

## Chapter 8

# Images of the Learning Society

THE VISION I HAVE PRESENTED is of a particular computer culture, a mathetic one, that is, one that helps us not only to learn but to learn about learning. I have shown how this culture can humanize learning by permitting more personal, less alienating relationships with knowledge and have given some examples of how it can improve relationships with other people encountered in the learning process: fellow students and teachers. But I have made only passing remarks about the social context in which this learning might take place. It is time to face (though I cannot answer) a question that must be in many readers' minds: Will this context be school?

The suggestion that there might come a day when schools no longer exist elicits strong response from many people. There are many obstacles to thinking clearly about a world without schools. Some are highly personal. Most of us spent a larger fraction of our lives going to school than we care to think about. For example, I am over fifty and yet the number of my postschool years has barely caught up with my preschool and school years. The concept of a world without school is highly dissonant with our experiences of our own lives. Other obstacles are more conceptual. One cannot define such a world negatively, that is by simply removing school and putting nothing in its place. Doing so leaves a thought vacuum that the mind has to fill one way or another, often with vague but

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scary images of children “running wild,” “drugging themselves,” or “making life impossible for their parents.” Thinking seriously about a world without schools calls for elaborated models of the nonschool activities in which children would engage.

For me, collecting such models has become an important part of thinking about the future of children. I recently found an excellent model during a summer spent in Brazil. For example, at the core of the famous carnival in Rio de Janeiro is a twelve-hour-long procession of song, dance, and street theater. One troop of players after another presents its piece. Usually the piece is a dramatization through music and dance of a historical event or folk tale. The lyrics, the choreography, the costumes are new and original. The level of technical achievement is professional, the effect breathtaking. Although the reference may be mythological, the processions are charged with contemporary political meaning.

The processions are not spontaneous. Preparing them as well as performing in them are important parts of Brazilian life. Each group prepares separately—and competitively—in its own learning environment, which is called a samba school. These are not schools as we know them; they are social clubs with memberships that may range from a few hundred to many thousands. Each club owns a building, a place for dancing and getting together. Members of a samba school go there most weekend evenings to dance, to drink, to meet their friends.

During the year each samba school chooses its theme for the next carnival, the stars are selected, the lyrics are written and rewritten, the dance is choreographed and practiced. Members of the school range in age from children to grandparents and in ability from novice to professional. But they dance together and as they dance everyone is learning and teaching as well as dancing. Even the stars are there to learn their difficult parts.

Every American disco is a place for learning as well as for dancing. But the samba schools are very different. There is a greater social cohesion, a sense of belonging to a group, and a sense of common purpose. Much of the teaching, although it takes place in a natural environment, is deliberate. For example, an expert dancer gathers a group of children around. For five or for twenty minutes

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a specific learning group comes into existence. Its learning is deliberate and focused. Then it dissolves into the crowd.

In this book we have considered how mathematics might be learned in settings that resemble the Brazilian samba school, in settings that are real, socially cohesive, and where experts and novices are all learning. The samba school, although not “exportable” to an alien culture, represents a set of attributes a learning environment should and could have. Learning is not separate from reality. The samba school has a purpose, and learning is integrated in the school for this purpose. Novice is not separated from expert, and the experts are also learning.

LOGO environments are like samba schools in some ways, unlike them in other ways. The deepest resemblance comes from the fact that in them mathematics is a real activity that can be shared by novices and experts. The activity is so varied, so discovery-rich, that even in the first day of programming, the student may do something that is new and exciting to the teacher. John Dewey expressed a nostalgia for earlier societies where the child becomes a hunter by real participation and by playful imitation. Learning in our schools today is not significantly participatory—and doing sums is not an imitation of an exciting, recognizable activity of adult life. But writing programs for computer graphics or music and flying a simulated spaceship do share very much with the real activities of adults, even with the kind of adult who could be a hero and a role model for an ambitious child.

LOGO environments also resemble samba schools in the quality of their human relationships. Although teachers are usually present, their interventions are more similar to those of the expert dancers in the samba school than those of the traditional teacher armed with lesson plans and a set curriculum. The LOGO teacher will answer questions, provide help if asked, and sometimes sit down next to a student and say: “Let me show you something.” What is shown is not dictated by a set syllabus. Sometimes it is something the student can use for an immediate project. Sometimes it is something that the teacher has recently learned and thinks the student would enjoy. Sometimes the teacher is simply acting spontaneously as people do in all unstructured social situa-

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tions when they are excited about what they are doing. The LOGO environment is like the samba school also in the fact that the flow of ideas and even of instructions is not a one-way street. The environment is designed to foster richer and deeper interactions than are commonly seen in schools today in connection with anything mathematical. Children create programs that produce pleasing graphics, funny pictures, sound effects, music, and computer jokes. They start interacting mathematically because the product of their mathematical work belongs to them and belongs to real life. Part of the fun is sharing, posting graphics on the walls, modifying and experimenting with each other's work, and bringing the "new" products back to the original inventors. Although the work at the computer is usually private it increases the children's desire for interaction. These children want to get together with others engaged in similar activities because they have a lot to talk about. And what they have to say to one another is not limited to talking about their products: LOGO is designed to make it easy to tell about the process of making them.

By building LOGO in such a way that structured thinking becomes powerful thinking, we convey a cognitive style, one aspect of which is to facilitate talking about the process of thinking. LOGO's emphasis on debugging goes in the same direction. Students' bugs become topics of conversation; as a result they develop an articulate and focused language to use in asking for help when it is needed. And when the need for help can be articulated clearly, the helper does not necessarily have to be a specially trained professional in order to give it. In this way the LOGO culture enriches and facilitates the interaction between all participants and offers opportunities for more articulate, effective, and honest teaching relationships. It is a step toward a situation in which the line between learners and teachers can fade.

Despite these similarities, LOGO environments are not samba schools. The differences are quite fundamental. They are reflected superficially in the fact that the teachers are professionals and are in charge even when they refrain from exerting authority. The students are a transitory population and seldom stay long enough to make LOGO's long-term goals their own. Ultimately the differ-

ence has to do with how the two entities are related to the surrounding culture. The samba school has rich connections with a popular culture. The knowledge being learned there is continuous with that culture. The LOGO environments are artificially maintained oases where people encounter knowledge (mathematical and mathetic) that has been separated from the mainstream of the surrounding culture, indeed which is even in some opposition to values expressed in that surrounding culture. When I ask myself whether this can change, I remind myself of the social nature of the question by remembering that the samba school was not designed by researchers, funded by grants, nor implemented by government action. It was not made. It happened. This must be true too of any new successful forms of associations for learning that might emerge out of the mathetic computer culture. Powerful new social forms must have their roots in the culture, not be the creatures of bureaucrats.

Thus we are brought back to seeing the necessity for the educator to be an anthropologist. Educational innovators must be aware that in order to be successful they must be sensitive to what is happening in the surrounding culture and use dynamic cultural trends as a medium to carry their educational interventions.

It has become commonplace to say that today's culture is marked by a ubiquitous computer technology. This has been true for some time. But in recent years, there *is* something new. In the past two years, over 200,000 personal computers have entered the lives of Americans, some of them originally bought for business rather than recreational or educational purposes. What is important to the educator-as-anthropologist, however, is that they exist as objects that people see, and start to accept, as part of the reality of everyday life. And at the same time that this massive penetration of the technology is taking place, there is a social movement afoot with great relevance for the politics of education. There is an increasing disillusion with traditional education. Some people express this by extreme action, actually withdrawing their children from schools and choosing to educate them at home. For most, there is simply the gnawing sense that schools simply aren't doing the job anymore. I believe that these two trends can come together

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in a way that would be good for children, for parents, and for learning. This is through the construction of educationally powerful computational environments that will provide alternatives to traditional classrooms and traditional instruction. I do not present LOGO environments as my proposal for this. They are too primitive, too limited by the technology of the 1970s. The role I hope they fill is that of a model. By now the reader must anticipate that I shall say an object-to-think-with, that will contribute to the essentially social process of constructing the education of the future.

LOGO environments are not samba schools, but they are useful for imagining what it would be like to have a "samba school for mathematics." Such a thing was simply not conceivable until very recently. The computer brings it into the realm of the possible by providing mathematically rich activities which could, in principle, be truly engaging for novice and expert, young and old. I have no doubt that in the next few years we shall see the formation of some computational environments that deserve to be called "samba schools for computation." There have already been attempts in this direction by people engaged in computer hobbyist clubs and in running computer "drop-in centers."

In most cases, although the experiments have been interesting and exciting, they have failed to make it because they were too primitive. Their computers simply did not have the power needed for the most engaging and shareable kinds of activities. Their visions of how to integrate computational thinking into everyday life was insufficiently developed. But there will be more tries, and more and more. And eventually, somewhere, all the pieces will come together and it will "catch." One can be confident of this because such attempts will not be isolated experiments operated by researchers who may run out of funds or simply become disillusioned and quit. They will be manifestations of a social movement of people interested in personal computation, interested in their own children, and interested in education.

There are problems with the image of samba schools as the locus of education. I am sure that a computational samba school will catch on somewhere. But the first one will almost certainly happen in a community of a particular kind, probably one with a high den-

sity of middle-income engineers. This will allow the computer samba school to put down "cultural roots," but it will, of course, also leave its mark on the culture of the samba school. For people interested in education in general, it will be important to trace the life histories of these efforts: How will they affect the intellectual development of their school-age participants? Will we see reversals of Piagetian stages? Will they develop pressures to withdraw from traditional schools? How will local schools try to adapt to the new pressure on them? But as an educational utopian I want something else. I want to know what kind of computer culture can grow in communities where there is not already a rich technophilic soil. I want to know and I want to help make it happen.

Let me say once more, the potential obstacle is not economic and it is not that computers are not going to be objects in people's everyday lives. They eventually will. They are already entering most workplaces and will eventually go into most homes just as TV sets now do, and in many cases initially for the same reasons. The obstacle to the growth of popular computer cultures is cultural, for example, the mismatch between the computer culture embedded in the machines of today and the cultures of the homes they will go into. And if the problem is cultural the remedy must be cultural.

The research challenge is clear. We need to advance the art of meshing computers with cultures so that they can serve to unite, hopefully without homogenizing, the fragmented subcultures that coexist counterproductively in contemporary society. For example, the gulf must be bridged between the technical-scientific and humanistic cultures. And I think that the key to constructing this bridge will be learning how to recast powerful ideas in computational form, ideas that are as important to the poet as to the engineer.

In my vision the computer acts as a transitional object to mediate relationships that are ultimately between person and person. There are mathophobes with a fine sense of moving their bodies, and there are mathophiles who have forgotten the sensory motor roots of their mathematical knowledge. The Turtle establishes a bridge. It serves as a common medium in which can be recast the shared elements of body geometry and formal geometry. Recasting

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juggling as structured programming can build a bridge between those who have a fine mathetic sense of physical skills and those who know how to go about organizing the task of writing an essay on history.

Juggling and writing an essay seem to have little in common if one looks at the *product*. But the processes of learning both skills have much in common. By creating an intellectual environment in which the emphasis is on process we give people with different skills and interests something to talk about. By developing expressive languages for talking about process and by recasting old knowledge in these new languages we can hope to make transparent the barriers separating disciplines. In the schools math is math and history is history and juggling is outside the intellectual pale. Time will tell whether schools can adapt themselves. What is more important is understanding the recasting of knowledge into new forms.

In this book we have seen complex interactions between new technologies and the recasting of the subject matters. When we discussed the use of the computer to facilitate learning Newton's laws of motion, we did not attempt to "computerize" the equations as they are found in a classical textbook. We developed a new conceptual framework for thinking about motion. For example, the concept of Turtle enabled us to formulate a qualitative component of Newtonian physics. The resulting reconceptualizing would be valid without a computer; its relation to the computer is not at all reductionist. But it is able to take advantage of the computer in ways in which other conceptualizations of physics could not, and thus gain in mathetic power. Thus, the whole process involves a dialectical interaction between new technologies and new ways of doing physics. The logic of these interactions is seen very clearly by looking at another item from my collection of good models for thinking about education.

Twenty years ago, parallel skiing was thought to be a skill attainable only after many years of training and practice. Today, it is routinely achieved during the course of a single skiing season. Some of the factors that contributed to this change are of a kind that fit into the traditional paradigms for educational innovation.

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For example, many ski schools use a new pedagogical technique (the graduated length method—GLM) in which one first learns to ski using short skis and then gradually progresses to longer ones. But something more fundamental happened. In a certain sense what new skiers learn today so easily is not the same thing that their parents found so hard. All the goals of the parents are achieved by the children: The skiers move swiftly over the mountain with their skis parallel, avoiding obstacles and negotiating slalom gates. But the movements they make in order to produce these results are quite different.

When the parents learned to ski, both vacation skiers and Olympic champions used turning techniques based on a preparatory counterrotation, thought to be necessary for parallel turns. The realization that more direct movements could produce a more effective turn was a fundamental discovery, and it rapidly transformed skiing, both for the vacation skier and the champion. For the novice the new techniques meant more rapid learning, for the champion it meant more efficient movements, for the fashionable skier it meant more opportunities for elegant movements. Thus, at the heart of the change is a reconceptualization of skiing itself, not a mere change in pedagogy or technology. But in order to have a complete picture, we must also recognize a dialectical interaction between the content, the pedagogy, and the technology. For as ski movements were changing, skis and boots were changing too. New plastics allowed boots to become lighter and more rigid, and skis could be made more or less flexible. The direction of these changes was so synergistic with the new ski techniques that many ski instructors and ski writers attributed the change in skiing to the technology. Similarly, the use of short skis for instruction happened to be so highly adaptable to the new technology that many people sum up the ski revolution as the “move to GLM.”

I like to think about the “ski revolution” because it helps me to think about the very complex junction we are at in the history of the “computer revolution.” Today we hear a lot of talk about how “computers are coming” and a lot of talk about how they will change education. Most of the talk falls into two categories, one apparently “revolutionary” and the other “reformist.” For many

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revolutionaries, the presence of the computer will in itself produce momentous change: Teaching machines in the homes and computer networks will make school (as we know it) obsolete; reconceptualizations of physics are the furthest things from their minds. For the reformists, the computer will not abolish schools but will serve them. The computer is seen as an engine that can be harnessed to existing structures in order to solve, in local and incremental measures, the problems that face schools as they exist today. The reformist is no more inclined than the revolutionary to think in terms of reconceptualizing subject domains.

Our philosophy, both implicit and explicit, tries to avoid the two common traps: commitment to technological inevitability and commitment to strategies of incremental change. The technology itself will not draw us forward in any direction I can believe in either educationally or socially. The price of the education community's reactive posture will be educational mediocrity and social rigidity. And experimenting with incremental changes will not even put us in a position to understand where the technology is leading.

My own philosophy is revolutionary rather than reformist in its concept of change. But the revolution I envision is of ideas, not of technology. It consists of new understandings of specific subject domains and in new understandings of the process of learning itself. It consists of a new and much more ambitious setting of the sights of educational aspiration.

I am talking about a revolution in ideas that is no more reducible to technologies than physics and molecular biology are reducible to the technological tools used in the laboratories or poetry to the printing press. In my vision, technology has two roles. One is heuristic: The computer presence has catalyzed the emergence of ideas. The other is instrumental: The computer will carry ideas into a world larger than the research centers where they have incubated up to now.

I have suggested that the absence of a suitable technology has been a principle cause of the past stagnation of thinking about education. The emergence first of large computers and now of the microcomputer has removed this cause of stagnation. But there is another, secondary cause that grew like algae on a stagnant pond. We

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have to consider whether it will disappear with the condition that allowed its growth, or whether, like QWERTY, it will remain to strangle progress. In order to define this obstacle and place it in perspective, we shall pick out one of the salient ideas presented in earlier chapters and consider what besides technology is needed to implement it.

Out of the crucible of computational concepts and metaphors, of predicted widespread computer power and of actual experiments with children, the idea of Piagetian learning has emerged as an important organizing principle. Translated into practical terms this idea sets a research agenda concerned with creating conditions for children to explore “naturally” domains of knowledge that have previously required didactic teaching; that is, arranging for the children to be in contact with the “material”—physical or abstract—they can use for Piagetian learning. The prevalence of paired things in our society is an example of “naturally” occurring Piagetian material. The Turtle environments gave us examples of “artificial” (that is, deliberately invented) Piagetian material. Pairings and Turtles both owe their mathetic power to two attributes: Children relate to them, and they in turn relate to important intellectual structures. Thus pairing and Turtles act as transitional objects. The child is drawn into playing with pairs and with the process of pairing and in this play pairing acts as a carrier of powerful ideas—or of the germs from which powerful ideas will grow in the matrix of the child’s active mind.

The attributes the Turtle shares with pairing might seem simple, but their realization draws upon a complex set of ideas, of kinds of expertise, and of sensitivities that can be broken down, though somewhat artificially, into three categories: knowledge about computers, knowledge about subject domains, and knowledge about people. The people knowledge I see as necessary to the design of good Piagetian material is itself complex. It includes the kinds of knowledge that are associated with academic psychology in all its branches—cognitive, personality, clinical, and so on—and also the more empathetic kinds possessed by creative artists and by people who “get along with children.” In articulating these prerequisites for the creation of Piagetian material, we come face to face with

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what I see as the essential remaining problem in regard to the future of computers and education: the problem of the supply of people who will develop these prerequisites.

This problem goes deeper than a mere short supply of such people. The fact that in the past there was no role for such people has been cast into social and institutional concrete; now there is a role but there is no place for them. In current professional definitions physicists think about how to do physics, educators think about how to teach it. There is no recognized place for people whose research is really physics, but physics oriented in directions that will be educationally meaningful. Such people are not particularly welcome in a physics department; their education goals serve to trivalize their work in the eyes of other physicists. Nor are they welcome in the education school—there, their highly technical language is not understood and their research criteria are out of step. In the world of education a new theorem for a Turtle microworld, for example, would be judged by whether it produced a “measurable” improvement in a particular physics course. Our hypothetical physicists will see their work very differently, as a theoretical contribution to physics that in the long run will make knowledge of the physical universe more accessible, but which in the short run would not be expected to improve performance of students in a physics course. Perhaps, on the contrary, it would even harm the student if injected as a local change into an educational process based on a different theoretical approach.

This point about what kind of discourse is welcome in schools of education and in physics departments is true more generally also. Funding agencies as well as universities do not offer a place for any research too deeply involved with the ideas of science for it to fall under the heading of education and too deeply engaged in an educational perspective for it to fall under the heading of science. It seems to be nobody's business to think in a fundamental way about science in relation to the way people think and learn it. Although lip service has been paid to the importance of science and society, the underlying methodology is like that of traditional education: one of delivering elements of ready-made science to a special audience. The concept of a *serious* enterprise of *making* science for the people is quite alien.

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The computer by itself cannot change the existing institutional assumptions that separate scientist from educator, technologist from humanist. Nor can it change assumptions about whether science for the people is a matter of packaging and delivery or a proper area of serious research. To do any of these things will require deliberate action of a kind that could, in principle, have happened in the past, before computers existed. But it did not happen. The computer has raised the stakes both for our inaction and our action. For those who would like to see change, the price of inaction will be to see the least desirable features of the status quo exaggerated and even more firmly entrenched. On the other hand, the fact that we will be in a period of rapid evolution will produce footholds for institutional changes that might have been impossible in a more stable period.

The emergence of motion pictures as a new art form went hand in hand with the emergence of a new subculture, a new set of professions made up of people whose skills, sensitivities, and philosophies of life were unlike anything that had existed before. The story of the evolution of the world of movies is inseparable from the story of the evolution of the communities of people. Similarly, a new world of personal computing is about to come into being, and its history will be inseparable from the story of the people who will make it.