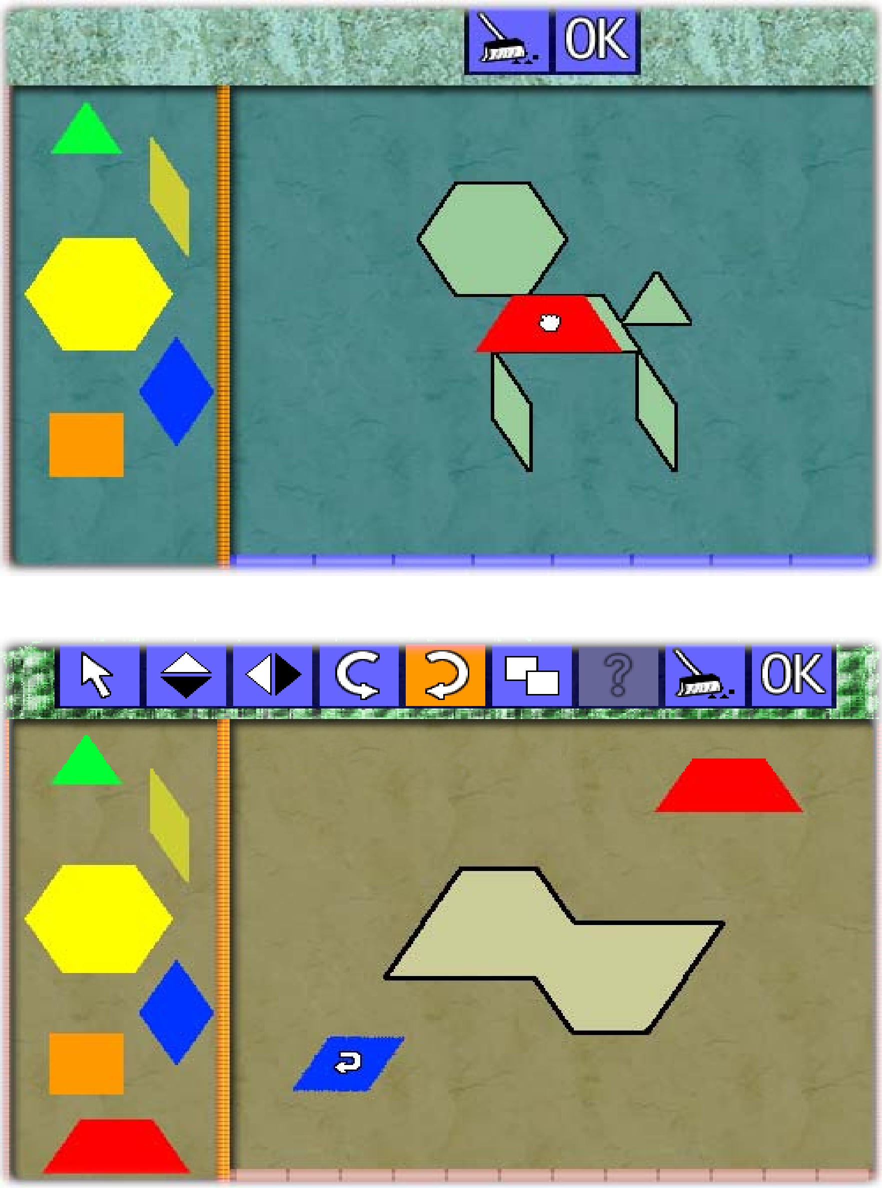
Finally, students use the “Create a Scene,” program, in which students create their own pictures *using* the mathematical ideas and skills they have developed. That is, they turn, flip, resize, glue, and even cut shapes to create objects for their pictures (see Fig. 4). Thus, these are examples of *extensible* manipulatives, embedded in a progression of CAI activities based on learning trajectories.

These *Building Blocks* activities illustrate effective software (empirical support can be found in Clements & Sarama, 2004, in press; Sarama, 2004, and at UBBuildingBlocks.org). To evaluate software, teachers should request empirical evidence, as well as applying general criteria for effective software (Grover, 1986; Haugland & Shade, 1990; Haugland & Wright, 1997), such as providing meaningful contexts, appropriate interface (including reading level), and high-quality feedback.

Strategies for Effective Teaching with Technology

The most critical feature of any high-quality educational environment is a knowledgeable and responsive adult (Bowman, Donovan, & Burns, 2001; Darling-Hammond, 1997; Ferguson, 1991). Technologically-enhanced environments are no exception (Watson, Cox, & Johnson, 1993). Technology is used well in classrooms where teachers use both high-quality software and effective pedagogical strategies.

Initial adult support helps young students use computers to learn (Rosengren, Gross, Abrams, & Perlmutter, 1985; Shade, Nida, Lipinski, & Watson, 1986). With such help, they can learn to use computers independently much of the time. Still, students are more attentive, more engaged, and less frustrated when an adult is available (Binder & Ledger, 1985). So, teachers might place computers where they or other adults can supervise and assist students (Sarama & Clements, 2002). In this section, we provide more details on research regarding arranging and managing the classroom, strategies for interacting with students in computer environments, and supporting students with special needs.



Figures 3a and 3b

Figure 4.

Arranging the Classroom

The physical arrangement of the computers can enhance students' social interaction (Davidson & Wright, 1994; Shade, 1994). The parts of the computer with which the students interact should be at the students' eye level, on a low table. The other parts should be out of students' reach. All parts should be stabilized and locked down as necessary.

Placing two seats in front of the computer and one at the side for the teacher encourages positive social interaction. If more than two students work with a computer, they assert the right to control the keyboard frequently (Shrock, Matthias, Anastasoff, Vensel, & Shaw, 1985). Placing computers close to each other can facilitate the sharing of ideas among students. Computers that are centrally located in the classroom invite other students to pause and participate in the computer activity. Such arrangements also help keep teacher participation at an optimum level. They are nearby to provide supervision and assistance as needed, but not intervening too much (Clements, 1991). Other factors, such as the ratio of computers to students, may also influence social behaviors. Less than a 10:1 ratio of students to computers might ideally encourage computer use, cooperation, and equal access to girls and boys (Lipinski, Nida, Shade, & Watson, 1986; Yost, 1998). Cooperative use of computers raises achievement (Xin, 1999). A mixture of use in pairs and individual work may be ideal (Shade, 1994). To encourage students to connect off- and on-computer experiences, teachers might place print materials, manipulatives, and real objects next to the computer (Hutinger & Johanson, 2000).

Managing the Computer Environment

Students should learn proper computer use and care, possibly through initial discussions and signs posted as reminders of the rules (e.g., no liquids, sand, food, or magnets near computers). It is often helpful to use a student-oriented utility that helps students find and use the programs they want and prevents them from inadvertently harming other programs or files.

Monitoring the time students spend on computers and giving everyone fair access are important considerations. However, at least one study found that rigid time limits generate social hostility and isolation instead of social communication (Hutinger & Johanson, 2000). Flexible time periods with sign-up lists encourage students to manage themselves (Hutinger & Johanson, 2000).

Prepare students for independence. Have individual or small groups of students work closely with an adult at first, and slowly increase the degree of such work. Provide substantial support and guidance initially; perhaps by sitting with students at the computer to build competencies with the software encourages positive social interactions such as turn taking. Then gradually foster self-directed and cooperative learning.

Once students are working independently, provide enough guidance, but not too much. Intervening too much or at the wrong times can decrease peer tutoring and collaboration (Bergin, Ford, & Mayer-Gaub, 1986; Emihovich & Miller, 1988; Riel, 1985). On the other hand, without any teacher guidance, students tend to "jockey" for position at the computer and use the computer in the turn-taking, competitive, manner of video games (Lipinski et al., 1986; Silvern, Countermine, & Williamson, 1988).

Research shows that the introduction of a computer often places many additional demands on the teacher (Shrock et al., 1985). Plan carefully the use only of computer programs that will substantially benefit your students.

Effective Strategies for Teaching with Computers

Critical to effective use of computers is teacher planning, participation, and support. Optimally, the teacher's role should be that of a facilitator of students' learning, such as establishing standards for and supporting specific types of learning environments. When using open-ended programs such as computer manipulatives, for example, considerable support may need to precede independent use. Other important aspects of support include structuring and discussing computer work to help students form viable concepts and strategies, posing questions to help students reflect on these concepts and strategies, and "building bridges" to help students connect their computer and non-computer experiences.

Teachers whose students benefit significantly from using computers are active. They guide students' learning of basic tasks, and encourage experimentation with open-ended problems. They are frequently encouraging, questioning, prompting, and demonstrating, *without* offering unnecessary help or limiting students' opportunity to explore (Hutinger & Johanson, 2000). They redirect inappropriate behaviors, model strategies, and give students choices (Hutinger et al., 1998). Such scaffolding leads students to reflect on their own thinking behaviors and brings higher-order thinking processes to the fore. Such metacognitively-oriented instruction includes strategies of identifying goals, active monitoring, modeling, questioning, reflecting, peer tutoring, discussion, and reasoning (Elliott & Hall, 1997).

Effective teachers make the mathematics to be learned clear and extend the ideas students encounter. They focus attention on critical aspects and ideas of the activities. When appropriate, they facilitate disequilibrium by using the computer feedback to help students reflect on and question their ideas and eventually strengthen their concepts. They also help students build links between computer and non-computer work.

Whole group discussions that help students communicate about their solution strategies and reflect on what they have learned are also essential components of good teaching with computers (Galen & Buter, 1997). Effective teachers avoid overusing directive teaching behaviors (except as necessary for some populations and on topics such as using the computer equipment) (Hutinger et al., 1998). Instead, they prompt students to teach each other by physically placing one student in a teaching role or verbally reminding a student to explain his or her actions and respond to specific requests for help (Paris & Morris, 1985).

Students work best with open-ended software when projects are suggested and guided rather than when children are told merely to "free explore" (Lemerise, 1993). They spend longer time and actively search for diverse ways to solve the task. Children told only to free explore quickly grow disinterested. Providing models and sharing students' projects may also help guide and maintain focus on learning mathematics (Hall & Hooper, 1993).

The *Building Blocks* curriculum follows these guidelines. The curriculum suggests ways to arrange the classroom. The software introduces both mathematical content and interface skills developmentally. The curriculum closely integrates on- and off-computer activities, introducing the activities, providing scaffolding as needed as students cycle through the computer activities, and including whole group discussion sessions following computer work.

Teachers, Technology, and Professional Development

Moreover, there is evidence that the more teachers receive support using computers, the more their students learn, especially if the support is targeted at effective use of computers with students (Fuller, 2000). Research has described features of effective professional development. Here we summarize this research in three categories: professional development, research-based programs for professional development, and using technology for professional development.

Professional Development in Early Childhood Educational Technology

Many agree on the general characteristics of effective professional development. For example, professional development should be multifaceted, extensive, ongoing, reflective, focused on common actions and problems of practice and especially students' thinking, grounded in particular curriculum materials, and, as much as possible, situated in the classroom (Cohen, 1996; Darling-Hammond & McLaughlin, 1995; Fullan, 1992; Garet, Porter, Desimone, Birman, & Yoon, 2001; Kaser, Bourexis, Loucks-Horsley, & Raizen, 1999; Rényi, 1998; Richardson & Placier, 2001; Sarama & DiBiase, 2004). With regard to technology, professional development must be "characterized by access to high-quality software, ongoingness, curriculum and instruction embeddedness, a variety of learning partners (e.g., coordinators, other teachers), a variety of learning formats (e.g., visits, workshops, meetings, group, one-to-one), opportunities for practice-practice-practice and feedback, and data on the impact" (Fullan, 1992, p. 46). It should also involve participants in teams from the same school, model constructivist approaches to learning, and promote ongoing conversations and reflections about practice, theories of learning, and how classroom practice might change in the context of technology (Dwyer, Ringstaff, & Sandholtz, 1991). Technology is a particularly challenging field because the learning task is daunting, the vision of high-quality use is not clear, and well-designed, intense, relevant, sustained assistance is critical (Fullan, 1992).

Research has established that less than ten hours of training in technology can have a negative impact (Ryan, 1993). It is thus unfortunate that only 15% of teachers in the U.S. report receiving up to 9 hours of training (Coley, Cradler, & Engel, 1997). This may not easily change, because, although college faculty in the U.S. reported being comfortable with computers, they were not satisfied with their ability to integrate this technology into their courses (Sexton, King, Aldridge, & Goodstat-Killoran, 1999). They were also unsatisfied with the extent to which computer technology is integrated into their education classes. Both need to be changed. Finally, teachers say that computer courses can be effective, but a third of these teachers had never taken such a course. U.S. teachers' most preferred method of learning about software is from a tutor; their least preferred is to learn from a manual (Mowrer-Popiel, Pollard, & Pollard, 1993).

What motivates teachers to learn about and use technology? In one study, the primary reasons Head Start teachers learned about computers were to improve their skills, teach students how to use computers and make teaching easier. The least motivating reason was "others said I should" (Bewick, 2000). Also revealing is that most of these teachers learned about technology by "messing about." In the following section, we examine some models of professional development stemming from large projects that address both motivation and learning systematically and successfully.

Research-based Programs for Professional Development

We begin with a brief overview of programs not specialized in early childhood. In general, these programs indicate that successful programs (a) should emphasize comfort and familiarity with computers and emphasize integration into subject-matter curricula; (b) benefit from support from administrative personnel and outside experts; (c) should provide ongoing, on site technical support, and educate parents and school boards, so they understand the demands technology makes on teachers (Ferris & Roberts, 1994). As an example, Gilmore (1995) evaluated a teacher development program that involved teachers in school-based, action-research projects supported by visits from resource personnel, who provided one-on-one attention. Clusters of teachers attended meetings to evaluate their experiences, share ideas, and discuss relevant issues. This program led to dramatic increases in teacher confidence in and commitment to using technology and, to a somewhat smaller extent, competence in using computers. Finally, they reported noticeable cognitive and social benefits for their students.

The TICKIT (Teacher Institute for Curriculum Knowledge about Integration of Technology) program (Ehman & Bonk, 2002) has documented its success in providing high-level professional development within teachers' schools. The researchers credit TICKIT's effectiveness to its duration (1-2 years), collaborative approach (participants help determine their program), and embeddedness (teachers work in their own classrooms to invent, teach, and reflect upon their technology integration and daily teaching practices). The researchers offered several recommendations in the form of lessons: avoid including teachers who are not volunteers; ensure teachers have a reasonable technology environment in which to work; teach technology use in the teacher's computing environment; ensure a local leader for a cohort of teachers in a school; provide challenge and high expectations; and require projects in a graduate course framework.

A similar comprehensive program, but in the early childhood realm, is the Early Childhood Comprehensive Technology System (ECCTS, Hutinger et al., 1998; Hutinger & Johanson, 2000). The ECCTS was a 3-year collaborative project designed to implement and maintain a comprehensive technology system based on combining four components of nationally recognized demonstration models and peer-reviewed outreach models funded by the Early Education Program for Students with Disabilities in the U.S. Department of Education. The models incorporated (a) on-going training, follow-up, and technical support for teachers and an on-site technology support team (Tech Team), with an emphasis on hands-on work with computers, software, and adaptive devices; (b) team-based technology assessments for students with moderate to severe disabilities; (c) technology integration into the classroom curriculum; and (d) transition into public school kindergartens and other programs. ECCTS components were effective in establishing, maintaining, and institutionalizing computer technology in a large preschool program.

The ECCTS curriculum experiences, based on ideas and themes found in classroom and community experiences, daily living, and interactive software designed to foster expectations of control over environments, provide students with opportunities to participate in equalized play activities, communication potential, and experiences involving most areas of the general curriculum, enhancing problem solving and higher-order thinking. Results pointed to positive outcomes for families and students, to increased technology skills among teachers, to the efficacy of an on-site Tech Team, and to conditions that promoted maintenance of the system. When technology was used to support learning, students achieved success; they could accomplish an activity. Further, students made substantial progress in all developmental areas, including social-emotional, fine motor, gross motor, communication, cognition, and self-help. The evaluation demonstrated that computers, when employed according to the ECCTS model, were efficient, compared to other classroom activities, in promoting attending behaviors, cause and effect reasoning, emergent literacy, and engagement. As a result of computer use, students' social skills increased, including sharing, turn taking, and communicating.

Students also increased in self-confidence, attention span, fine motor skills, and visual-motor skills (e.g., tracking). Results on adults showed that teachers, parents, and administrators were more likely to use computers when they learned to use adult productivity software such as word processing, databases, and spreadsheets, in addition to the software applications for students.

What helped the program achieve these results for students and adults? Effective technology use depended on establishing a functional, well-trained, on-site Tech Team at the school, which provided leadership and support that held the system together. This led to an institutionalization of the program after external funding ended. ECCTS findings indicated the teachers were more likely to adopt changes when they observed positive student outcomes and when they had opportunities to see others using the innovation. The program also "started small and grew."

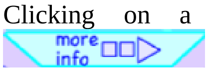
Other early childhood projects produce consistent findings. For example, one project trained teacher facilitators to introduce technology to young students, instruct their peers in the use of early childhood computer programs, and improve family literacy and computer literacy through parent education (Ainsa, 1992). These efforts, which emphasized language arts skills, holistic approaches to computing, "hands-on" activities, and software for young students, led to significant improvements in the use of technology.

Using Technology *for* Professional Development

Sarama (2002) conducted a survey of hundreds of early childhood professionals and found that 71% of the respondents had access to the Internet and 80% would be interested in some sort of distance learning. Thus, professional development may be able to reach many individuals through non-traditional means. There are several projects that have used technology to extend professional development experiences of teachers; however, some of them did not focus on early childhood. For example, one study reported that collaboratively produced network-based communication was significantly more reflective than face-to-face discourse between teachers (Hawkes, 2001).

Our TRIAD (Technology-enhanced, Research-based Instruction, Assessment, and professional Development) project enhances professional development with a variety of technologies, including discussion boards, e-mail, distance-learning centers, and Web sites and applications, enhancing the scalability of the professional development. The most important of these is the *Building Blocks Learning Trajectories* web application.

Building Blocks Learning Trajectories provides scalable access to the learning trajectories via descriptions, videos, and commentaries. Each aspect of the learning trajectories—*developmental progressions* of students' thinking and connected *instruction*—are linked to the other. For example, teachers might choose the 

(curriculum) view and see the screen on the left of Figure 5. Clicking on a specific activity provides a description. Clicking on 

slides the screen over to reveal descriptions, several videos of the activity "in action," notes on the video, and the level of thinking in the learning trajectory that activity is designed to develop, as shown below on the right.

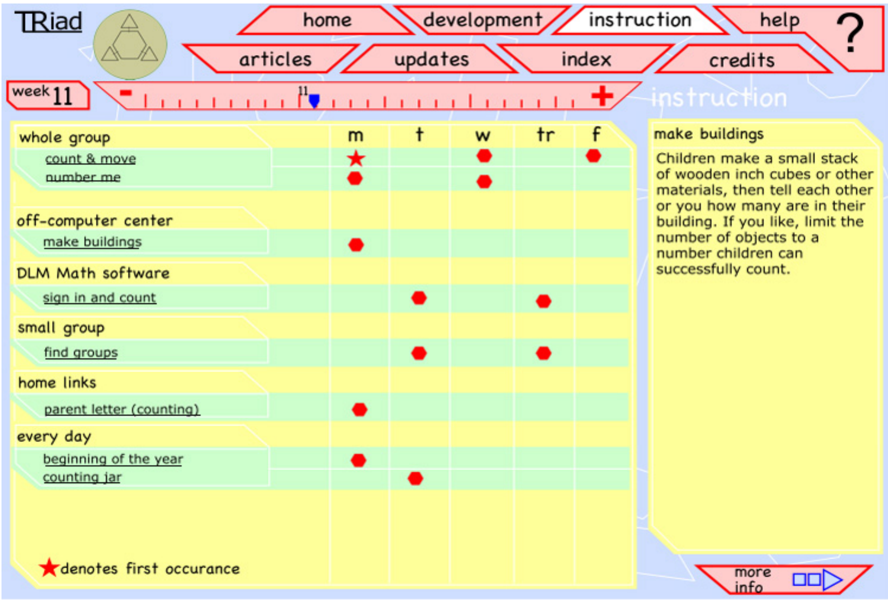
Alternatively, the user may have been studying developmental sequences. After choosing 

, teachers see a list of the mathematical topics and the developmental sequences. If they had chosen "Counting," then the "Counter (Small Numbers)" level, and then "More Info," they would see the same screen as above. The video commentary shown is just one of three commentaries. Commentaries are by researchers, assessors, and teachers. Further, the level of thinking is illustrated by both video of clinical interview assessments *and* video of classroom activities in which students show that level thinking (the icons above the video allow the selection of alternative video), an approach that has received empirical support (Klingner, Ahwee, Pilonieta, & Menendez, 2003).

Of course, the *Building Blocks Learning Trajectories* application is only a tool. All TRIAD teachers are provided a full range of professional development opportunities, based on the research previously described. They participate in a credit-bearing course with several components, including a 2-day institute in the summer and 1-day follow up each month, electronic communications, and coaching and mentoring within each teacher's classroom. All of these components use the web application as a tool.

Evaluation

Building Blocks has been tested at various phases of development, from one-on-one interviews with children during early phases, to multiple classrooms randomly assigned to treatment or control conditions. In the first summary research study, *Building Blocks* classrooms significantly outperformed the control classrooms on tests of number and geometry (including measurement, patterning, and so on), with effect sizes from 1 to 2 standard deviations, up to double what is considered a strong effect (Clements & Sarama, in press).


TRiad
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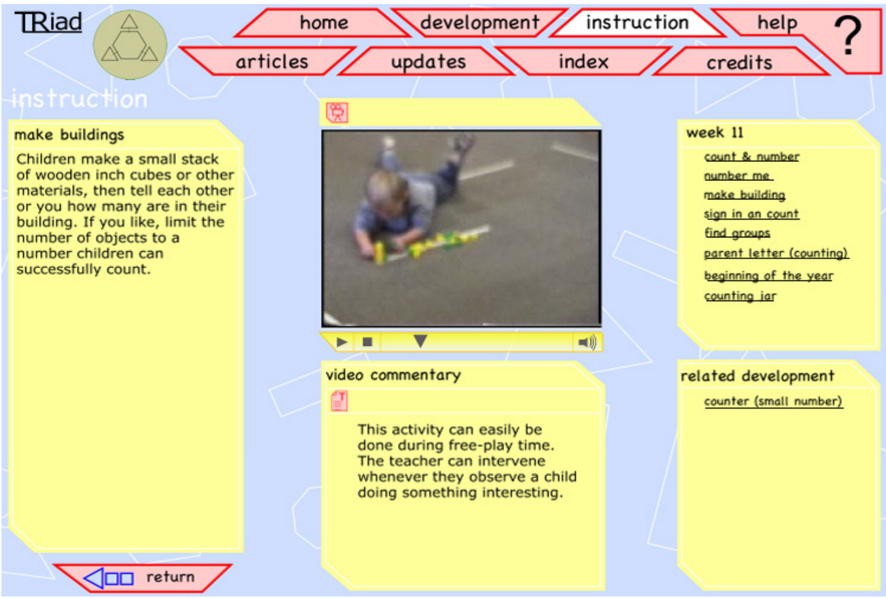
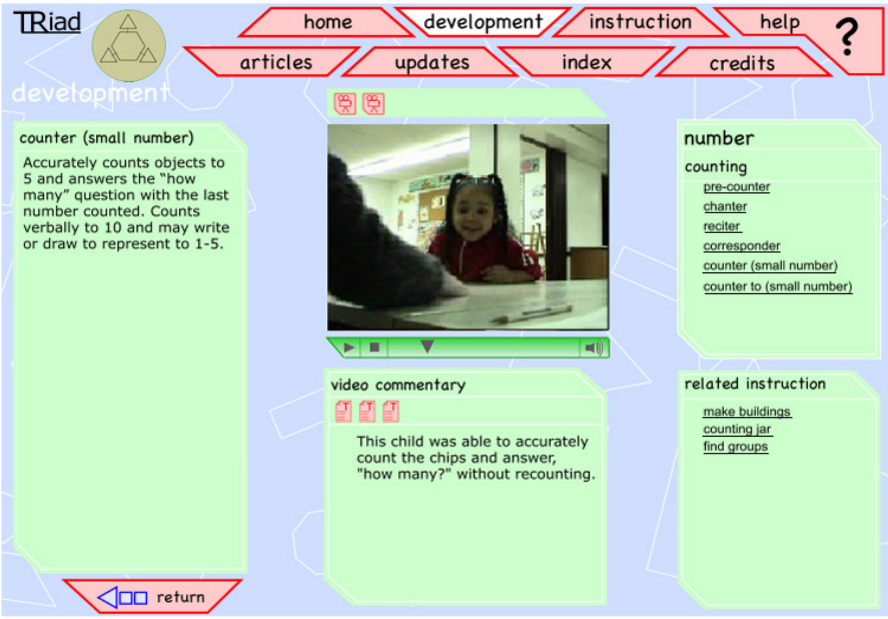
count & move
number me
off-computer center
make buildings
DLM Math software
sign in and count
small group
find groups
home links
parent letter (counting)
every day
beginning of the year
counting jar
denotes first occurance
make buildings
Children make a small stack of wooden inch cubes or other materials, then tell each other or you how many are in their building. If you like, limit the number of objects to a number children can successfully count.
more info


TRiad
home
development
instruction
help
?
articles
updates
index
credits
instruction
make buildings
Children make a small stack of wooden inch cubes or other materials, then tell each other or you how many are in their building. If you like, limit the number of objects to a number children can successfully count.
return
video commentary
This activity can easily be done during free-play time. The teacher can intervene whenever they observe a child doing something interesting.
week 11
count & number
number me
make building
sign in an count
find groups
parent letter (counting)
beginning of the year
counting jar
related development
counter (small number)



Clicking on the related developmental level, or student's level of thinking, ringed above, switches to the development view *of that topic and that level of thinking*. This likewise provides a description, video, and commentary on the developmental level—the video here is of a clinical interview task in which a student displays that *level of thinking*.

Figure 5.

In a larger study involving 36 classrooms, using the TRIAD model for curriculum implementation on a large scale, the *Building Blocks* curriculum was compared to an alternate, intensive, Pre-K Mathematics Curriculum and control classrooms with standard curricula. Building Blocks classrooms significantly outperformed both other groups in mathematics achievement, with effect sizes above 1 standard deviation compared to the control group and about a half of a standard deviation compared to the alternate intensive curriculum. They also significantly outperformed the control group in classroom observations of the mathematics environment and teaching.

Thus, we have confidence in our findings. We believe that research such as that reviewed here offers substantial guidance in teaching effectively with technology. Every aspect we have described needs committed people working actively at the core. Computers can contribute significantly, but that contribution may be maximized when they are used as a tool by knowledgeable, supported educators working with research-based curricula and software.

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