The Children's Machine

RETHINKING SCHOOL IN THE AGE OF THE COMPUTER

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Teachers

THERE was a time when I believed, as many people do, that teachers would be the most difficult obstacle in the way of transforming School.* This simplistic belief, whose insistent presence is in reality a far greater obstacle to educational change than the fact that some teachers actually are conservative, can be traced back to deeply rooted cultural representations. In my case, I remember being impressed in junior high by George Bernard Shaw's cynical aphorism: "He who can, does; he who cannot, teaches." Someone who "cannot" is not likely to be a constructive partner in bringing about major change.

Culturally shared negative attitudes toward teachers are nourished by personal experiences. As a rebellious child I saw teachers as the enemy. Then, with time, these feelings merged with a theoretical position which had the illogical consequence of further demonizing teachers by identifying them with the roles that School forced on them. I disliked School's coercive methods, and it was the teachers who applied the coercion. I disapproved of judgment by grading, and it was the teacher who gave the grades.

*The ideas in this chapter took shape in conversations with Carol Sperry.

Yet I certainly had grounds in early experience for a more sympathetic view of teachers.

Like most people with generally bad memories of school, I have some wonderful impressions of individual teachers. For example, Mr. Wallis has lost none of his presence. "Daisy" (as we called him, though not to his face) officially taught me Latin and Greek, but gave me far more insight into Lewis Caroll than Cicero or Herodotus. He also left me with an eleventh commandment: "Thou shalt invent three theories every day before breakfast and throw them away before dinner." I loved him, and see even now that I am indebted to him for at least some strands of the playful epistemological stance that informs my present thinking. But at the time, and until recently, I classed Daisy as an exception, thus leaving my antiteacher prejudice as entire as the racism of those who say: "Me? Why, some of my best friends are. . . ." The net effect was not to think better of teachers but to say, "Daisy's no teacher, he's a real mensch." I had to write *Mindstorms* and develop Logo to find out how many other teachers are, too; it is School that disguises them as something else.

Logo gave many thousands of elementary teachers their first opportunity to appropriate the computer in ways that would extend their personal styles of teaching. This was not easy for them. They were frustrated by poor conditions: They usually had to work with minimal computer systems and often had to share them among several classrooms; opportunities to develop their own computer knowledge were limited; and School's immune response often snatched away the successes they did achieve. Even the Logo they had in those days looks sadly primitive when I look back on it from the perspective of another decade of growth of the language. More recent versions of Logo are far more user-friendly, intuitive, and flexible. But although only a minority of these pioneering teachers succeeded in using Logo to build a satisfying classroom environment, what they tried to do is a rich source for understanding the force for change latent in their profession. It turned my own thinking around completely. One thinks of a book

as a vehicle through which the readers come to understand how the author thinks. *Mindstorms* worked for me in the opposite direction as well.

I had not written the book with teachers in mind; at most, I imagined it being read by a small vanguard among them. So when the estimated number of teacher readers climbed into six digits, I was pleased but perturbed. What did they like in my book? It was troubling that there was something about my own work I did not understand.

Fortunately, the book also helped me find answers to the questions it raised. It was a passport into the world of teachers. I received hundreds of letters from teachers telling me about their yearnings and hopes, their plans and resentments. I was flooded with invitations to give speeches and seminars, visit schools, and participate in projects. All this offered a special opportunity to understand what teachers were expressing in their experiments with computers. As I did so, my identification of "teacher" with "School" slowly dissolved into a perception of a far more complex relationship. The shift brought both a liberating sense that the balance of forces was more favorable to change than I had supposed and, at the same time, a new challenge to understand the interplay of currents in the world of teachers that favor change and that resist it. Finding ways to support the evolution of these currents may be among the most important contributions one can make to promote educational change.

As background to understanding these currents, I begin by looking at a story recounted by education writer Fred Hechinger in a sorely missed *New York Times* column. I cannot imagine a teacher who will not hear in the story the echo of some personal experience.

The principal of a New York school dropped in to listen to a chemistry class. The lesson was brilliant. The principal was enthralled. After the class he congratulated the teacher on a superb piece of teaching, and then asked to see his lesson plan. The teacher replied that since he knew this material so well and cared

about it so much, he didn't think he needed a lesson plan. The principal clearly had no complaint about the lesson itself, but the teacher was guilty of not following procedures and had a letter of reprimand placed in his file.

There is more than one way to read this poignant account of a system defeating its own purposes in the attempt to enforce them. One can take it as a satirico-comic account of a run-in between an overzealous supervisor and a naïve worker, the former ridiculously literal-minded about a minor transgression of the letter of the rules and the latter refusing to understand the importance of appearances, which could have been saved by writing a token lesson plan. On this reading, the story is only incidentally about School; it could be matched by bureaucracy stories from other walks of life.

On another reading, however, the story touches the nerve of what School is really about. It evokes tensions between a warm idea of School as a nurturing place for children and a chilling idea of School as a machine to perform laid-down procedures. It evokes yearnings for teaching that will help us fall in love with knowledge, and frustrations at being made to learn lists of facts, loved or not, that experts have decided must be known.

The choice between these readings of Hechinger's story reflects the central question about education: Is the trouble with school a superficial one that could be fixed by a good dose of good will and common sense, or is it a deep flaw in the foundational assumptions on which the entire system is built? Is School's malady a cold or a cancer?

The meaning of these two views is brought out by comparing Hechinger's incident with my central example from the previous chapter. School has evolved a hierarchical system of control that sets narrow limits within which the actors—administrators as well as teachers—are allowed to exercise a degree of personal initiative. Neither side ever fully accepts these limits. The Hechinger story shows a border skirmish in a permanent struggle for power in which participants constantly test their strength without actually

challenging the system itself. The seeds of a sharper challenge were present in the decision to allow Brian and Henry to spend their time on computer choreography. The chemistry teacher could, had he wished, have written a token lesson plan, as many of his colleagues routinely do. Thelma did not have this option. There could not be a lesson plan for the simple reason that there was no "lesson."

Thus the original decision about how to use computers placed the teacher on a collision course with School's system of control: As soon as she decided not to control the students, she took away School's established way of controlling her. The question has moved from how power is distributed within the educational hierarchy to whether hierarchy is an appropriate mode of organization for education. There are activities where hierarchical organization is obligatory: The military is an obvious example. At another extreme there are activities where any sensible person would judge hierarchical organization to be absurd, for example, in poetry or painting. In other areas there is room for choice in the balance between hierarchy and its opposite—for which I follow Warren McCulloch in using the name *heterarchy,* which suggests a system in which each element is equally ruled by all others. Where on this spectrum between soldiering and poetry should one place the organization of a school?

There is a danger of thinking about this as a "management problem" that a school could address (and many do) by bringing in a general-purpose expert on how to run organizations. But injecting a new management plan into an otherwise unchanged School is like injecting computers or a new curriculum while leaving everything else unaltered. The foreign body will be rejected. School's hierarchical organization is intimately tied to its view of education and in particular to its commitment to hierarchical ways of thinking about knowledge itself. What one will consider to be the proper place for School on the heterarchy-hierarchy scale of organizational forms depends on the location of

one's theory of knowledge on the heterarchy-hierarchy scale of epistemologies.

A caricatured hierarchical theory of knowledge and of school might run something as follows: Knowledge is made of atomic pieces called facts and concepts and skills. A good citizen needs to possess 40,000 of these atoms. Children can acquire 20 atoms per day. A little calculation shows that 180 days a year for 12 years will be sufficient to get 43,200 atoms into their heads—but the operation will have to be well organized, for while some overrun on time can be absorbed, as little as 10 percent would make it impossible to achieve the goal. It follows that the technicians in charge (hereafter called teachers) have to follow a careful plan (hereafter called the curriculum) that is coordinated over the entire 12 years. They must therefore be required to write down each day which atoms they have delivered into the students' memory banks. The problem of quality control is facilitated by the discovery that there are hierarchical relations among the atoms: Facts fall under concepts, concepts can be classified as subjects, and subjects split up as grade levels. A hierarchy of people can be constructed to match the hierarchy of knowledge. Teachers can be supervised by curriculum coordinators and department heads, these by principals, and these in turn by superintendents.

Such a theory might appeal to the analogy of building a Gothic cathedral out of 40,000 blocks of stone. Clearly, strict organization is needed to perform such a task. One cannot have individual workers deciding that they want to put a block here or there just because they are inspired to do so. Educating a child is a similar process. Everyone has to follow the plan.

Of course, nobody would subscribe to these theories in a literal sense. Yet I honestly believe that they capture the essence of the academically respectable theories from which the hierarchical organization of School derives its legitimacy. If the Gothic cathedral model of learning were true in principle, Thelma would have been courting disaster by letting the children in her class decide, so to speak, where to place bricks; and the administration of her school

would have been severely remiss for allowing her to do so. But she was not being lax, lazy, or irresponsible. Teachers who give so much autonomy to their students are thereby declaring their belief in a radically different theory of knowledge, one that entails far more work for them as well as for their students.

My use of the term "theory of knowledge" rather than "method of teaching" is deliberate. Progressive educators do not see themselves as offering an alternative way for students to learn the same list of items of knowledge. They value a different kind of knowledge.

For example, I occasionally use an elevator that has a security code. One has to key in a four-digit number before it will move. Since the code is changed frequently and I use the elevator only rarely, I usually remember each new code in a vague form. "There's a 17 and a 34," I say to myself; "perhaps it is 1734 or 3417, or maybe the numbers are 71 and 43." I make a few tries and the elevator moves. I think that's fine. It works. In school, however, I would fail the elevator-skills test. This is a trivial example of an important phenomenon that I call knowledge-in-use. When knowledge is doled out in tiny pieces, one can't do anything except memorize it in class and write it down in the test. When it is embedded in a context of use, one can push it around and fix minor bugs such as reversing the digits of the elevator code.

I am not suggesting that knowledge-in-use is the essence of progressive epistemology or even that every progressive teacher would accept this principle. I am using it here only as an example of a "different kind of knowledge." What teachers who reject School's philosophy of education actually believe varies widely. In fact, every teacher should be encouraged to go as far as possible toward developing a personal style of teaching. A less specific metaphor that I used in *Mindstorms,* however, does seem to capture a widely shared element well enough to provide a framework for looking more closely at the aspirations and problems of progressive teachers. The basis of the metaphor was an observation about the idea that children display "aptitudes" for their various

school subjects. It is thoroughly embedded in our culture that some of us have a head for figures while most don't, and accordingly, most people think of themselves as not mathematically minded. But what do we say about children who have trouble learning French in American schools?

Whatever the explanation of their difficulty, one certainly cannot ascribe it to a lack of aptitude for French—we can be sure that most of these children would have learned French perfectly well had they been born and raised in France. Perhaps they lack an aptitude for learning French as it is taught in American schools, but that is a different matter altogether. In the same way, we have no better reason to suppose that these children who have trouble with math lack mathematical intelligence than to suppose that the others lack "French intelligence." We are left with the question: What would happen if children who can't do math grew up in Mathland, a place that is to math what France is to French? Many teachers accepted the challenge to build something like a Mathland in their classrooms, and took Logo and its turtle as building material. Thelma's classroom shows in a general way how many went about doing this. Following this metaphor, one can think of Brian and Henry as being in Mathland; what they were doing with the computer was more like learning French in France, while what happened in the regular math class was more like learning math as a foreign language. In these computer contexts, as in learning French in France, the learner can begin by knowing something in a very fumbly sort of way before it becomes established. In the math class, where knowledge is not used but simply piled up like the bricks forming a dead building, there is no room for significant experimenting.

Many progressive teachers might have doubts about whether creating a Mathland is really feasible and hesitations about what inconveniences it might bring if it is; but leaving aside practical considerations, it seems obvious to them that learning French in France and math in Mathland is in principle a better way than those of the traditional classroom.

The immediate consequence for the practice of teaching is the one I have already noted. The learning of a dead subject requires a technical act of carving the knowledge into teachable bites so that they can be fed to the students one at a time by a teacher, and this leads straight into the traditional paraphernalia of curriculum, hierarchy, and control. By contrast, Brian and Henry were able to find their own way to structure their knowledge with only occasional advice. Learning-in-use liberates the students to learn in a personal way, and this in turn liberates teachers to offer their students something more personal and more rewarding for both sides. But this prospect does not come without problems, and some teachers will see it more as a threat than as a liberation.

Thelma's rewarding feeling that she had exercised a creative (and unintentionally subversive) act in setting up her plan for computers brought psychological as well as bureaucratic risk. School's definition of roles and procedures restricts the teacher but also offers protection, as we see in the following story whose main features I have heard from many who have taken the same course as Thelma.

The following is a reconstruction of what I heard from Joe, a fifth-grade teacher:

> From the time the computers came I began to be afraid of the day my students would know more about programming than I ever will. Of course, at the beginning I had a big advantage. I came fresh from a summer workshop on Logo, and the students were just beginning. But during the year they were catching up. They were spending more time on it than I could. Actually, they didn't catch up the first year. But I knew that each year the children would know more because they would have had experience in previous grades. Besides, children are more in tune with computers than we grown-ups.
>
> The first few times I noticed that the students had problems I couldn't even understand, let alone solve, I struggled to avoid facing the fact that I could not keep up my stance of knowing

more than they did. I was afraid that giving it up would undermine my authority as a teacher. But the situation became worse. Eventually I broke down and said I didn't understand the problem—go discuss it with some of the others in the class who might be able to help. Which they did. And it turned out that together the kids could figure out a solution. Now the amazing thing is that what I was afraid of turned out to be a liberation. I no longer had to fear being exposed. I was. I no longer had to pretend. And the wonderful thing was that I realized that my bluff was called for more than computers. I felt I could no longer pretend to know everything in other subjects as well. What a relief! It has changed my relationship with the children and with myself. My class has become much more of a collaborative community where we are all learning together.

Reflection on this story will show that there is no simple answer to some obvious quantitative questions that some readers must by now have asked: How many teachers fit the optimistic description of Thelma? How far would they take these ideas? How much effort and sacrifice would they make? My description gives Thelma the purity of a rare dedicated idealist. Many more have the doubts, the fears, and the ambivalence that Joe shares with most of the teachers who were drawn to experiment with computers as an instrument of change. Joe embarked on the experiment with trepidation. He did not fully see in advance what problems he would have, and when they came up he hesitated. Events turned out well in his case, but most others in his position balked and retreated. Many had their computers merged into computer labs. Some followed them, giving up the classroom to become computer teachers. Many felt seduced and abandoned by the talk of a computer revolution as the use of the computer became routinized. Just how many stayed in and how many dropped out is too hard to determine and would, in any case, not be worth knowing since we see from Joe's account that the individual case depends on a fragile balance that can tip one way or the other. What is certainly of no value whatsoever for those interested in change is to play down

the adverse factors: Only by understanding them can we craft sensible strategies for the future. By the same token, they give little grounds for comfort to those who still predict that computers do not have a significant future in education.

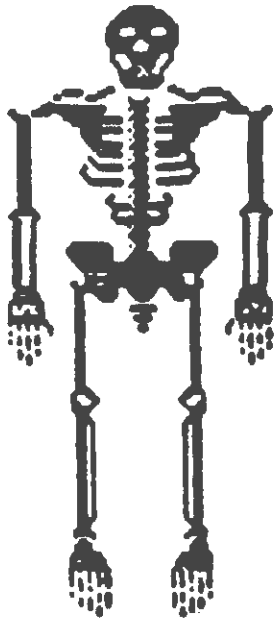
Despite his doubts, Joe went further than the others I have mentioned so far. Hechinger's chemistry teacher tried to express his own intellectual enthusiasm in his teaching; Thelma tried to create an environment in which children would develop their own enthusiasms; Joe took a further step by explicitly formulating the idea (which the others may have had tacitly) of joining the fun as a co-learner with his students. The progression is psychologically understandable. Wanting to learn is a basic human desire, and being with children who are doing it while being deprived oneself is like being a dieter watching the diners in a fine restaurant. Why don't all teachers do it?

Many aspects of School block teachers from the fulfillment of functioning in a class as co-learners. The mundane matter of schedule is most often mentioned if one asks progressive teachers. They say that there simply is not enough time. I think Joe shows the fallacy in this explanation, however. There would indeed not be enough time for him to keep everything else and also get in his own learning. But he had the courage to implement a plan with a better chance of working: He changed the life of his class in such a way that students could give as well as take, and his learning was not competitive with theirs but contributed to it. To do this he had to face something that it took courage to admit: Most of the work he made his students do was too boring to entice him to join in! The computer changed the situation because it itself is an interesting object to learn about and because it added dimensions of interest to other areas of work.

What I actually saw Joe doing with his class involved a much broader range of learning than the technical aspects of computer programming that had been the object of his fears. Some of his students were doing work like Brian and Henry, but most were engaged in projects of a very different kind in which mathematics

was integrated into fact-oriented subjects such as history or science. An aspect of these projects was something I first saw in the work of a fourth- and fifth-grade teacher at the Hennigan School in Boston.

Before computers entered her life, Joanne had developed a project as part of her classwork on human biology. The topic of study was the skeleton, and her style of handling it was to ask the students to choose a bone and make a report on it. When the computers came she simply did what she had always done, except that the students knew enough Logo by then to make their report on the computer screen instead of using pencil and paper. In one sense nothing changed except for a shift of media. But the shift had consequences. One of these was related to the fears ex-



This picture was generated by a LogoWriter program written by four fourth-grade students.

pressed by Joe. The computer is an open-ended technical device that incites at least some students to push their knowledge to the limit to enhance the project through an unlimited variety of "effects"; thus learning more about computer techniques becomes part of the project in a way that had not happened with pencil and paper. This might seem to distract from the "main purpose," which was studying biology. It did not: Thinking about representations on the screen produced a richer engagement with the skeleton than had been usual in the precomputer days. The skeleton illustrated, the collaborative work of four students, shows several features that are typical of what happens in a computer context.

First, the students transformed the assignment of representing a bone into one of representing the entire skeleton, a goal that was made possible by the fact that the computer allowed much better conditions of work: Parts made by the collaborators could be put together more easily. A close look will show that modules could be used in several places, and most important, changes would be made easily without the messy process of erasing or the tedious one of starting over. Second, these same working conditions facilitated a double intention that is clearly visible in this object: The figure was made with an eye to visual aesthetics as well as to scientific accuracy. This raises challenging issues about the nature of knowledge and the criteria for judging it. I would call it an epistemological responsibility of the teacher to enter into discussion with these students (which in fact I had the privilege of doing) about what was sacrificed in each for the sake of the other. There can be no absolute answer, but there can be articulate and thoughtful discussion.

The issue of science and aesthetics is just one of many that make a different kind of demand on—and offer a richer kind of opportunity to—a teacher than is usual in a science class. Whether this is seen as a demand or as an opportunity, it certainly requires knowledge and sophistication for which there is no place in the course catalog of the typical school of education.

Where can teachers find help in developing themselves in these directions? What kind of development would help them?

To define this problem, which may be the most important of all those facing the adoption of computers in education, it might help to review some of the obstacles faced by teachers who try to find a solution. The most brutal of these simply prevents the interesting situation from arising. The designers of the skeleton had access to computers for about one hour a day, and their regular teacher had the freedom to use this time as she wished. Thus they and the teacher could be immersed in the project sufficiently for interesting issues to come up and be dealt with in an interesting way.

The odds are against anything like this happening—though it is a tribute to the amazing resilience of students and teachers that it sometimes does—when students have forty minutes a week of computer lab and learn about word processing, data bases, and what's in the computer, as well as "do a little Logo." A second obstacle is the concept of teacher training. Although the name is not what is most important about this concept, it is curious that the phrase "teacher training" comes trippingly off the tongues of people who would be horrified at the suggestion that teachers are being trained to "train" children. The phrase makes me think of toilet training, basic training, and tiger training. I know that the word *training* is often used for respectable kinds of learning. For example, I said in the second chapter that I was trained as a mathematician. But justifying "teacher training" in this way feels to me—and to quite a number of teachers I know—like justifying the use of the pronoun *he* on the grounds that it embraces woman. On purely abstract linguistic grounds both usages are "correct," but in both cases what is involved is not an issue of syntax but one of ideology. Why the asymmetry? Why do we talk about teachers and children so differently? The answer brings me back to my main theme: School does not have in its institutional mind that teachers have a creative role; it sees them as technicians doing a technical job, and for this the word *training* is perfectly appropriate.

Whether or not one accepts this analysis in general, it is hard not to recognize its truth in the kind of preparation School generally considers appropriate for computer teachers. In many school systems, what the teachers who will use the computers are offered in preparation is quite appropriately called training, for it consists of a small number of two-hour sessions, misnamed "workshops" or "seminars," whose goal is to impart technical skills. To highlight the limitation, it is worth looking at two examples of providing better conditions for teachers to learn and grow.

About eight years ago I conducted a summer workshop on Logo for a small group of teachers. I was a little nervous because I suspected that one of the participants was there not out of commitment to learning Logo but because she was under orders from a principal who wanted a computer project in his school at a time when that was still something exceptional. I knew that a single participant's bottled-up resentment at losing summer vacation time could poison the spirit of the group, even if the others had come out of a personal desire to learn.

One of my preferred styles of working with such a group is to propose a form of project sufficiently open to allow very different approaches and sufficiently restricted to allow the different approaches to be compared. In this workshop I proposed that everyone write a program to represent some aspect of the notion of "village." Programming the computer to draw a village on the screen presents itself as a good theme for beginners to exercise techniques of programming. One can start by writing a procedure to draw a single dwelling; once this is debugged, it can be used as subprocedure for a superprocedure to obtain a group of identical dwellings; and having obtained a product, one can go on to introduce variability and add all manner of frills and details including animation, text, and hypertext. From a teaching point of view, it has the advantage that students can stop at different levels, matching their technical abilities and personal tastes, and yet all have something to show for the work.

As the days went on, my fears did not seem to be founded. Everyone was caught up in the activity. I was especially relieved to observe that the member of the group I had thought would be most difficult seemed hardly able to contain her excitement. In every discussion period she bubbled over with ideas about how she would use what she was learning; even when she was working at her computer she would exclaim from time to time that she couldn't wait to take this back to her classroom. "My kids will love it!" By all the usual rules of evaluation, the workshop was going well. My educational objective for my students (the teachers) was set as learning Logo and the principles of programming, and the class was making reasonably rapid progress in this direction—and showing enthusiasm as well.

Despite this, I had a nagging feeling that something was wrong. I couldn't put my finger on what it was until a slight commotion broke out in the workshop. One of the other participants apparently had the same misgivings as I did but more quickly diagnosed the problem. Losing patience with the expressions of enthusiasm she muttered, "Forget the [expletive] children!" The reaction of the others in the room was electric: Some were shocked and protested; one immediately responded with a supporting remark. I was at first taken aback and then realized that the outburst captured what had been troubling me. The discordant element had been a sense I couldn't yet articulate that the participants thought of themselves as teachers-in-training rather than as learners. Their awareness of being teachers was preventing them from giving themselves over fully to experiencing what they were doing as intellectually exciting and joyful in its own right, for what it could bring them as private individuals. The major obstacle in the way of teachers becoming learners is inhibition about learning.

After the incident I felt something like Joe's sense of liberation. I was freed from a nagging fear about what was wrong and from needily seeking security in the teachers' exclamations of delight. My freedom allowed me to look more closely at what the individu-

als were doing with their programming, and soon I noticed a striking difference in style. Some were constructing the houses by putting together clean geometric shapes, in the simplest case following the example I had used in *Mindstorms:* A "house" can be made by putting a triangle on top of a square. One of the participants seemed uncomfortable with these shapes. Perhaps they had bad associations with School math or perhaps her personality biased her toward fuzzier things. Whatever its origin, the discomfort led her to pick up an idea from someone else's failure to make a neat geometric pattern to represent a flower garden. It came out as a wiggly line that might have been a failed flower garden but was just the thing to turn into smoke rising from the chimney of the house. After a while all the houses had smoke in varying patterns.

One thing led to another. The smoky effect could be adapted to draw clouds floating over the village and, with a little more adaptation, to draw trees and other less square objects than houses. Sometimes very small actions by a teacher can seed growth in a class. One that became important in this workshop was naming the emerging programming style. I dubbed it "smoky programming" and contrasted it with "hard-edged" programming.

The immediate effect was to encourage the original smoke maker. At this point it was an individual act involving teacher (myself) and student. Gradually it turned into something more social. Naming styles became a habit and encouraged personal pride in them; they became something to discuss and something to own. A vocabulary developed for talking about them, a sense of values for respecting others' styles even while taking pride in one's own.

In short, a process was under way that I would call the beginnings of a microculture. Talking about styles is an excellent seed for the development of a learning culture; it contributes to the richness of the immediate learning but also allows the benefits to flow into other areas, since styles can be recognized across a

variety of different contents and activities. All learning benefits from talking about it—so long as the talk is good—and comparing styles is one of the best conversation starters provided that the differences are clear and the participants authentically respect the styles of others while defending their own. But for the talking to be good it must be both rooted in the real concerns of the participants and supported by knowledge and experience.

The issue of the contrast between the smoky and the hard-edged styles of programming was indeed very well rooted. It was not just a simple difference of style, though I was trying to promote a culture in which any difference would in fact be respected; on the contrary, the issue has been central in debates about alternative epistemologies. The hard-edged style is closer to the analytic, generalizable ways of thinking valued by the traditional "canonical" epistemology, which has come under fire from feminists as androcentric, from Afrocentrists as Eurocentric, and generally from many on the political left as representing the thinking of dominating groups. Indeed, research by MIT sociologist Sherry Turkle and myself shows that it is more likely to be the preferred style of white males. This is enough to make it very relevant to teachers, but in fact there is another aspect that makes it even more directly so. Moving from the hard-edged to the smoky style involved a step away from an abstract and formal approach to one that invites all the words that Piaget (taken as representative here of a far wider span of psychological thinking) would attach to the thinking of younger children: concrete, figural, animistic, and even egocentric.

Thus the issue is rooted in the teacher's concern about what kind of thinking is appropriate for children—but in such a complex way as to lend great importance to the second criterion for good talk about learning: the necessary knowledge and experience. Much more than "training" is needed for teachers to develop the ability to benefit from the presence of computers and to bring this benefit to their students.

It is instructive to note how a small Central American country has been able to handle this problem in a way that puts most

North American school systems to shame. I would suggest that this is largely because the country classified itself as a "developing country" and made this an advantage compared with countries that see themselves as "developed"—and so presumably have nowhere further to go. One moral of the story is that we might all do better if we dared classify ourselves as "developing."

In 1986 Oscar Arias was running for election as president of Costa Rica. The same mentality that would enable him to win the election, launch the peace process in Central America, and gain the Nobel prize was reflected in an election promise to take steps toward ensuring that Costa Rican children think of themselves as belonging to the modern world and not as Third World outsiders looking on longingly. One of his steps would be to bring computers into all the elementary schools of the country. Later I shall have several occasions to refer to aspects of what turned into a project with many exemplary features. Here I focus only on how the project did more than "train" its teachers.

For better or for worse, a decision was taken to invite corporations to submit complete plans, not only to supply and maintain computers but to determine the educational content, teacher preparation, and the evaluation process. This was a commercial plum involving many thousands of computers, so it was not surprising that fourteen companies submitted bids. IBM brought me in as a consultant and followed my advice to submit a plan that was exceptional in the proportion of effort devoted to the preparation of teachers in advance and their support during the project. This may not have seemed to make sense in terms of trimming prices in a competitive bid; but at the head of IBM's Latin American Education group was an energetic, intelligent, and not at all bureaucratic woman. Alejandrina Fernández persuaded her superiors in the corporation that IBM could afford to lose money in the first year of this project. It turned out that paying attention to the role of teachers won her the contract and has led to a successful model that has been used in half a dozen Latin American countries.

The Costa Rican government created a foundation to oversee

the project—an unusual case of a government having the wit to protect a project from its own bureaucracy! Within the foundation the discussion centered on the role of teachers. One group argued that the mode of use should be as easy on the teacher as possible. Many of the teachers in the rural districts had very little experience with technology and no formal education in anything technical. These teachers, it was argued, would be excluded by any mode of using the computers that required technical skills. Thus this group argued for using CAI software, and had this side won the contract would probably have gone to a company offering the kind of ("teacher-proof") turnkey system where the computer is switched on and the teacher doesn't even have to load a diskette—everything is automatically done under central control. The argument of the other group, though they did not quite put it in these words, was to make it as hard as possible for the teachers. In the end Costa Rica, under the leadership of Clotilda Fonseca, has mounted an exemplary program in which hundreds of teachers, most of whom indeed had no technical background, learned to program in Logo and derived a great new sense of confidence in themselves and their country by mastering something that was experienced as challenging, modern, difficult, and "not for people like them." This is in quite remarkable contrast with the position adopted by many American school districts that Logo is "educationally good" but "too hard for teachers"!

The debate was settled by an experiment in which a group of teachers participated in an intensive three-week Logo workshop. Although there is no objective way to make such measurements, I think it was obvious to all observers that an exceptional quantity of learning took place in these weeks. I think it was almost as obvious that this happened because the participating teachers felt that much more was involved than a technical improvement in learning basic skills. They were making a personal assertion of their will to appropriate this modern thing; a professional assertion against a view of teaching as a lowly profession; and a national assertion against the view of their country as under-

developed. Many of them were also making an assertion of gender; for a large percentage of elementary school teachers are women and the organizers of the project had had the good sense to reflect this in the selection process.

The Costa Rica project showed in a specially clear form the computer playing a role in identity formation by teachers and brings us back full circle to the issue of negative representations of teachers. In a conversation with Oscar Arias, who asked me what I thought was the most interesting aspect of the project, I focused on what I have been saying here about teachers. Amazement and delight were written all over his face when he heard me talk about how much effort teachers had put into the project. He explained that what he had heard about teachers in the past was on the lines that they wanted more money for less work, and told me how pleased he was that his computer project had educated him as well. I left the presidential palace feeling proud to have been part of an opportunity for teachers to show themselves for what they are and to become a little more.

In addition to allowing teachers the opportunity to make the project part of a developing sense of identity, the *Programa Informatica Educativa* has another feature that makes it developmental for teachers. This is a compromise between the idea of a computer lab (which was imposed by financial constraints) and the classroom computer. The students do go to a separate room where the computers are located, but their regular classroom teacher goes with them. Moreover, the teacher learns with them, too, for in the lab there is also a computer teacher who has had an opportunity for development (to a degree that is rare even in the most "developed" countries) not only as a technical expert but also as the interpreter of a culture of learning.

Another version of the compromise had been the goal of a model pioneered by my MIT research group, first at the Lamplighter School in Dallas and then in Project Headlight at the Hennigan School in Boston. The model, which needed more resources than Costa Rica had been able to afford—though far less in

proportion to the national wealth of the two countries—originally incorporated three essential principles. First, the number of computers would be sufficient for every class to spend at least one period each day with its regular teacher, when every student could have full access to a computer. Second, although any educational software might be used on occasion, the primary use of the computers would be based on the assumption that everyone, students and teachers, would be able to program the computer in Logo from the outset. Third, all the teachers would have not only sufficient expertise but also sufficient freedom of choice to use the computers in a manner that would express their personal styles of work. Later, a fourth principle grew out of these three when the Gardner Academy, a largely Latino inner-city elementary school in San Jose, developed its own implementation of the three principles under the name Project Mindstorm. This fourth principle asserts the advantage of the explicit development from within the school of a unique indigenous learning culture and philosophy of education. The project's name marked an intention to adopt my ideas; its divergence from what I had described myself was, in my view, part of a confirmation that it had succeeded. In education, the highest mark of success is not having imitators but inspiring others to do something else.

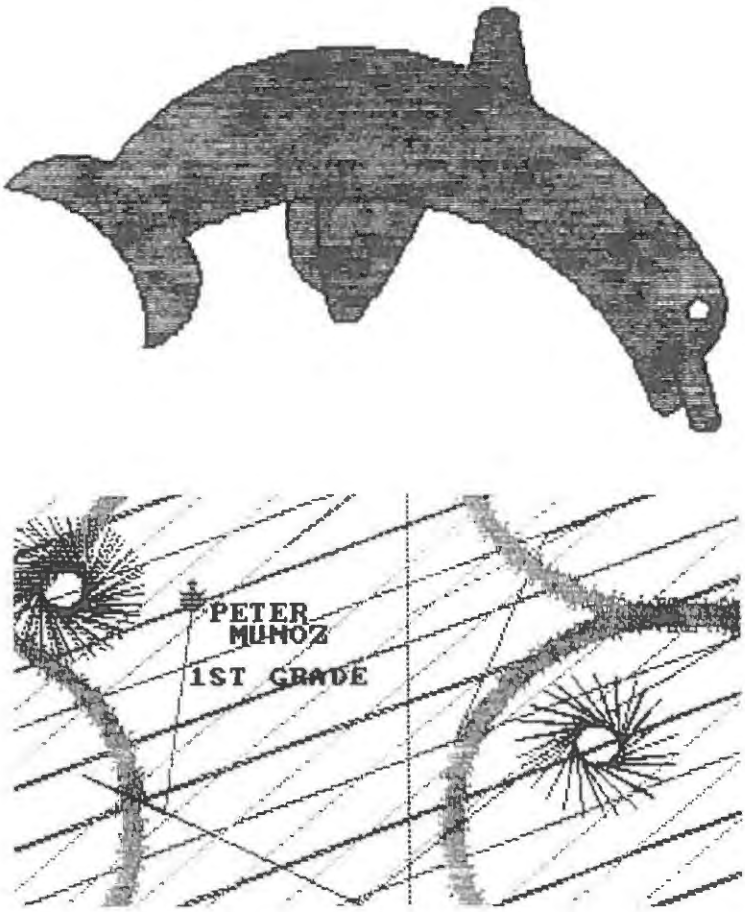
The project was created by the Technology Center of Silicon Valley, which let the project evolve without interference after it had selected a school and a director. The director was Carol Sperry, who came to computers after many years as a classroom teacher. I believe her own experience helped to empower the teachers in the project to create a culture in the school and to see it as *theirs*. She was not someone who came from a university or a school bureaucracy to tell teachers what to do with computers. Because she was a teacher herself, and did not feel answerable to anyone outside the school, she could ask the other teachers to join her in "putting herself in the disk drive along with the Logo disk." The intensity of the personal involvement created an unusually strong culture of teachers, and this in turn gave several of the

teachers the intellectual confidence needed to nurture an unusual culture among students. An example will illustrate the point.

When I was discussing Brian and Henry, I quoted a student who talked about putting "grace" into his computer graphics. The student, who was from Project Mindstorm, explained that he wanted to grow up to put art and mathematics together. What is unusual here is not the fact that a student would say this, but rather that the teachers could cope with this way of thinking about mathematics. The special demand on the teacher is seen in another light: As long as there is a fixed curriculum, a teacher has no need to become involved in the question of what is and what is not mathematics. But here the teacher was willing to take on what would be considered a philosopher's question, and to become involved in serious discussion with students and with colleagues about whether this student's activities—which looked very different from *any* math in the curriculum, as the figures on page 80 show—were nevertheless mathematics.

In this chapter my thinking has been conceptual: I have presented a concept of School, a concept of the teacher, a concept of the bureaucrat, and a concept of struggle. I conclude here with some more pragmatic remarks on strategy for change.

What can be done to mobilize the potential force for change inherent in the position of teachers? First I must make some qualifications. The conflict I have described is one of idealized principle. In order to bring out the ideas, it comes too close to presenting an image of pure angels engaged in a holy war with evil demons. Real teachers have mixed positions. Everyone who has grown up in our society has internalized something of School's way and teachers are no exception. At the same time, most school administrators were once teachers and continue to share some of their yearnings. Hechinger's story is not about a wicked principal; it is about the *role* of principal: the office, not the person. Carol Sperry has written about "contradictions" even in teachers who think of themselves as militantly working for



Is making this math?

change. From a feminist stance she sees women as the essential agents of change in education; but the same women have themselves internalized a model of women in a nonaggressive role of accepting authority and as teachers doubly so. The result is that when they try to implement change they often undo in subtle

ways with the left hand what they have wrought with the right, often undermining their own view of things by their use of such language as, "I am just a teacher, but. . . ."

In brief, we are dealing with a situation of uneven development. The problem for society is to give teachers the same pluralist support that the best of them give their students. Individuals at different places need support to move from where they are. They cannot be cajoled or ordered into a too distant place. In my writing I hold out the image of an ideal; but even adopting the ideal fully is meaningless unless one can see the next small step. The practical consequence is that change cannot come about except pluralistically.

The central practical problem is to find ways in which teachers who are at different places in the willingness to work for change can do so. There cannot be a uniform change across the board—any attempt to do that will reduce the pace of change to that of the least common denominator. Society cannot afford to keep back its potentially best teachers simply because some, or even most, are unwilling.