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ABSTRACT

Educators are asking about the appropriate role of computers in the classroom, whether computers have a legitimate place in a classroom for young children or will supplant more important activities, and whether children under the age of 8 should use microcomputers. These general questions must be examined in order to discover the real, underlying issues and how they can be addressed. One concern is that this new technology is not "real," but that the microcomputer is a symbolic machine that is used to represent and manipulate symbol systems. The symbolic nature of the microcomputer per se, however, does not make it incompatible with or inappropriate for use by young children. A critical issue is how the child engages with a particular system via the microcomputer. Microcomputers can be used to provide cognitive support; as a means for reflecting on other activities and better understanding activities in other media; and to help children take a broader view of the computer as an important piece of technology. The concern that the technology will take over, and that teacher behavior or beliefs will not matter, is contradicted by existing research. Answering questions about microcomputer use by young children calls for a complex and cooperative enterprise among teachers, researchers, and developers. Twenty-four references are listed. (LMM)

CENTER FOR CHILDREN AND TECHNOLOGY

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THE MICROCOMPUTER AS A MEDIUM FOR YOUNG CHILDREN*,**

Karen Sheingold

Picture a classroom of young children. There is a young boy in a smock, paintbrush in hand, excitedly putting brush to paper, creating his own work. The smell of the paint and the feel of the brush on paper are an integral part of his experience. Two young girls are building a farm in the block corner, discovering that their stable is not sufficiently large for twelve plastic horses to be housed there. In the book corner, a group of young children is creating a story together, which their teacher commits to writing.

What role could or should a microcomputer play in such a lively environment where children are actively working with materials and inventing their own worlds? The computer, a piece of electronic "adult" technology, certainly doesn't smell like paint or feel like blocks. It is not an object in the world the way the class guinea pig is. Does it have a legitimate place in a classroom for young children or, once it arrives, will it supplant these more important activities?

These are the kinds of questions on the minds of many educators of young children. They want to know whether children younger than eight should use microcomputers. I have been a witness to and a participant in many lively debates on this topic in the last few years. The intensity and passion with which views are expressed has led me to reflect on what underlies both the questions and their intensity. It is important to "unpack" these general questions to discover what the real issues are and how they can be addressed. The purpose of this paper is to provide such an analysis.

In the absence of a substantial base of theory and research relating to young children's use of microcomputers, this analysis is difficult to

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accomplish. That no one knows much about what it means for young children to use microcomputers, however, provides an arena ripe for reflection, experimentation, debate and cooperation among educators and researchers. Examining educators' questions about microcomputers leads inevitably and fruitfully into research questions, which then lead back into questions about educational practice. In the following pages, I will suggest some reasons for the deep concerns I hear about using microcomputers with young children and relate these to ideas about development, about what the microcomputer is or could be, and to how the power of this educational innovation is interpreted. Wherever possible, I will point to important research issues.

Symbols and Reality

It is not possible to talk about young children or microcomputers without first talking about symbols. By a symbol, I mean anything that represents some kind of information. A word is a symbol because it refers to or denotes a thing, idea, or feeling. Symbols--pictures, numbers, words, gestures--convey meanings. Symbol systems, such as language, mathematics, and dance, are organized, complex, and related patterns of symbols which, taken together, comprise broad cultural systems of meaning. Symbolic products--stories, poems, songs, symphonies, scientific experiments--are the results of our active engagement with these systems. Symbolic products are created in particular media or materials.

There is a sense in which symbols are not "real." A picture of a tree or the word "tree" are not the same as the tree. Looking at a real tree is a different experience from looking at a picture of one or reading a story about one. Symbols are _about_ the world and how we give meaning to it.

What does this have to do with young children and microcomputers? First among the concerns that I hear about young children's use of microcomputers is that this new technology is not real in the way other classroom materials are--like paint, clay, crayons, or rhythm instruments. The microcomputer is fundamentally a symbolic machine. We use it to represent and manipulate symbol systems--language, mathematics, music--and to create symbolic products--poems, mathematical proofs, compositions. In this sense it is _about_ the world and not _of_ it.

But is a symbolic machine incompatible in some fundamental way with young children--with what they know, what they do, and how they learn and develop in the early years? What we know about early development, about how and in what realms children learn and develop during these years can help answer this question.

Early Symbolic Development

While for many years it was difficult to characterize development between infancy and the school years except in negative terms (the child is preoperational, illogical, and so forth), research in the last decade has modified this view in two significant ways. First, it has become clear that the young child is capable of many cognitive activities at first thought accessible only to older children. Researchers (Gelman & Baillargeon, 1983; Siegler, 1981) have shown that the ways in which tasks are structured for young children dramatically affect what they can demonstrate about what they know. In carefully designed situations, for example, young children reveal that they are not entirely egocentric or perception-bound (Gelman, 1978; Lempers, Flavell, & Flavell, 1977), and can achieve some success on many tests of concrete operations (Donaldson, 1978; Siegel & Brainerd, 1978). What young children know, however, tends to be implicit rather than explicit. That is, these children demonstrate skills and knowledge which they are not aware of and cannot tell us about except by their actions in tasks of the psychologist's design.

The second way in which our views of early childhood have been modified is that there has emerged a more positive characterization of early childhood as a time of accomplishments in the development of symbolization (Gardner, 1983; Gardner & Wolf, 1979). During this period, there is a genuine flowering of symbolic capacities and activities such that, by age five, the child has "first draft knowledge" (Gardner, 1983, p. 305) of symbolization in language, pictures, three-dimensional objects (blocks, clay), dance, music, pretend play, as well as some number and logical knowledge. Between the ages of five and seven, children acquire the rudiments of notational systems--systems which themselves refer to symbol systems. So the child begins to learn a written language, which itself refers to a spoken language.

Symbolic Machine

The lack of "realness" which is attributed to the microcomputer derives, I believe, from the fact that the microcomputer is a symbolic machine. When children use a microcomputer they are interacting with symbols--words, numbers, pictures, graphic representations. But much of the activity young children naturally engage in is also symbolic--communicating with gestures, speaking, pretend play, counting, tapping a rhythm, singing, making a picture or a clay object. In the classroom described at the beginning of this paper, the children were all making symbolic products--a painting, a block scene, a story. The symbolic nature of the microcomputer per se does not make it incompatible with or inappropriate for use by young children. One could, in fact, make just the opposite argument. To do so out of hand, however, would be to ignore the critical issue of <u>how</u> the child engages with a particular symbol system via the microcomputer.

There is a direct, active involvement of children with crayons and blocks which is assumed to be absent with the microcomputer. But is this absence intrinsic to working with a microcomputer? The image many people have of microcomputer use in schools reflects the drill-and- practice software that has dominated the educational software marketplace. Used this way, the microcomputer gives children questions to answer or problems to solve, and then tells them whether or not their answers are correct. In some cases, the drill and practice is "dressed up" to look more like a game, but the basic format is the same. For young children, a very large proportion of existing software is devoted to letter and number recognition.

This type of activity is relatively passive. Children respond to questions. Answers are correct or incorrect. There are few degrees of freedom in what they do, and no opportunities for invention, for shaping the medium to make their own products or achieve their own goals. This type of activity, however, is an extremely small and limited subset of the ways in which the children can interact with the machine.

Within any given symbol system represented on the microcomputer, there are many different kinds of activities the child can do, some of which are more and some less constrained by the software itself. Take graphics, for example. A program can ask a child to do one of several things. One program might ask the child simply to detect correspondences among specific shapes. Another might provide an array of shapes and objects which the child can arrange in a design of her choosing. A third might provide the equivalent of paint and brushes and permit the child to create from scratch her own pictures or designs. Not only are these all very different kinds of tasks requiring different skills, but the options open to the child increase as we move from the first program to the third. In both the second and third examples, the child can make something, rather than simply respond. At least in principle, the microcomputer is a medium which the child can use for making, doing, and creating.

Moreover, there are many different ways of giving information to the microcomputer, the keyboard being the most familiar as well as the most indirect. Mice, paddles, and joysticks, for example, are analog devices that make possible a direct mapping between the child's hand and finger movements and what happens on the screen. Many games make use of paddles and joysticks for controlling moves on the screen. Children can even manipulate directly what happens on the screen by touching it with a light pen. Special keypads have been developed for young children--and others could be--which have larger, fewer, and/or different symbols from what is on the keyboard. So, not only can the microcomputer be a medium for making and doing, but it can be more or less similar to other media with which the child is familiar.

The microcomputer is not one thing or one kind of experience, for young children or anyone else. Its flexibility presents a great challenge to our imaginations. The challenge is to determine whether and how the microcomputer can be made interesting, appropriate, and useful for young children.

Possibilities for Microcomputer Use with Young Children

What would we have this technology be for the young child? What would we use it for? Such questions are difficult to answer in the absence of careful research and development work, but there are four possibilities which come to mind. Not an exhaustive list, they are examples of how we might think about using microcomputers with young children. I propose them as hypotheses to be tested, not as answers. First, we could use the microcomputer to acquaint the child with properties which are unique to it, such as dynamic movement and programmability, and thus provide experiences not possible with other classroom media. Second, we could use the microcomputer to support learning so that children can explore aspects of experience that would normally require skills they do not yet have. Third, we could use the microcomputer as a way for children better to understand what they do in other media. Fourth, we could use the microcomputer to help children gain a broader view of what the comuter is as an important piece of technology in the world.

Exploring Unique Properties of the Microcomputer

There is no doubt that young children will approach the microcomputer as they do other new objects--with curiosity and excitement--and subject it to whatever means of exploration they have at their disposal so that it reveals its properties and "secrets" to them. But since the microcomputer is not just one thing, teachers must decide which software to use and which properties children might profitably explore.

One question that many educators ask themselves is whether microcomputer-based activity offers anything that is substantially different from what can be obtained in the classroom by other means. In its programmable and dynamic properties the microcomputer is different from most other media children interact with. Introducing young children in simple ways to these properties may provide interesting learning opportunities. For example, children could explore the dynamic properties of movement by having a set of objects which they could cause to move on the screen in ways which they would specify. Children could convey their instructions via simple, specially designed input devices (e.g., keypads, mice, light pens). With a dynamic tool kit of shapes and movements, children could construct their own moving pictures and scenes. In this new medium children can make something interesting to look at, play with, share with others, and redesign at will.

Programmability is another property unique to computers, and one to which I believe young children can be exposed in simple form. What might a young child learn about programmability? First, that a person can make a choice or give an instruction to the microcomputer to make something happen. And second, that instructions can be combined to make a sequence of events occur. Programmability could be taught with respect to a number of different symbol systems, but graphics and music come to mind as ones that are likely to be particularly interesting for young children. These "simple ideas" about instructions and sequence can be introduced to young children without using programming languages per se.

These ideas that I refer to as simple are not necessarily so, and it will be important to discover whether young children are able to comprehend and use them with fluency. I have no doubt that young children will find it easy and interesting to give instructions to the microcomputer which result in events occurring on the screen. Many older children do. But there may be a problem in our interpretation of what is understood by the child. In work with older children, we find that they are capable of producing impressive arrays on the screen without having a flexible or deep understanding of the program which resulted in that array (Mawby, 1984; Pea, 1983). Programming languages are, it turns out, very complex symbol systems, the mastery of which takes much time and intensive effort (Kurland & Cahir, 1984; Pea & Kurland, in press). So, while I think it worthwhile to introduce young children to ideas about programmability, it is equally as important for us (educators and researchers) to look carefully at what is actually learned and understood. We cannot assume that, if a child can create some sequenced instructions on the microcomputer, she "knows how to program."

Microcomputer as Cognitive Support

The second way in which it might be interesting to use the microcomputer is as a support for or facilitator of activities which young children would not normally be able to do. It is widely assumed that there are sequences of skills which must be learned before one can produce a symbolic product. So, in most cases one learns a musical instrument and musical notation before attempting to compose. Yet it is not clear that such skills are prerequisite to composing. While composing is generally reserved for a small segment of skilled musicians, we know that children as young as two make up their own songs (McKernon, 1979). In a similar vein, one must be able to put letters and words on paper before being able to write a story. Again, it is not clear that composing with language depends on being able to form those letters and words. Young children are good at telling stories (Sutton-Smith, 1972). Yet writing them down poses difficulties of many kinds. Can young children create these complex symbolic products without having mastered the notational systems and all of the cognitive skills an adult or older child would bring to the enterprise?

A microcomputer might afford such opportunities. What is required, to begin with, are much simplified versions of existing word processors and music editors. Making such software simple enough and simple in the right ways is a significant design challenge. By allowing children to bypass some of the physical and cognitive obstacles in a particular arena, we may make it possible for them to enjoy creative experiences which would be difficult, if not impossible, to obtain without such support.

There is, however, another sense in which microcomputer-based work may serve to support and extend children's cognitive activities. It turns out that, for older children, microcomputer-based work in classrooms tends to be collaborative (Hawkins, Sheingold, Gearhart, & Berger, 1982; Levin & Boruta, in press). Children work together and use each other as resources while they do such varied activities as programming, writing stories and articles, engaging in games and simulations, or simply figuring out how to get the microcomputer to work. This kind of joint activity provides a kind of "scaffolding" by the social environment for children to accomplish what they might not be able to on their own. Here we have the intriguing possibility that the microcomputer may serve as a kind of cognitive support, not by itself, but because of its impact on the social life of the classroom. When teachers allow it, microcomputer-based activities "invite" collaboration, which can assist accomplishments for children both as individuals and in groups.

Reflecting on Other Activities

> The computer, rather than being a superbrain, teaching us with its consistent and logical "thinking," is instead a

fantasy world which, like a hall of mirrors, reflects back to us images of our commonsense ways of making things and making sense. (Bamberger, 1983, p. 1)

In these words, Jeanne Bamberger is proposing that we think about the microcomputer in yet another way--as a medium that can help us discover and reflect on what we already know intuitively. By playing with what we make in the microcomputer world, she suggests, we come to see familiar actions and objects in new ways.

She describes how, for example, in translating a drummed rhythm into a simple program for the microcomputer, we discover new properties of the rhythmic structure. Her general argument is that we have implicit knowledge about many things--how to clap a rhythm, build a block tower, draw a picture. Having to program that same activity on the microcomputer requires making explicit the knowledge that we have "in our muscles." In so doing, we know differently and better what we knew before.

Does this argument apply to young children? I think it does, if made more broadly. Since there is more than one way of knowing, giving children access to multiple ways of knowing may lead to better understanding in a particular domain (Dewey & Bentley, 1960). If some kinds of microcomputer experience offer ways of knowing which differ from what the child does with other media in the classroom, then it is precisely through the connecting of these related, but different, kinds of experiences that new learning may be possible.

To try but one example, let us give the child a microcomputer to paint with. In a typical paint program, the child chooses a brush thickness, and can even choose the type of pattern the brush will make as it moves around on the screen. Colors can be selected, mixed, and tried out. Shapes can be created and made smaller or larger. Many possibilities can be explored alone or in combination, can be erased, changed, or moved. Painting with the microcomputer could make children aware of choices and possibilities which they would otherwise accept as givens when they use paint and paper. With such rapid experimentation, the child may make discoveries in microcomputer painting that enable her to attempt new things with paint and paper.

The flaw in this argument rests on how the child makes connections from one medium to another. Research conducted with older children at the Center for Children and Technology leads me to doubt that such connections will come naturally or easily. For example, children learning to program were often unable to apply a command or concept they had used successfully in one program to another program (Pea, 1983). That is, making connections within programming was difficult. Moreover, there was no general transfer of planning and problem-solving skills to a noncomputer task by children who had learned programming for a year, compared with those who had not (Pea & Kurland, 1984). It follows, then, that if we are to use the microcomputer to help children see and reflect on connections from one medium to another, teachers will need to structure children's experiences and provide support to make this possible.

Microcomputer as Object

I want to conclude by going back to the original acsumption about the microcomputer as something that is not truly real because it is a symbolic medium. There is, of course, a sense in which it is very real and will become increasingly so for the young child. It is an object in the world, with its own physical and tactile properties. It is also a very powerful tool with which people can do many important and interesting symbolic tasks, from writing a book, to designing a house, to constructing a budget, to communicating with people on another continent.

As children use microcomputers at home and in classrooms, they will develop their own ideas about what this machine is and what it is for (Mawby, Clement, Pea, & Hawkins, 1984). It will require serious and clever research to find out just how it is that young minds comprehend this peculiar and flexible object. There is no doubt, however, that children's notions will be influenced by the kinds of experience they have had with the machine and the kinds of intepretations of it offered by teachers and peers. What they think it is and what they think it is for will, at least in part, reflect what they do with it and what they see others doing. Therefore, educational choices about how children use microcomputers in classrooms have implications for children's initial understanding of a significant piece of cultural technology.

My personal view is that I would like children to approach this machine matter-of-factly. I would want them to understand, at some level, that this is a tool that does more than one thing, that people use it for their own purposes, and that children too have a variety of purposes for which its use is appropriate. Such a view would be fostered in a classroom where the technology was treated matter-of-factly, where children were helped to use the machine in a number of ways, and where they could make use of it when they were interested or had something to do that they thought the microcomputer could help them with.

In such a classroom, the functionality and purposes of the microcomputer--the ways in which it helped teachers and students to do things and its connections to other classroom activities--would get worked out over time by children and teachers as uses were discovered, tried, and found to be productive. The microcomputer, then, would not be a thing apart; it would simply be another material for the classroom. As with other media, some children would find it more interesting than would others. And there would be individual differences in the ways children chose to use the machine. In their imaginative play, children wouldn't "play computer," just as they don't "play telephone." Rather, they would incorporate the microcomputer into their play about other things.

Shaping an Innovation

I believe that the greatest source of concern about having microcomputers in classrooms for young children is that the microcomputer activities will supplant the many activities children do with "real" materials. It is feared that having a microcomputer in a classroom means these other activities will disappear in the face of their computerized versions. There is no doubt that working with materials is important for young children, and it would be unimaginable--not to say absurd--to have a microcomputer replace the water table, block corner, or pet rabbit.

What seems to underlie this concern is a sense that the microcomputer innovation has a life of its own that is proceeding at an intense and unstoppable pace. Such a fear is understandable when schools are acquiring microcomputers at an ever-accelerating rate, when parents are playing an active role in urging schools to buy microcomputers, and when advertisements for microcomputer hardware and software attempt to make us believe that serious cognitive deprivation and/or failure to get ahead in life will result if children do not have access to microcomputers at an early age.

On the other hand, this view implies that the technology will take over, that what teachers do or believe will not matter. Whatever research knowledge we have on this issue suggests quite the opposite--that what school systems and teachers do with computers--what they use them for, how they interpret them, how they present them to children--has an enormous effect on what happens in a particular system or classroom (Kane & Endreweit, 1983; Sheingold, Char, Hawkins, Wootten, Sheingold, & Roberts, 1983; Sheingold, Hawkins, & Char, 1984). The technology does not have a life of its own nor does it stand on its own. Its use is always by people in a social context. Because it is such a flexible tool, people make choices in using it, and thus importantly shape its use. What teachers do does matter and will continue to matter. Teachers will help to shape this innovation by their decisions about how to use this new technology, by their willingness to experiment with it and to share what they learn, and by their involvement in research and software development efforts. Finally, they will have an impact on this innovation by their willingness to say no to uses of technology that they believe are not in the best interests of young children.

As I see it, questions about whether and how microcomputers can be used by young children cannot be answered in the abstract. Nor can these questions be answered simply by putting currently available software into classrooms and "seeing what happens." There is a complex and cooperative enterprise called for among teachers, researchers, and developers. We need software that is well-designed for the young child, teachers who are willing to experiment with interesting uses for it in their classrooms, and researchers who can ask insightful questions about the learning which the technology affords. With such interactive endeavors in place (among teachers, researchers, and developers), we will gradually be able to answer some of our questions about the use of microcomputers by young children. We will also discover new questions that will require new research, development, and classroom implementation to answer. At each stage of this recursive process, we may learn more about the questions that have always intrigued us--how children learn and develop, how new technologies transform and support such learning, and how sensitive practitioners create effective learning environments for young children.

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