Information Technology in Childhood Education (2001)

Developmentally Appropriate LOGO Computer Programming with Young Children

CATHERINE WILSON GILLESPIE AND SALLY BEISSER
Drake University School of Education
3206 University Avenue
Des Moines, IA 50311 USA
catherine.gillespie@drake.edu
sally.beisser@drake.edu

The Iowa Early Childhood Papert Partnership (IECPP), a partnership among two public school systems, a private university school of education, a Head Start agency, a state area educational support agency, and renown technology theorist Seymour Papert, explored ways that LOGO computer programming can be used in developmentally appropriate ways with young children. The National Association for the Education of Young Children (NAEYC), defined developmentally appropriate practice as (a) age appropriateness, (b) individual appropriateness, and (c) sociocultural appropriateness. Each of these factors are considered, with particular attention being devoted to the developmental theories of Jean Piaget, Erik Erikson, Howard Gardner, and Lev Vygotsky. It is found that although Piaget is the theorist most commonly cited with reference to young children's work with computers, LOGO programming by young children is also (perhaps even more strongly) supported by the theories of Erikson, Gardner, and Vygotsky. Implications for practice are discussed in detail, drawing on the experience of those who have introduced the Reggio Emilia approach in their early childhood programs. Implications for curriculum design, pedagogy, family involvement, research, and development are all discussed.

The Iowa Early Childhood Papert Partnership (IECPP), a partnership among two public school systems, a private university school of education, a Head Start agency, a state area educational support agency, and world famous technology theorist, Dr. Seymour Papert, is exploring ways that LOGO computer programming can be used in developmentally appropriate ways with young children. Starting out with five experimental classrooms, including a Head Start, a kindergarten, a studio art, a first and second grade multiage, and third through fifth grade multiage classroom, we are grappling with the very real as well as theoretical issues that arise when young children are given laptop computers loaded with *MicroWorlds*™ software, programmable Legos®, instructions on how to use them, and daily blocks of time devoted to creating with them.

For those unfamiliar with the technology terms, LOGO is a computer programming language developed for children by Dr. Seymour Papert (1980, 1993) of the Massachusetts Institute of Technology so children could become active participants in their interactions with the computer. *MicroWorlds* includes a strong graphics-orientation, so children can create their own animated graphics on the computer. *MicroWorlds* is a graphics software that uses LOGO. It allows children to create their own miniature (micro) world where they learn through experimentation, exploration, and self-directed activity about the cause and effect relationships encountered in computer programming and throughout most of life's experiences. The Lego company also employs LOGO computer language in it's programmable *RCX*™ bricks. Kits containing the *RCX* bricks were named *Mindstorms*, after Papert's 1980 seminal book, *Mindstorms*. These bricks are small, yellow three dimensional rectangles that can be easily held in the palm of your hand. They are computers and contain receiving devices so that a program can be written on the laptop or desktop computer and then downloaded through infra red light rays into the *RCX* brick. When the "run" button is pushed on the *RCX*, whatever program has been downloaded into it will run. If the brick is part of a Lego vehicle, for instance, then children can control the operation of the vehicle by programming the brick to do whatever they wish. The terms LOGO, *MicroWorlds*, and programmable *Legos* will be used throughout this article. Another term associated with Papert's work is "constructionism."

Papert has dedicated his retirement years to helping teachers and students use *Lego®/Logo* technologies as intelligent manipulative tools to nourish children's active construction of knowledge. Papert's "Constructionism," a theory of education, is based on two different senses of "construction" of knowledge. First, it is grounded on the idea the children learn by actively constructing new knowledge, not by having information poured into their heads. Second, constructionism asserts that effective learning takes place when the learner is engaged in constructing personally meaningful artifacts, such as using creating computer animations, robots, plays, poems, or pictures representing one's own learning. (MIT Epistemology and Learning Group, 2000). By using *MicroWorlds* software and programmable *Lego* sets, young children and their teachers are using technology in exciting ways.

According to the National Association for the Education of Young Children (NAEYC), developmentally appropriate practice is defined as (a) age appropriateness, based on what we know from child development theory, (b) individual appropriateness, based on what we know about each child's interests, skills, and abilities, and (c) sociocultural appropriateness, based on what is known about the social and cultural experiences and milieu in which the child lives, with a particular emphasis on the child's family (Bredekamp & Copple, 1997). Each of these factors will be considered in turn, with particular attention being devoted to the developmental stage theories of Jean Piaget and Erik Erikson in the discussion of age appropriateness, to the work of Howard Gardner regarding individual appropriateness, and to the writings of Lev Vygotsky in the discussions of individual and sociocultural appropriateness.

AGE APPROPRIATENESS

When determining age appropriateness, NAEYC counsels to turn to developmental theorists to determine what a typical child should be doing at a particular age. This approach seems to lend itself well to stage theorists who predict what children should and should not be focusing on throughout various ages and stages of development. However, a number of challenges in determining age appropriateness were faced. First, the Iowa Early Childhood Papert Partnership spanned quite a wide age range of children, from the three- to five-year-old children attending Head Start to the seven- to ten-year-old children enrolled in a third through fifth-multiage classroom. A second challenge is that the stage theorists did not coordinate their ages and stages. For example, Piaget (1952, 1963) predicted that a two- to six- or seven-year-old would be firmly in the pre-operational stage but Erikson (1982) had shorter stages so that a three-year-old would be struggling with autonomy versus shame and doubt, whereas a four- or five-year-old would be facing the opportunity of initiative versus guilt, and a six-year-old would have moved into challenges relating to industry versus inferiority. A third challenge in determining age appropriateness is that even the ages that theorists originally proposed as delineating their stages have since been called into question. Neo-Piagetians, for instance, have consistently found that within the early age-stage ranges, children are more capable than Piaget had predicted (e.g., Novak & Goodwin, 1989; Raymond, 1991). Nonetheless, some characteristics of children at various ages can be established by relying on stage theorists such as Piaget and Erikson.

Piaget's (1952, 1963) pre-operational child, from approximately ages two to seven, is predictably endowed with certain characteristics that defy adults' conceptions of logic. A pre-operational child is very rule-bound and will hold fast to a rule, despite evidence to the contrary. Cognitive features of a pre-operational child include (a) centration, where the child focuses on one central feature of a situation and ignores what the child deems to be its peripheral aspects; (b) nonreversibility, where the child does not yet recognize that in order to get back to a starting point, the procedures of an operation must be gone through in reverse order; and (c) egocentrism, where the child is not yet aware of viewpoints or perspectives other than their own. These three characteristics of the pre-operational child are considered in turn.

If a preoperational child is employing centration when building a Lego structure, it is very possible that engineering problems will take a long time to solve. Let us take the example of a child whose vehicle is destroyed when it bumps into something. A child who focuses on only one aspect of the vehicle may not be effective in building something stronger. For instance, the child may pile more Legos on top of the vehicle. When this proves not to work after some trial and error, a child who is exhibiting centration is likely to add even more Legos to the pile, rather than trying a different approach. This can lead very quickly to frustration and disappointment. Therefore, teachers must assist children to attend to different aspects of a situation. It may be too much to ask the child to attend to more than one aspect at the same time, but after attending to one aspect unsuccessfully, a teacher can guide the child in focusing on a different aspect of the problem.

When using *MicroWorlds* on the computer, nonreversibility can present a problem. Most often, a computer is loaded with many software programs and it is not at all difficult or uncommon for a child to close *MicroWorlds* and open another program within the space of a few seconds. A teacher is usually summoned, but sometimes not until the child has already attempted to rectify the situation, and without the concept of reversibility, the child is unlikely to retrace his steps, and is more likely to get deeper into a problematic situation. Thus, teachers need to be aware of this tendency and encourage them to seek help immediately if the program seems to be malfunctioning, rather than attempting to fix it themselves.

Egocentrism can pose problems when children are animating objects on the computer screen in *MicroWorlds*. It is easier to anticipate the behavior of a turtle if one understands how animated objects "think." An egocentric child is likely to assume that an object on the screen will "do as I do; think as I think." But of course this is not true. So they may be dismayed when a number of moving objects on the screen unconcernedly run right over one another and keep on going. "I" would not do such a thing, therefore it seems impossible from an egocentric point of view to understand why an animated object would do it. Fortunately, many neo-Piagetians have challenged the age of onset of understanding others' perspectives (e.g., Newcombe & Huttenlocher, 1992) and point out that although young children are still self-centered, by three years of age, most children can understand others' perspectives.

Knowledge of Piaget's description of the characteristics of a preoperational child can help teachers in making the use of computer technology in their classroom age-appropriate. There are some aspects of this age child that teachers will have to work around. Other aspects may lend themselves well to growth in a Vygotskian zone-of-proximal-development (ZPD) approach (Vygotsky, 1978), whereby children are assisted only to the extent that they cannot accomplish a task independently, and that assistance, or scaffolding, is withdrawn as soon as the child attains independent ability.

Vogotsky's ZPD was obvious in one situation where a few children became interested in following the kit directions for building a Lego structure. Even though the directions were pictorial and contained no words, the first time around, children needed an adult's assistance to learn how to follow the step-by-step construction directions. It was something that none of the children in the class could do independently. However, it was within their ZPD, because they could accomplish the task with assistance. After success in following one set of directions, two or three children in the class could attempt the task independently. Therefore, the teacher withdrew scaffolding by offering assistance to them on this task only when it was sought. In addition, the children who could now accomplish the task independently became more competent peers who could assist their classmates in developing this new skill.

Erikson (1963, 1982) described the opportunity or challenge of a four- to five-year-old as a tension between initiative and guilt and that of a six- to eleven-year-old as a tension between industry and inferiority. Erikson sought a healthy balance between the two competing outcomes. He did not recommend that children should develop without a healthy sense of guilt in appropriate situations, or without a realistic sense of inferiority when appropriateness. However, his favored outcomes in the preschool age emphasized initiative, so that a child developed a sense of direction and purpose in his/her activities. In the elementary age range, Erikson favored outcomes emphasizing industry so that a child could develop a sense of mastery and competence.

When working with young children who are using LOGO programming language, their progress through Erikson's stages of development could greatly affect how they should best be spending their LOGO time. Children in the initiative versus guilt stage (four to five years old) must be given ample opportunity to explore and manipulate objects. They need to be encouraged, and not made to feel guilty about their curiosity. Building, constructing, and LOGO programming fit well into this stage. These uses of computer technology not only lend themselves, but actually require children to take initiative and to explore the materials. The materials themselves are merely starting points for whatever children choose to create with them. This is why almost all preschool classrooms contained a well-used and well-loved set (or two) of blocks. Children at this stage enjoy building and initiating their own creations. We have run into one problem with preschoolers and Legos. Assuming that children do not put the Legos in their mouths (which is a great leap with some children), there is a manual dexterity problem in pulling apart Legos that are stuck together. Little fingers have a hard time completing this task. Duplos® are easier for children to manipulate, but at this time, there is no *RCX*, or programmable feature, compatible with Duplos.

Children in the industry versus inferiority stage (six to eleven-years old) are becoming aware of how things work and how they are made. They need opportunities to become masterful and competent. Again, building, constructing, and LOGO programming fit well into this stage. Because children use the materials in such self-directed ways, children can experience mastery and competence at many different levels, as they become more adept at building and programming. It is very common to hear children in the experimental classrooms participating in the Iowa Early Childhood Papert Partnership exclaim, "Look what I made!" or gleefully and proudly shout, "It works!"

There is a remarkable goodness-of-fit between developmentally appropriate LOGO computer programming and Eriksonian theory. Most educators rely more heavily on Piaget than Erikson, but the previous examples point out that computer programming can support children's psychosocial development just as effectively as it supports their cognitive development.

INDIVIDUAL APPROPRIATENESS

For the use of any material, including computer technology, to be developmentally appropriate, it must fit with a young child's interests, skills, and abilities. The individual interests were addressed by giving children the option of creating *MicroWorlds* animated graphics projects on the computer or constructing with programmable Legos, or moving back and forth between the two, during LOGO time. Also, children were encouraged to pursue their individual interests within these two basic activities. Some choose to build vehicles with Legos and then (get some help to) program the *RCX* brick so that the vehicle will go forward, turn, and perhaps be sensitive to light so that it can be guided by a flashlight. Others choose to create their own stories in *MicroWorlds*, similar to the concept of *Living Books*, except these projects are entirely student-made creations (with adult assistance, of course). Students can animate their *MicroWorlds* projects; for instance they can show horses galloping by castles, and then tell the story in words either through text boxes on the screen or voice input. Kindergartners who have only been in school for one month can do this. It is happening, even among kindergartners who do not come from advantaged backgrounds.

One way of viewing individual skills and abilities is to refer to Howard Gardner's theory of multiple intelligences (1983, 1991). This theory holds that there are multiple ways of knowing, including linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, inter- and intra-personal, and naturalistic. Gardner asserts that although we should play to children's strengths, children will learn best if they are exposed to the school curriculum through a variety of intelligences. The LOGO computer programs that were used in the Iowa Early Childhood Papert Partnership used a number of these multiple intelligences. LOGO is a computer language. When children learn LOGO, they develop their linguistic skills in the same way that they might if they were introduced to another foreign language. Calculating how to move objects where you want them to go (the command: "forward any number, then right 90 four times" makes a square) uses the logico-mathematical intelligence. *MicroWorlds* contains a musical feature in which children can create tunes and play them back. Building with Legos and animating graphics in *MicroWorlds* are very spatial activities. Children use their bodies to type, use a touch-pad or mouse, click, build, and deconstruct. Interpersonal skills are used when children ask for, receive, and give help among peers. They are often observed creating an object, then showing it to a peer. Recently in one experimental classroom, two boys constructed very similar programmable cars in about 30 minutes of their LOGO hour. They then played cooperatively with the cars for the remainder of the hour. Intrapersonal intelligence is used when children decide how they are going to spend their LOGO time. They know how they are feeling that day, whether they want to work on the computers or with the Legos, and if they want to work alone or with others. Teachers assist this process by employing a plan-do-review approach where children are queried about their plans for the day and then either write (or draw) in the journals as review, or share what they did in a large-group meeting at the end of LOGO time. Perhaps the only multiple intelligence not addressed by programming with LOGO is the newest intelligence acknowledged by Gardner, that of naturalistic intelligence. Technology is almost by definition not of nature, and therefore opportunities to utilize the naturalistic intelligence must be found elsewhere during a child's day.

One way individual skills and abilities were addressed was when a child was struggling with something, was to assist, or scaffold, until the children were able to conduct a task independently. This of course is directly from Vygotsky (1962, 1978), and is something that is practiced in most early childhood classrooms regardless of teachers' familiarity or agreement with the writings of Lev Vygotsky. If a child wants to build a vehicle, but upon completion finds that it falls apart when it bumps into anything, then the teacher helps show the child how to make it stronger. If a child wants to program an object in *MicroWorlds*, but is still working on letter identification, a teacher assists here also, including providing tagboard cards with the most frequently used commands and icons to indicate what action the letters represent. In addition to a teacher, of course more competent peers are sought out by other children as classroom experts. Once one child has successfully built an apparently indestructible vehicle, then he/she is called on to consult with other children on their vehicles. Clearly, the skills and abilities involved in LOGO time include reading, writing, spelling, small motor development, math, and engineering. No child will be the best in all of these areas, so they can help each other and act as the more- or less-competent peer in different situations.

There is a tension, of course, in any whole-group activity, between the sometimes competing interests of the individual compared to the whole group. What if the whole group (or some significant part of the whole group) is engaged in a construction project? How does a child's individual interests play a part of this? The most familiar approach in practice today is one suggested by the early childhood curriculum in the town of Reggio Emilia, Italy (Edwards, Gandini, & Forman, 1993). Reggio children are encouraged to contribute to a group project, but they are not forced to do so and they may choose to pursue their individual interests. This approach was taken in the Iowa Early Childhood Papert Partnership. In one classroom, many children constructed Lego amusement park components such as rides and booths. It seemed to give the children an extra energy to participate in a shared endeavor. However, children also pursued their individual projects, sometimes when taking a break from work on an amusement park ride.

SOCIOCULTURAL APPROPRIATENESS

Although sociocultural influences go well beyond family influences, in the lives of young children, their families are their strongest influence, even before their school experience. Fittingly, the NAEYC statement of developmentally appropriate practice

(Bredekamp & Copple, 1997) emphasizes families with regard to the sociocultural component of developmentally appropriate practice.

One teacher in the Iowa Early Childhood Partnership is instituting LOGO computer programming classes for parents. Other teachers encourage parent participation and invite parents to come to school to learn about LOGO and assist with LOGO time. However, LOGO is a language that even those with home computers may not know, and parents are interested in learning it in a more structured way than they might be able to at home. Because many parents in our experimental classrooms do not have access to a home computer, the opportunity to explore LOGO could be, at least at first, limited to times that they are using computers in their children's classrooms.

According to Vygotsky (1962, 1978), children learn in the context of social interaction with adults and more competent peers. That is true. But it is also true that when children surpass adults' knowledge, then adults may learn in the context of social interaction with more competent children. But generally, adults are taken aback when children know more than adults about any topic. This situation turns out to be a wonderful motivator for adults to learn more about Legos and LOGO. Parents want to keep up, and they are given the opportunity to do so. This is true not only for parents, of course, but for participants in the project (teachers, administrators, and university faculty) as well as for other adults who are more peripherally involved (undergraduate student participant-observers, for instance). Partnership participants are involved in an ongoing series of training sessions. But those more peripherally involved are not so fortunate. They must be entirely self-directed. And evidence shows that they are taking initiative. After participating and observing for one month in one of the experimental classrooms, two undergraduate students requested a set of Legos to take home to their sorority house, "so that we can help the kids." After just one month they realized that the children had questions and problems that they did not know how to address, and the undergraduates—just like the parents—wanted to keep up with the children.

One aspect of sociocultural appropriateness regarding technology is that children need to remember that no matter what your race, religion, ethnic background, or gender, you can build, program, and become a technology expert. The Anti-Bias Curriculum (Derman-Sparks & the ABC Task Force, 1989) specifically addresses issues of equity in a proactive manner. One of the interesting things about working with young children, computers, and Legos, is that children do not seem to have yet decided that these are gender-specific materials. Children seem to be more likely to make choices based on their strengths and interests rather than their gender. Walking through one of our experimental classrooms, you would see both boys and girls working on laptop computers, and both boys and girls (sometimes in mixed-gender groups, sometimes in single-sex groups, and sometimes alone) constructing with Legos. Perhaps the challenge here will be to remind parents and other adults that computer programming and Legos are not for boys (and men) only, and that girls (and women) can, for instance, build strong cars and program them to go fast.

In addition to the family culture, there are some classroom culture issues that are challenged by work with Legos and LOGO. For instance, computers do not understand invented spelling. It is now standard practice for beginning writers to be encouraged to use approximations of traditional spelling as they are learning to become fluent writers (Dailey, 1991). But "close," while perhaps comprehensible to another person, is incomprehensible to a computer. Therefore, children need to learn to type in a way that that the computer understands. This is a wonderful opportunity to introduce children to the concept of traditional versus invented spelling.

One aspect of sociocultural appropriateness is the relevance of the activity at hand to the larger culture. And here, computer programming of any kind is clearly an activity that is valued and needed by society at large. Constructing with Legos, while not immediately obvious as a skill with immense societal value, does directly and indirectly use multiple intelligences that have a clear and useful purpose in our society.

SUMMARY

Piaget's description of the preoperational child helps to understand the limitations that must be placed on ourselves when working with children under the age of seven. It helps to see children's logical "errors" as predictable and stage-related. There is no question that Piagetian theory has contributed greatly to developmental and educational psychology in general, however, reliance on Piaget's contributions has eclipsed the work of other theorists, particularly Erikson's theory of psychosocial development. Building, constructing, and LOGO programming fit well into Erikson's stages of initiative versus guilt (preschool-age through the beginning of kindergarten) and industry versus inferiority (elementary school age). These activities offer frequent opportunities for children to initiate their own ideas and to experience mastery and competence at many different levels, as they become more adept.

Less neglected in the area of educational psychology are Howard Gardner and Lev Vygotsky. Gardner takes a perspective that children have multiple intelligences. LOGO computer programming is consistent with at least eight of the now nine intelligences (except naturalist). Vygotsky believed that children learned in the context of social interaction and that their learning should be supported, or scaffolded, to the extent that they could not accomplish a task independently. Throughout the Iowa Early Childhood Papert Partnership experimental classrooms, the teachers had strong Piagetian training and beliefs. However, the interactions between students and teachers, and students and more competent peers appear to mesh well with Vygotsky orientation. Teachers may base their overall decisions of how to approach a lesson or project with reference to Piaget, but when a child asks for help, they are given just the help they need in order to accomplish the task. This is true in cases of teacher-assistance, as well as peer assistance. In summary, while the literature suggests that Piaget is the theorist most commonly cited with reference to young children's work with technology, the IECPP experimental classroom experiences have shown that use of LOGO programming by young children is resolutely supported by the theories of Erikson, Gardner, and Vygotsky. Notably, opportunities for successful integration of technology through "constructionism" is developmentally appropriate when children actively construct knowledge out of their own experiences using the Lego/LOGO building and programming components.

IMPLICATIONS

For an activity to be developmentally appropriate, it must meet NAEYC's three criteria of (a) individual appropriateness, (b) age appropriateness, and (c) sociocultural appropriateness. We have referred to a number of theorists, including Piaget, Erikson, Gardner, and Vygotsky to establish the comprehensive developmental appropriateness of programming in

LOGO in early childhood settings, including preschool, Head Start, and kindergarten. But how can these theories be put into action? What are the implications for educational practice? What can be learned from the experience of others who have changed their approaches to teaching and learning? What is the impact on research and development of educational hardware and software?

The Reggio Emilia approach to early childhood education and the Anti-Bias Curriculum have both been mentioned as examples of ways that developmental appropriateness can be practiced in early childhood education. In particular the Reggio Emilia approach is not in and of itself a theoretical approach, but rather a way of teaching and learning that was developed in the town of Reggio Emilia, Italy after World War II and that received inspiration from the writing of theorists including Piaget and Vygotsky. It is a current, working example of a best practice in early childhood education.

Although the Reggio approach is known for its integration of the arts and not for technology, the joys and frustrations of schools, teachers, students, and families in exploring the Reggio approach as a new way of teaching and learning provides strong examples of the types of challenges and successes that will likely be faced when programs attempt to explore the developmentally appropriate use of technology with children and their families. Books (Hendrick, 1997) and articles (Gillespie, 2000) have been written describing the experiences of those who have begun to incorporate the Reggio approach into early childhood programs. Similar joys and challenges to those reported by schools, teachers, students, families, and others in their efforts to change, can be expected, including:

Joys

1. *Engaged learning.* Usually this starts with the teachers: all a sudden, teachers have a renewed interest in their own professional and personal development. They are eager to learn new things and to try them out in their classroom. When they do, children also become engaged. If they are given freedom to pursue what interests them, then they become even more engaged. When they are given assistance so that their frustrations and lack of skills or experiences do not become overwhelming, they are able to sustain this engagement and love of learning for the entire school year. This is of course true for teachers and families as well. The learning endeavor becomes collaborative among teachers, students, and their families as they all learn more and try out new things.

In IECPP classrooms, teachers interact as facilitators. Lessons are problem-based as they invite children to use technologies in innovative ways. Teachers are learners, along with their students encountering problems that neither of them may have seen before. While children are constructing knowledge with these manipulatives they demonstrate skills such as:

- initiating and completing work cooperatively,
- participating in group and individual decision-making,
- using hands-on objects for discovering ideas,
- classifying objects according to color, size, position, function, and motion,
- naming geometric shapes (circle, square, arc),
- using directionality and motion (forward, backward),
- applying vocabulary that is specific, accurate and suitable to tasks, and
- exploring mathematical and scientific concepts (light, motion, ratio, velocity, cause/effect).

Children make decisions about their own learning. Learning is purposeful. Their constructions change with new units of study. One IECPP teacher reported, "Children have an opportunity to show their expertise. They call upon each other to solve problems and to persist in problem resolution." Rather than complete a worksheet, they create and revise their constructions. Not only have student attention spans increased, learners tend to persist in the tasks they encounter.

2. *Family involvement*. Although families are not always familiar with the new approaches that teachers are introducing, they want their children to learn and to love learning. They also realize that some of the things their children are learning are beyond their own current capabilities. So families are supportive, and become involved in their own learning when they have the opportunity to join in the classroom activity, either with classroom visits or separate workshops held for parents outside of school time.

   The IECPP teachers and university research partners collect data including powerful learning stories from their students through student journaling, anecdotal notes, digital photos, and video clips. They share insights and interaction with parents at conferences. Parents are invited to come to school to learn about LOGO, to assist with LOGO time, or attend the after school Lego/LOGO club. Parents, who were reluctant to become involved in their child's school experiences, are finding the excitement contagious.

Challenges

1. *Time*. Learning new ways of doing things takes time. Teachers need time apart from children to learn and to collaborate in learning with their peers. Children also need regular, unhurried time in school to learn and collaborate with their peers. As an ideal, we would recommend 45-90 minutes per day over the course of a number of months in order to maximize children's learning. In our classrooms where students have only been given once-a-week opportunities to learn and collaborate, the students are learning less, forgetting more from class to class, and requiring more teacher direction than children who are given daily opportunities to interact with programmable Legos and *MicroWorlds*.
2. *Money*. It always seems to be in short supply, and everything seems to costs something. Materials (Legos, especially the programmable *RCX* bricks, and even AA batteries), software (*MicroWorlds*), computers (laptops and desktops of any make) are all quite expensive. In addition, substitute teachers must be paid for teachers' professional development release time, support people and experts must be paid, teachers' travel to, and accommodations for, workshops must be funded. The usual answers of grant money, matching funds, and fundraising projects are all tried and true methods to fund new initiatives. It continues to be a struggle.
3. *Communication*. Keeping all interested parties informed of classroom changes, school initiatives, advances and discoveries, and upcoming events could be a full time job for more than one person. Yet to attain and maintain support and ongoing implementation of any new program, communication is key. Methods tried include workshops, regular collaborative meetings, an electronic bulletin board, e-mail, U.S. mail, phone and face-to-face conversations, classroom visits, and presentations/demonstrations for legislators and school boards. It is impossible to prioritize these attempts to maintain clear lines of communication, as for each individual the level of success of one mode versus another is different. The authors' recommendation is to make sure that multimodal communication approaches are used, and that all interested parties are informed in more than one way on a regular basis.
4. *Systems thinking*. Particularly in school systems, teachers need support at every level. The principal and school board must be supportive. They need to understand what is being done and why, and provide financial and professional support to the project. Knowledgeable technical assistance must be made available in order to keep the hardware and software up and running, as well as to field questions that have not

been answered through conversations in the hallway or appeals to electronic bulletin boards. The IECPP was established with a systems thinking view (Senge, 1990). Agencies that should work together but do not always collaborate effectively were brought together at the beginning to establish a partnership. It is highly recommended that any effort to introduce major change in education include a teacher preparation institution, more than one public school system, one or more preschool program, as well as professional and technical support. The authors' have found this type of partnership to be dynamic and fruitful and are sure that others will too.

Change does not come about overnight, nor is it without cost. However, when communication is strong and with systematic support, change can occur. Teachers, students, and families can learn and grow and experience the joys of becoming involved and engaged learners in a way that is developmentally appropriate at any age, both individually and socioculturally.

RESEARCH AND DEVELOPMENT

One of the primary motivators for the establishment of the IECPP was the need to explore ways to make computer hardware and LOGO software developmentally appropriate for children under the age of eight. Older children have been successful for years with LOGO, but there are many barriers to young children's use of LOGO, the strongest of which is their emergent, but not yet firmly established ability to read and write conventionally.

One hardware problem anticipated was young children's need for a computer mouse, and their inability to use a track pad. This was an unrealized fear. Children can use track pads, and for those who feel more comfortable with the mouse, external mice can be attached to laptops, or desktops with mice are also available to them.

The software problem anticipated has turned out to be real. Partnership teachers are now piloting some iconic LOGO interfaces so children can program by clicking on an arrow showing a right turn rather than typing "RT 90." Approaches such as these are definitely needed to make LOGO more accessible to young children. However, it is not entirely clear what is the best way to go about this. One approach would be for software manufacturers to include iconic programming in their software packages. Another approach would be to enable teachers and parents to write their own iconic programs, which they could tailor to the needs of their own children. This second approach is preferred, but it makes the challenge for software developers more difficult: to create an interface for adults or older children who could use it and in turn create an interface for younger children to use.

Despite software challenges, as well as the challenges of finding enough time, money, and support to pursue the implementation of developmentally appropriate LOGO programming with young children, it is a worthwhile, exciting, and developmentally appropriate endeavor that will undoubtedly continue into and beyond the foreseeable future.

References

Bredekamp, S., & Copple, C. (1997). *Developmentally appropriate practice in early childhood programs* (Rev. Ed.). Washington, DC: NAEYC.

Daily, K.A. (1991). Writing in kindergarten: Helping students understand the process. *Childhood Education*, 170-175.

Derman-Sparks, L., and the ABC Task Force. (1989). *Anti-bias curriculum*. Washington, DC: NAEYC.

Duplos [retail product]. (1969). LEGO Systems, Inc., Enfield, CT. [Online]. Available: http://www.lego.com/dacta

Edwards, C., Gandini, L., & Forman, G. (Eds.) (1993). *The hundred languages of children: The Reggio Emilia approach to early childhood education*. Norwood, NJ: Ablex.

Erikson, E.H. (1963). *Childhood and society* (2nd ed.). New York: W.W. Norton.

Erikson, E.H. (1982). *The life cycle completed: A review*. New York: W.W. Norton.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Gardner, H. (1991). *The unschooled mind: How children think and how schools should teach*. New York: Basic Books.

Gillespie, C.W. (2000) Six Head Start classrooms begin to explore the Reggio Emilia approach. *Young Children*, *55*(1), 21-27.

Hendrick, J. (Ed). 1997. *First steps toward teaching the Reggio way*. Upper Saddle River, NJ: Prentice-Hall.

Legos. [retail product]. (1958). LEGO Systems, Inc., Enfield, CT. [Online]. Available: http://www.lego.com/dacta

Lego® MindStorms™. [retail product]. (1998). LEGO Systems, Inc., Enfield, CT. [Online]. Available: http://legomindstorms.com

MicroWorlds 2.03® [computer software]. (1997). Logo Computer Systems Inc., Highgate Springs, VT. [Online]. Available: http://www.lcsi.ca

MicroWorlds Pro® [computer software]. (2000). Logo Computer Systems Inc., Highgate Springs, VT. [Online]. Available: http://www.lcsi.ca

MIT Epistemology and Learning Group. (2000). [Online]. Available: http://el.www.media.mit.edu/groups/el/elprojects.html

Novak, J., & Goodwin, D. (1989). *Learning to learn*. Cambridge: Cambridge University.

Newcombe, N., & Huttenlocher, J. (1992). Children's ability to solve perspective-taking problems. *Developmental Psychology*, *28*, 635-643.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.

Papert, S. (1993). *The children's machine: Rethinking schools in the age of the computer*. New York: Basic Books.

Piaget, J. (1952). *The origins of intelligence in children* (M. Cook, Trans.). New York: International University.

Piaget, J. (1963). *The child's conception of the world*. Patterson: Littlefield.

Raymond, C. (1991, January). Pioneering research challenges accepted notions concerning the cognitive abilities of infants. *Chronicle of Higher Education*, A5-A7.

Senge, P.M. (1990). *The fifth discipline: The art and practice of the learning organization*. NY: Doubleday.

Vygotsky, L.S. (1962). *Thought and language*. Cambridge, MA: MIT Press.

Vygotsky, L.S. (1978). *Mind in society*. Cambridge, MA: Harvard University.