

COMPUTERS, CHILDREN AND EPISTEMOLOGY

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When was the last time you spoke of epistemology when you thought of elementary school children? If you're like thousands of educators before you, the answer is probably "never." When was the last time you recognized, as an educator, that the latest educational innovation was hardly an innovation but only a recycling or restatement of an idea or method that had seemingly been in existence for decades? You and the aforementioned thousands of educators probably echo "often."

Surely, many an educator would be fascinated by the thought of a young child as epistemologist: one who practices, participates in, enjoys learning theory. Surely, any educator worth his salt yearns for the opportunity to be part of the excitement that exists in true innovation.

These two elements may well have been the prime motivating forces in the implementation of a computer education program at Punahou School that now spans grades K through 12. Prior to 1981, the study of computers existed only in grades 9-12 under the auspices of the mathematics department. With the advent of microcomputers, however, and with various members of the faculty and administration anticipating their potential impact on education, the 1981-82 year was designated a "study year," one in which the faculty vowed dedication to research the subject and in which the school was to present in-service seminars and workshops.

The latter took the form of a two-day "demystifying" seminar in December, followed by a five-session "Introduction of Computer Programming" course in the spring. Each involved roughly 100 volunteer participants. Concurrent with the spring course, students in grades 5-7 were already embarking upon introductory courses in BASIC programming — conducted by teachers with varying degrees of computer background and skill. Early on, however, the philosophy of the teacher as guide and participant in a joint learning process was established. Underlying that was an acceptance of a model in which students were encouraged to innovate, to explore, to take command of the computer as a learning tool. Programming the

computers created a free-form curricula in itself — the teachers' task often was to ensure that the students remained unfettered.

Even as these first tentative steps were being taken, thoughts were turned towards the needs of younger students for the ensuing fall. And that led to explorations about LOGO, perhaps the newest of computer languages and certainly the most suitable for young children. Developed by Seymour Papert at MIT and based largely on Jean Piaget's theories of child development, LOGO seemed to suggest potential far beyond the computer-assisted instruction models prevalent in some elementary schools around the country. A visit to the Lamplighter School in Dallas, Texas — a pilot school for LOGO — a careful perusal of Papert's *Mindstorms*, and some reading about other LOGO experiments on the eastern seaboard confirmed the notion that what had already begun at Punahou might be further enhanced by attempting to create a LOGO environment with the very youngest of children — in this case those in kindergarten through fourth grade. One could not help but be attracted to visions such as the following from Papert:

"... my central focus is not on the machine but on the mind, and particularly on the way in which intellectual movements and cultures define themselves and grow."¹

"Two major themes — that children can learn to use computers in a masterful way, and that learning to use computers can change the way they learn everything else — have shaped my research agenda on computers and education."²

"The child, even at preschool age, is in control: The child programs the computer. And in teaching the computer how to think, children embark on an exploration about how they themselves think. The experience can be heady: Thinking about thinking turns the child into an epistemologist, an experience not even shared by most adults."³

Rarely, if ever, would one find a curriculum for elementary school children with such a focus. Yet consider how satisfying it would be to deal with students far beyond the traditional school curriculum. No matter how abundant a school's curricular offerings, computers appeared to have the potential for providing a new mode of learning, one which could tap the wellsprings of rich resources within children, those resources which teachers intuitively know lurk below the surface of traditional schooling.

As if to underscore the quality of child-centeredness in computer education, Papert's ideas gnawed at the base of an inherent weakness in education throughout schooling: the fear of failure.

"Our children grow up in a culture permeated with the idea that there are 'smart people' and 'dumb people.' This belief about the structure of human abilities is not easy to undermine. It is never easy to uproot popular beliefs."⁴

"The ethic of school has rubbed off too well. What we see as a good program with a small bug, the child sees as 'wrong,' 'bad,' 'a mistake.' School teaches that errors are bad; the last thing one wants to do is pore over them, dwell on them, or think about them. The child is glad to take advantage of the computer's ability to erase it all without any trace for anyone else to see. The debugging philosophy suggests an opposite attitude. Errors benefit us because they lead us to study what happened, to understand what went wrong and, through understanding, to fix it. Experience with computer programming leads children more effectively than any other activity to 'believe' in debugging."⁵

"In the LOGO environment, children learn that the teacher too is a learner, and that everyone learns from mistakes."⁶

Thus it occurred that the model of computer education at Punahou developed its philosophical underpinnings. Reliance on intuition, on trial-and-error experiences, and on the "debugging" mode itself were innate in the establishment of the Punahou program — no testing-and-measuring, no neatly prescribed behavioral objectives, no scope and sequence. All those will have to come in due time, but, interestingly enough, not at this time.

After the first year and a half of implementation of the program, the results have been exhilarating. First and foremost, the students have taken to their computer studies with no apparent temerity. They take charge of their environments with alacrity, sharing and experimenting with peers both young and old. Secondly, the program has become an important vehicle for sharing ideas with the state's educational community. Throughout the nation,

one of the vital concerns in computer education has been that because of their cost computers may cause greater inequity among schools. If efforts to share experience and information are incorporated into the planning that will serve as the model for our state, certainly all students can benefit equally. From the interaction among educators that has developed here during the past year, there already appears to be an emerging philosophy which may well put the student in control of the computer at an early age.

Inevitably, one must return to these two engaging thoughts: (1) rarely, perhaps never, has education of elementary-age children embraced an epistemological concern so dramatically, and (2) seldom has an educational trend been so truly new, so really innovative, as has computer education. The excitement of dealing with these matters could hardly find its equal elsewhere in education.

Implementation

In planning the direction of Punahou's computer education, two factors considerably influenced our decisions about the computer curriculum: Seymour Papert's philosophy of computer use as stated in *Mindstorms*, and our own experience with computers on a trial basis. While Papert opposed using BASIC with young children, we chose to determine for ourselves if this would hold true for our students. During the study year, several groups of first, second, and third graders were teamed with fifth and sixth graders working with BASIC. The younger students responded to some interactive programs set up for them and tried some beginning programming, but it was soon apparent to us that BASIC was a difficult programming language for young children. Computer-assisted instruction software was previewed, and most proved inadequate for our needs as they failed to utilize the potential of the computer as a tool for creative thinking. The loan of a Texas Instruments computer and a LOGO module let some of our teachers and students experience LOGO. They were thinking with the computer and executing commands to test their ideas. We all began to see the possibilities of a new kind of learning emerge. It was apparent that the philosophy of LOGO met our objectives of putting the child in control of the computer and using it as a tool to think with. Once the decision was made to use LOGO, the hardware choices were narrowed to the Apple II+ and Texas Instruments 99/4A computers, the only two computers providing LOGO at the time. Color monitors, disk drives, and expanded memory capacity were necessary peripherals for our LOGO use. Apple and Texas Instruments offered different versions of LOGO, each with some unique features. The purchase of 12 Texas Instruments 99/4A computers for

grades K-2 and 15 Apple II+ computers for grades 3 and 4 allowed us to enjoy the best qualities of both versions. Special furniture was designed for the computers to make each unit portable and secure. Designs were approved and the carts were built by school personnel. A large gift from a trustee financed the major cost of hardware purchases. Maintenance agreements called for temporary replacement of any computer if service required more than 24 hours.

Teacher training was the next major consideration in implementing LOGO in the classrooms. Following Papert's recommendation, we chose to put the computers in the classrooms rather than in a computer center staffed by a computer expert. This meant 30 teachers and nine assistants needed to learn LOGO. Many of the teachers had already expressed an interest in learning programming by attending the workshop and five-session BASIC course during the study year. Since there were no local resources available to do LOGO training, the two administrators for grades K-4 went to the mainland to receive special training. By the end of the summer, having spent three months working intensively with LOGO, they were able to plan and lead the workshops for the teachers. During the faculty orientation week immediately preceding the opening of the 1982-83 school year, teachers were given a four-hour session to introduce them to LOGO. Once-a-week workshops continued throughout the school year where teachers could share their experiences and continue to learn new LOGO commands. These meetings provided valuable support to teachers who were actually learning with the children. While some of the faculty worried about teaching a subject they were not thoroughly prepared for, they relaxed when they observed how interested the students were in LOGO and how easily they became accustomed to the computer. Teachers realized they need not be absolute experts on all aspects of LOGO, and they could enjoy discovering new ideas with the children.

Teaching materials for the computers were also developed during the summer. Two sets of activity cards were written, one for each version of LOGO. Each card was a lesson teaching a new command, presenting a practice activity, or giving a challenge. After the first few cards, most older children were able to work independently with them, proceeding at their own speed and creating their own activities. Other teaching aids were developed for use by teachers presenting lessons. Revised versions of the cards have been written, and a commercial package published by Scott, Foresman and Co. is available.

The scheduling and grouping of computers was quite experimental the first year; teachers were encouraged to try various configurations. During the first semester,

when computers were being introduced for the first time to all children, the computers traveled to each classroom in sets of seven, eight, or nine for a period of six days. This allowed for large-group teaching of initial lessons, with every child having time each day on the computer. It took the entire first semester for each classroom to have the computers for six days. In the second semester, grades one and two sent three computers to each classroom for 21 school days. This model worked very well and children made good progress working on the computer on a daily basis for this amount of time. In grade three, the teachers chose to place one computer in each classroom for the entire second semester. This proved to be the least successful model, as it was a long time between turns at the computer, and with a single machine in the room, the teachers found they gave it too little attention. During the 1983-84 school year, they rotated the computers in groups of three for a period of six out of every 18 days. Grade four continued moving their computers in a large group of eight. Each class had the computers in its room for 20 days during the year, and during that time, teachers focused their lessons on the computers. Also, team-teaching is used in the fourth grade where each student has a math/science teacher and a language arts teacher. The computer experiences doubled for every child since they used the computers in both classes. Language arts teachers worked more with word and list procedures, while the math/science teachers did more with turtle graphics. The kindergarten circulated two computers to each classroom for approximately three weeks each semester. Children received off-computer instruction on LOGO also, with many preparatory lessons given even before the computers came into the classroom. The younger children experienced programming mechanical toys that obeyed commands similar to those given the turtle in LOGO.

Probably the most difficult aspect of using LOGO during the 1982-83 school year was the lack of available resources. In this new field so much is yet to be done, and eventually will be. Only two books were in print on LOGO, so we relied heavily on periodicals. Resources of special value include the MIT LOGO Memos, Computing Teachers, Electronic Learning, and the August 1982 issue of Byte magazine. On a continuing basis, two monthly newsletters, "Turtle News" and "The National LOGO Exchange" have been of exceptional help. Telephone calls and personal correspondence with other LOGO users have also aided us. Many LOGO titles are expected to be on the market soon and resources should be plentiful in the near future.

Evaluation and Future Plans

Evaluation of the first year of the program was informal.

Teachers were invited to discuss their observations and insights concerning the program during the weekly workshops and at sessions following completion of their scheduled period with the computers. At the end of the year, there was an opportunity to comment in writing in annual reports and also in a separate topic-centered paper about the computer experience.

Below are teachers' comments about each of the topics discussed:

Cognitive learning, especially in problemsolving, predicting, spelling, geometry, proofreading, writing, and comparisons of size, shape, number, and distance. The challenge activities were an effective way to present concepts, yet allow for individual differences in approaching problem situations. Getting the "bugs" out was one of the best parts of computer learning for problemsolving. Thinking skills showed up, especially for the shy child who might not speak up in class; thinking skills become apparent when working on the computer. At times I could almost "see" the children "think" and that's a thrill! As children engaged in problemsolving, they predicted, estimated, proofread, and compared; they quickly discovered how precise they must be in spelling and typing. I was especially thrilled to see my "slower" readers thrive on these machines. Even "mistakes" gave surprising off-beat results that often led to new challenges!

Affective learning revealed in courtesy, sharing, attitudes, ethics, motivation and persistence. Teachers taught children. Children taught teachers. Children taught children. What an environment! One student reported that he thought the computer was more fun than playing on the playground. He continued to write, "I wish it were my brother, but the only thing wrong is my mom would be a computer." The element of creativity provided wonderful feelings of self-confidence and self-satisfaction. Hands-on experiences with the computers were definite highlights in my classroom. Peer teaching and sharing of ideas took place. Excitement in learning and experimentation without hesitation were common occurrences. The children might tire of drill-type programs, but LOGO is challenging. The kindergarten age is receptive. Some children in the second grade were working on programs up to the very last minute of school on the last day. Wonderful to watch an otherwise "slow" student do well and become highly motivated on the computer. A few children said they were "bored" with computers; these were usually the ones who had some difficulty or who were not adept at creating new programs. There is no doubt that the children enjoyed their first activities with the computers. It was interesting to note that if a child is

hesitant — does not like to make decisions, is afraid to make a mistake — that these same attitudes are also visible when he or she comes to the computer. The younger children were not always good at sharing one computer; what was more successful was to have two computers side by side, so that they could share ideas! They love to demonstrate how they did a program. Attitudes about the ethics of copying commercial disks concern me. The children were respectful of each other's work; there were very few incidents such as turning off someone's program in progress. When the computers moved on, the children said they were "lonely."

Off-computer instruction. In my class, we had good fun simulating the turtle and sprites in movement activities with visual aids. There were successful follow-up activities; in kindergarten children enjoyed drawing what they had first done on the computer. Interviewed relatives and friends about computers and shared their homework. The "brain" toy was used to show programming in kindergarten. "Turtle walking" helped children visualize geometric figures and concepts of "RIGHT 45" or "LEFT 90" with their own bodies. Thought the sprite hats were flaky, but the games did work in teaching concepts. The eight days of off-computer instruction, discussing what the children think a computer can do, studying and working with a copy of the computer keyboard, and dramatizing computer commands, saved a lot of time once we got the computers. Each day's activities were recorded in a notebook.

Integration of computer learning with other content areas. Creative writing, math, counting, geometry, reading, spelling, movement, vocabulary, proofreading, art, following written directions, written expression, social studies (more is anticipated next year). Concerned at the beginning about the lack of direct teaching of basic subjects while the computers were in the room; more independent work and small group work was accomplished during this time instead.

Physiological effects on eyes and posture, including stress. Eyestrain not noticed in children (not on the computer long enough). Posture okay; stress on teacher only! If they were on the computer for 45 minutes, a few complained of eyestrain. Are posture and hand position important for typing? I did notice stress due to frustration with some of the children. Good eye-hand coordination and posture were encouraged. We observed little stress in kindergarten; individuals seemed to know what they could handle and be comfortable with.

Equipment reliability, computer maintenance and ergonomic factors of the furniture design. Great . . . very few problems. We had minor breakdowns which were fixed

by turning off the machine and letting it "cool down." Excellent support from the dealer, who came and exchanged any computers still under warranty that had a problem. The K-2 furniture could have been a little lower to fit the kindergarteners, and some chairs didn't quite fit, but otherwise the furniture designed and built at the school was described as excellent.

Materials such as software, activity cards, teachers' guides, children's notebooks, manuals, newsletters and other resources. Activity cards provided a good foundation and were super to start with. All were quite helpful and organized (they were revised throughout the year). Challenge activities were helpful, especially the second semester. Children can also make up their own to challenge one another. Computer notebooks or cards were kept in many classes. The children would write a program before actually doing it on the computer. The notebook provided a reference of programs and commands for each child and a record for the teacher of what each child had done; sometimes this record included drawings of what happened on the screen. Parents enjoyed looking over the notebooks when they came to see a computer demonstration by the children.

Workshops for the faculty, parents, teachers from other schools and other groups. All were helpful. Felt very positive about faculty workshops and after-school help sessions. They were most valuable when actually working on computers (sometimes there were not enough computers for the number of teachers who wanted to practice). Weekly workshops were voluntary; there were some inquiries about credit or other incentives for additional training in the future (one teacher used a summer sabbatical in 1983 for LOGO courses on the mainland). Time for teachers to experiment and plan on the computer was mentioned as a problem; one was always in the office area for teachers. The two "LOGO For Parents" course were filled soon after they were announced. Several courses and workshops for educators in the community have also been taught, including six "LOGO For Teachers" courses in the summer of 1983, involving 120 teachers.

Parental attitudes and their interest in participation at school, as well as the effects of using computers at home. Parents were excited; one class had 100 percent attendance for a show-and-tell demonstration by the children. Some children have computers at home but having a computer at home is not always useful at school; there's more games-playing at home and more exploration of what the computers can do at school.

Plans for the 1983-84 school year included the acquisition of six Commodore 64 computers which will also be used

for LOGO. This is compatible with our philosophy of encouraging the children to become familiar with various types of computers. Word-processing skills will be introduced, beginning at the second-grade level. A continuing theme will be to fit learning with computers into the curriculum in order to make the most of this new resource, while keeping an appropriate balance with all subject areas.

Professor of mathematics education Anthony Picard and Charles Guili, evaluation specialist, both with the University of Hawaii at Manoa's College of Education, will continue their research project at Punahou, which they began during 1983, for the next two years. The purpose of the project is to gather data in two major areas: (1) Cognitive Skills, which include (a) communication (spelling, punctuation, sentence structure) and (b) reasoning and problemsolving; and (2) Attitudes toward (a) school and education, (b) cooperation and sharing, and (c) technology.

The project will be descriptive and the data collected will describe the changes observed in the children. The researchers hope that the conclusion based on the data will provide some insight into the processes which shaped the changes as well as documenting the changes themselves.

After only a year-and-a-half of experimentation and exploration, we feel reaffirmed in the decision which led us to follow Seymour Papert's view:

"In my vision, *the child programs the computer* and, in doing so, both acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building."⁷

Footnotes

¹Papert, Seymour. *Mindstorms: Children, Computers and Powerful Ideas*, Basic Books, 1980, p.9

²*Ibid.*, p. 8.

³*Ibid.*, p. 19.

⁴*Ibid.*, p. 43.

⁵*Ibid.*, p. 114.

⁶*Ibid.*

⁷*Ibid.* p. 5.

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