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ABSTRACT

This brief review of how computers are currently being used and studied in the schools stresses ways in which computers will be used to enhance learning and development, and the need for research on computer learning to consider the multi-functional uses of computers in various contexts, instead of seeing it as a medium with a single effect on learning. A mediational approach based on research with first grade children learning Logo is suggested, and it is argued that any research on computer usage needs to employ a multi-layered approach accounting for: (1) value questions concerning learning content; (2) the social context in which computers are placed; and (3) theoretical principles explaining the process of learning with computers. The choice of Logo for research on learning and development and the structuring of Logo instruction to take into account both the social context of learning and theoretical principles are explained, and the learning environment created through Logo is described in the context of Vygotsky's work and its relationship to the field of metacognition. It is concluded that the value of Logo lies in its propensity to give children a feeling of success; however, it is felt that the implementation of a full-blown computer curriculum for Logo complete with workbooks and how-to instruction would be premature, and that researchers need to use both naturalistic and experimental methods to sort out effects of learning on different types of learners in different contexts. (DJR)

Verbal Mediation in Logo Instruction: Learning from a Vygotskian Perspective

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Before presenting our view on learning Logo, we would like to address first several basic questions which frame approaches to education in this culture. The first two questions, what should be the content of learning, and who will be the learners, are usually pursued by educational philosophers and historians to ascertain the type of knowledge important to preserve, the kind of knowledge needed for the future, and the persons who shall be educated. These are the value laden issues which empirically minded investigators have often overlooked.

The second question, What is the form and structure of learning, is one pursued most often by curriculum theorists, as they examine constraints imposed on learning by the social organization in which it occurs. These constraints can be generated through the instructional arrangements situated within the classroom, the classroom composition at the school level, or at the societal level. A key issue for critical theorists is whether schools help children break free of existing constraints created by class, race and sex differences, or whether they merely reproduce the cultural and economic inequalities within society at present.

The third question, what are the processes by which learning occurs, has a long history within the psychological realm. To the familiar litany of behaviorism, social learning, instructional chains, and aptitude by treatment interaction, comes a new term, metacognition, and a new field, cognitive science, both of which merge ideas from a number of different disciplines. The cross-fertilization of ideas enriches our understanding of how learning is achieved by individuals operating within specific kinds of contexts. Of particular interest is the notion that performance may be context specific; and embedded within a sociocultural nexus which emphasizes not only individual effort, but also the role of social interaction in influencing both learning and development.

These questions become the lens through which we view technological change. Any new technology brings with it a corresponding change in instructional forms and functions, and computers will prove no exception. Given the rapid proliferation of microcomputers into our schools, to the questions posed above can be added a fourth one, What effect will microcomputers have on children's education? To date, there is relatively little substantive research which provides unequivocal answers, but it does seem that the research falls into one of three broad categories: computer as tutor/tool (use of CAI and canned software packages); computer as socializing agent; and computer as mind expander (Wilkinson & Patterson, 1983).

We will stress two points in this paper: (1) the question of real interest is - How will computers be used to enhance learning and development?; and (2) research on computer learning should consider the multi-functional uses of computers in various contexts instead of seeing it as a medium with a single effect on learning. To make our case , we will briefly review how computers are currently being used and studied in the schools, and suggest an mediational approach based on our research with first grade children learning Logo.

Computers in education

By far, computers are most commonly used, and abused, in the form of computer-assisted instruction or computer-managed instruction (CAI or CMI), which in the opinion of many makes the computer nothing more than an electronic worksheet (see Baker, 1981 for a comprehensive overview in this area). Although Kulik (1983) amassed considerable evidence to suggest computers can effectively deliver instruction, particularly in remedial skills, Salomon and Gardner (1986) have pointed out it is an overly simplistic question to ask: Does it teach better than....? Even worse, from a curriculum standpoint, the use of pre-packaged software materials is likely to extend technical control over content areas, and lead to a further deskilling of education (Apple, 1982). The lure of this new technology may tempt teachers to overlook the fact that they themselves are no longer in control of what is being taught, but instead handmaidens to the machine. To sum up our view in this area, using the computer as a tutor in this fashion will exacerbate existing inequalities in the schools, and provide no opportunity for children to experiment with the real learning power inherent in the computer.

Let us leave aside for a moment a discussion of the computer as an <u>intelligent</u> tutor (via interactive software like Logo and other packages developed through research in artificial intelligence), and look at the computer as a tool. Here, we must draw a distinction between the concept of tool as a means to an end (e.g., using a word processing package to write this paper), and tool as an object to think with (following Vygotsky's perspective). If computers are not being used for CAI purposes, then the next most common view is that they are useful for utilitarian functions like database management, word processing, and graphics production. While we certainly don't disagree with these functions, we will suggest that it is using the computer as a cognitive tool which may yield the greatest payoff in learning.

The second broad category of computer research can loosely be labelled under the rubric: computer as socializing agent. This research would include such issues as student access to computers in terms of sex, race, social class, or ability (Becker, 1983; Karoff, 1984; Crist-Whitzel, Dasho, & Beckum, 1984); effects of peer cooperation in computer instruction (Center for Social Or-

ganization of Schools, 1983; Emihovich, 1986; Webb, 1984); and features of the instructional setting in which computers are placed (Amarel, 1983). What quickly becomes very clear from reading this literature is that computer usage cannot be divorced from the social context in which it occurs. Unfortunately, discussions of computer literacy often revolve around selecting the best programming language, and fail to consider the broader social context in which computer use is embedded (Seidel, Anderson & Hunter, 1982).

The third category, computer as mind expander, involves relatively uncharted waters, but also promises to be the most exciting in setting new research directions. Olson (1985) has suggested computers may operate as tools for the intellect, but Salomon and Gardner (1986) have sounded the warning that "mindful" experiences with a computer do not happen automatically. Research on Logo learning has demonstrated their point quite well; in the absence of any formal training or explicitly defined curriculum, children do not discover 'deep' underlying mathematical principles, but instead mindlessly generate steps for the "turtle" to follow (Leron, 1985; Zelman, 1985). Little evidence has also been obtained to demonstrate that programming in Logo leads to a transfer of cognitive skills to a related task; the more successful efforts in this area have depended upon a structured approach which is well grounded in theoretical concepts of learning and development (Clements, 1985; Clements & Gullo, 1984; Miller & Emihovich, in press).

If we advocate using the computer as a tool for cognitive application, does it necessarily follow that we need not pay attention to other types of uses (e.g., CAI, word processing)?, or that we need not consider broader questions such as what should children learn with computers, and how should learning on computers be structured? Not at all. What we suggest in this paper is that any research on computer usage needs to employ a multi-layered approach which accounts for three factors: (1) value questions concerning the content of what children are asked to learn; (2) the social context in which computers are placed; and (3) theoretical principles to help explain the process of learning with computers. We will discuss these three factors in relation to our work on children learning Logo.

Why Logo?

We chose Logo because we had both read Papert's (1980) book, Mindstorms, and became excited about his vision that children learning Logo would learn a new way of thinking about the world because it was based on the concept of syntonic learning, learning which is compatible with the learner's sense of life. Papert felt strongly that too often children are asked to perform tasks which make little sense; his view is consonant with recent trends

in the developmental literature that children perform better when tasks make "human sense" (Donaldson, 1978).

But our choice of Logo was not simply dictated by Papert's views; we too had a vision that all children should benefit from this type of learning, not just a selected few. More specifically, children from minority or low income backgrounds, children labelled as "slow learners" or "poor achievers" are the ones who rarely have opportunities for exploratory or discovery learning; they are the ones who are relegated to endless drill and practice to improve basic skills. While we do not question the fact that this instruction is useful, keeping these children away from more cognitively sophisticated tasks like programming until they have mastered the other does them a disservice. Learning Logo can be as much of a discovery process for them as for the children deemed more 'ready' for programming experiences.

Choosing Logo represented a value decision on our part; we subscribe to Papert's view that it can open children's eyes to new possibilities in learning. What we did not accept, however, was Papert's assertion that learning could take place in the absence of any defined curriculum. How we structured the Logo instruction brings us to a discussion of both the social context of learning, and the theoretical principles we chose to explain the process of learning.

Learning from a Vygotskian perspective

Papert based his concept of Logo on Piagetian principles of learning and development. Recent criticism of Piaget's work suggests he failed to consider adequately the role of social interaction in cognitive development (Doise & Mackie, 1981; Perret-Clermont, 1980). At the same time, Vygotsky's theories of socio-cognitive development are becoming more prominent in this country. Our research draws heavily upon the work of Vygotsky and its relationship to the field of metacognition. According to Vygotsky (1978), children's "higher order mental capabilities" progress from external to internal processes. The mechanism underlying the internalization of higher mental functions is social interaction. Specifically, children learn to internalize higher order mental functions through social interactions, typically with adults or even with more capable peers. Adults serve as mediating agents to help a child learn to control and regulate their cognitive activities. After numerous mediated social learning experiences, externally imposed higher order mental regulative processes are eventually taken over and internalized by the child.

In our view, then, the computer operates as a tool to facilitate meaningful mediated activity. When children 'speak' to the "turtle" using the appropriate commands, they are externalizing

their thought processes in carrying out a solution to a problem (e.g., make a square). The externalization of mental processes through the child's verbal descriptions of ongoing actions and intentions fosters their subsequent internalization. The transformation process from externalization to internalization occurs as children engage in meaningful mediated verbal interactions with adults (and peers) during Logo.

Mediated verbal interaction is the critical component in our research; it provides the "scaffold" (Wood, Bruner & Ross, 1976) by which children cross the "zone of proximal development," defined as:

> the distance between actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, 1978, p. 86)

In our research, the learning environment we created through Logo fostered a collaborative experience in which children were helped to "make sense" of events just beyond their level of understanding. We accomplished this task by employing metacognitive teaching strategies to help children internalize ongoing regulative processes to 'stretch' them beyond their present capabilities. Examples of these strategies are given in Figure 1.

At this point, someone may say, well, the theory is nice, but where's the curriculum? We did have a curriculum to follow in the sense that we generally outlined what we wanted children to learn in a particular lesson. We eschew, however, a formal curriculum in the prescriptive sense of telling teachers what to do step by step. Such a curriculum would destroy the whole point of what Logo can accomplish in helping children to think out aloud, and later internalize, solutions to a problem. Our contention is that teachers need to reconceptualize their role to being facilitators of information (teaching children how and when to use strategies for learning) rather than simply providers of information in the form of direct instruction. Logo and other forms of interactive software lend themselves to this role shift very nicely; the use of CAI does not. Of course, this shift does not require the use of computers; it is already taking place in other areas, especially reading.

Returning to the questions posed in the beginning of this paper, we can summarize our research with reference to those frames. Regarding the content of what should be learned, we feel the value of Logo lies in its propensity to give a sense of control and feeling or power over their "microworld" created by

the "turtle." This feeling is especially important for children who often feel powerless or disenfranchised in the school environment. While research on what cognitive prerequisites are necessary for computer programming, and whether learning Logo or other programming languages leads to transfer of cognitive skills across tasks should be continued, we should not overlook the value of a learning experience which gives children a feeling a success in an arena reserved for the more 'talented' children.

The second question dealt with the form and structure of how learning is organized. At this stage, we feel the implementation of a full-blown computer curriculum for Logo complete with workbooks and how-to instructions is premature (if indeed, we ever should have it). We concur with Salamon and Gardner's (1986) assertion that the context exerts a powerful influence on how learning proceeds; the assumption of uniform treatment effects can no longer be sustained. Researchers will need to use both naturalistic and experimental methods to sort out effects of learning on different types of learners in different contexts. As software becomes progressively more interactive with the development of artificial intelligence, a learning environment where everyone does the same thing may be its first victim.

Finally, considering the processes by which learning occurs means that research on Logo and computer usage will need to be theoretically based. We base our research primarily on Vygotsky, but we are also working on a reference model which ties together theoretical perspectives from several disciplines (Emihovich & Miller, 1985). The collaborative efforts of researchers across disciplines is expected to strengthen our knowledge of how children will use computers to acquire the knowledge they need for becoming citizens of tomorrow's society.

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Figure 1

Cognitive Teaching Acts for Logo Training

Name of Act	Description	Examples
Meta elicit (Mel)	Agent asks receiver to recall information previously learned	-Remember what those were for? -What is ___ supposed to do? -How do we get a new line?
Meta evaluation (Mev)	Agent asks receiver to evaluate ongoing actions	-What happened? -What did the turtle just do? -What's going to happen when we put _____? -Do you know why that's there? -How far did he go? -Did the turtle do what you told him? -Did you want him to go that way? -Do you know what I am doing?
Meta prompt (Mp)	Agent is asking receiver to think about or reflect on what they want to do next.	-What do you want the turtle to next? -Which way do you want him to point? -How will you make him go there? -What else do you want him to do?
Planing prompt (pp)	Agent indicates there is a next action planned but it has not been in response to reflective thinking.	-Let's try the other one. -Let's make him go forward and put a line up here.
Direct intervention (Di) or Direct (D)	Agent explains and demonstrates what to do to the receiver Agent explains or tells what to do the receiver	-Let me show you something. -And now put 'd' -Put space and then 70. -Tell Kia what she should do.
Self-cuing (Sc)	Agent verbalizes some meta and other direct statements to guide their actions.	-OK, What am I going to do? -Hmmm, I will have to put in a BK. -I think I know what happened? -How will I make hime get there? -Did that turtle do what I told him?