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Some Poetic and Social Criteria for Education Design

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Ten years is in some ways a challenging and in some ways a very awkward period for predicting the impact of computers in education. If you asked me whether the practice of education will have undergone a fundamental change through the impact of computers in either five years or in twenty-five years, I could answer with complete confidence "NO" to the first question and "YES" to the second. But what happens in ten years depends very sensitively on how hard we try; on when they people with the requisite financial, intellectual and moral resources recognize the opportunity and urgency of action. If we act smartly it is still possible that by 1985 the existence of model schools and learning centers will have changed the ball-park in which society sets the sights of its educational ambitions.

I mean, there might be changes comparable in spirit and extent to those technology and science have brought to transportation or medicine over the past century. But it is also possible that the practice of low cost micro-computers in every classroom will not have produced deeper changes than have come from all the other odds and ends of technology in the classroom. There seems to me to be little profit in guessing which way things will be in 1985. On the other hand it is urgent to start asking firmly and loudly how things could be in 1985. Doing so might actually influence how things will be; and this is especially true if, as I believe, a major determining factor is lack of awareness amongst policy makers of what is possible, of what choices are open to research communities today and

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could be open to society as a whole by 1985. My purpose in this paper is to contribute to this awareness by describing one image of what could be done.

I see this as a design problem. This paper is an exercise in designing a learning environment for children on the assumption that certain technologies are or will become available. My purpose is neither to prophesy that schools will necessarily conform to this design nor to persuade you that they ought to do so. What I would like to learn from the exercise is much more important and generalizable. I want you to see what it is like to go through the experience of designing an educational system as opposed to merely improving the existing one. This distinction may be hard to sustain rigorously. But I do think that in spirit it is accurate and useful to classify almost all educational research and reform as concerned with local modifications to an on-going system rather than with the problem of total re-design. (Of course it is quite possible that the people looking back at us with the hind-sight of, say, the next century will see anything we can imagine today as mere local fiddling with essentially antiquated concepts; much as we see the ingenious ways in which pre-railroad engineers sought to speed up long distance transportation by using the new progress in metallurgy to improve the horse-drawn carriage.)

So let us go to work. The project is to design a learning environment, let us say for children at the ages presently identified with the elementary school. Where do we start?

Consider three possible starting places.

(1) We could start with the present elementary school. If we make this choice we would look at what happens now in the school, try to identify weaknesses and seek fixes for them using the new technologies.

(2) We could start with the technologies. This choice would lead us to predict what machines would be available and seek uses for them. An extreme example of this "machine-directed design" is the current fad for seeking ways to use the little hand calculators with small children.

(3) A third starting point, and the one I shall use, is radically different in spirit. I shall start off by selecting a highly successful example of learning (or, if you like, of education); try to identify features which make it successful and then ask how to transfer these features into situations in which learning is not typically as successful. On previous occasions I have used as the "successful model" the child's early acquisition of language or of Piaget's concrete operations. In both of these examples learning takes place not only "painlessly" but also with almost complete success in the sense that all "normal" children learn to talk and, for example, to use such principles as conservation and transitivity. This contrasts dramatically with the way in which, say, children at school "learn functions". The latter process is painful for most children and highly unreliable in that very many children do not in fact acquire any degree of competence despite (or because of?) constant coercion by teachers and parents. I have discussed elsewhere whether the difference is due to deep and non-transferable factors as,

for example, in Chomsky's theory that language is not (really) learned but (essentially) innate. I have also discussed whether the difference could be entirely attributed to shallow factors such as the total amount of time spent (rather than the conditions of learning.) I conjecture that the primary factor is neither innate differences nor mere quantity of exposure but rather the nature of the learning process. But the question will eventually be settled not by conjecture or speculation but by conducting experiments (of the sort I am about to describe) in building totally different learning environments. So let us return to our design process whose first step is to select and describe a "success model".

The model I shall use on this occasion is like those already mentioned (such as language acquisition) in its natural-ness and larger degree of painless success. It is different in a number of ways including the possibly very important fact that it is not confined to children only. The model is an organizational form I had the opportunity to study last summer in Rio de Janeiro. It's generic name translates literally from Portuguese as "Samba School" although I suspect that were such a thing to exist in the United States, it would not use the word "school" in its name. It would be more likely to describe itself as a "club", for although it is a school in the sense that people do learn there, it is not a school in that learning is no more the primary reason for participation in the Samba School then it is for membership in a baseball team or for playing any game.

If you dropped in at a Samba School on a typical Saturday night you would take it for a dance hall. The dominant activity is dancing, with the expected accompaniment of drinking, talking and observing the scene. From time to time the dancing stops and someone sings a lyric or makes a short speech over a very loud P.A. system. You would soon begin to realize that there is more continuity, social cohesion and long term common purpose than amongst transient or even regular dancers in a typical American dance hall. The point is that the Samba School has another purpose then the fun of the particular evening. This purpose is related to the famous Carnival which will dominate Rio at Mardi Gras and at which each Samba School will take on a segment of the more than twenty-four hour long procession of street dancing. This segment will be an elaborately prepared, decorated and choreographed presentation of a story, typically a folk tale rewritten with lyrics, music and dance newly composed during the previous year. So we see the complex functions of the Samba School. While people have come to dance, they are simultaneously participating in the choice, and elaboration of the theme for the next carnival; the lyrics sung between the dances are proposals for inclusion; the dancing is also the audition, at once competitive and supportive, for the leading roles, the rehearsal and the training school for dancers at all levels of ability.

Some of the many ways in which this can be taken as a success model for education are too complex to discuss briefly here as a mere example. So I shall select just one, the simplest and most visible of its school-like aspects: it's function as a dance school.

From this point of view a very remarkable aspect of the Samba School is the presence in one place of people engaged in a common activity - dancing - at all levels of competence from beginning children who seem scarcely yet able to talk, to superstars who would not be put to shame by the soloists of dance companies anywhere in the world. The fact of being together would in itself be "educational" for the beginners; but what is more deeply so is the degree of interaction between dancers of different levels of competence. From time to time a dancer will gather a group of others to work together on some technical aspect; the life of the group might be ten minutes or half an hour, its average age five or twenty five, its mode of operation might be highly didactic or more simply a chance to interact with a more advanced dancer. The details are not important: what counts is the weaving of education into the larger, richer cultural-social experience of the Samba School.

So we have as our problem: to transfer the positive features of the Samba School into the context of learning traditional "school material" - let's say mathematics or grammar. Can we solve it?

To the uninformed mathophobe the problem will appear very (perhaps impossibly) difficult for the "simple" reason that dance is fun and math is dreary. But a point is being missed. What is "Dance" and what is "Math". Math for the kid often means a lonely, impersonal experience of manipulating symbols in accordance with rules learned by rote! If you denatured dance by reducing it to rules to be learned and operated in the same alienated way... it would not be more fun then denatured mathematics. On the other hand, mathematicians find that math is fun. Does mathematics have to be denatured to be done by kids? This, indeed, is the question. If not why, why, why do they denature it in the schools?

I have a firmly held and well elaborated theory. You do have to denature mathematics to teach it in the traditional way. But this is not on account of the age of the learner. It is the inelectable consequence of the technology traditionally employed in schools, namely the technology of paper and pencil! The relevant feature is that it is static, and to be contrasted with the dynamic technology of computers.

My theory now says: if you can do mathematics with a dynamic technology instead of with a static one, then perhaps you can do real mathematics instead of denatured mathematics and thereby open the possibility of a Samba School effect. So we are led to a next step in our design process: find or invent some real mathematics suitable for children and which can be meaningfully embedded in a feasible technology.

The task of inventing some new mathematics is not a trivial one. But one should not expect designing an educational environment to be trivial. To carry the task through sufficiently we may need to draw new kinds of people into education research; for example, people with better developed skills of mathematical creativity than is usual amongst people concerned with educating children. But before proposing that as an important national (and international) objective some evidence is necessary to make it plausible that some such mathematical nugget lies there to be found. And as an existence proof I cite once again our own contribution to this area, namely Turtle Geometry in all the ramifications which our MIT team is forever extending.

If you are a reader who does not know what Turtle Geometry is, I cannot do more than give you a very summary impression and then send you to find out more about it, perhaps by writing to me at the M.I.T. Artificial Intelligence Laboratory or by consulting the references in the bibliography.

One of its key ideas is to create an environment in which interesting actions can be produced and controlled by using a mathematical language to "talk to" and to "teach" a computer. The Turtle is a computer controlled robot which will move in whatever patterns you know enough geometry to describe, and Turtle Geometry is a computer language (in our work embedded in LOGO, though it need not be) which can be used to describe movements. The wonderfully rich fact is that Turtle Geometry is at once more powerful, more accessible and more intuitive than the non-computational geometries of Euclid, Descartes, etc.. I believe that this analogy is very deep: Learning Math by talking to Turtles is like learning dancing by dancing with people while learning math by doing pencil and paper "sums" is like learning dancing by rote memory of pencil and paper diagrams of dancing "steps".

At this point in the design process we run into some methodological problems and some need for inputs from experiment and possibly psychological theory. The first methodological problem is this: I can (I know from experience and so do many of you) weave what I would call a poetically coherent and even compelling story about mathematics and turtles. But is that a good reason for believing in my analogy as a practical design goal? Is it, for example, a good enough reason for you to take Turtles into account in making your forecasts about the ten year impact of computers on education? Or for you to give me the resources necessary to attempt to translate my visionary dream into reality?

In the past I have avoided this issue (which I shall call, so we can refer to it later, the "Poetry principle") by saying: "But there are <u>facts</u>; there are <u>partial</u> <u>realizations</u> of a Turtle-based learning environment; in it many children do in fact learn mathematics (and many other things too) with vastly more involvement and success than in regular school; besides, listen: here is how it all fits into our new interpretation of Piaget's theoretical framework and the new trends in cognitive psychology."

Well, all that is true and I have written it down in other places in more detail than I can repeat here. So I shall let the previous paragraph suffice for now as a pointer to issues you will want to study more closely if you are, by any chance, led to think further about what I am saying. The aspect I want to emphasize right now is another side of the Poetry Principle. I have just acknowledged that this principle is not sufficient as a basis for educational design. Obviously not. But I have come to realize more and more that it is a necessary part of any design for an education. I am trying to say something like: the total experience of the child in learning must have something which I want to call poetic cohesion. I want to suggest that the total lack of the "poetic" is a major (not the only) reason for the intransigent rejection by so many kids of the painfully prosaic stuff of the math class (new math and old math are scarcely different in this respect!). Now I have slipped over, you might observe, into talking about the Poetry Principle from the child's point of view. I find that it is easier to persuade people that the child needs poetry in his vision of mathematics than that the teacher, the educational psychologist and the curriculum designer all need it. I believe they do. And so does our society at large! And all this is a plea for not being trapped into thinking that being "scientific" means rejecting the

Poetry Principle on any of these levels.

I have only apparently strayed from computers to poetry. Or rather: the opposition many people see between computers and poetry is quite profoundly false. In fact my present thesis would not suffer much from being re-stated as: the embodiment of mathematics in properly designed computers is the most powerful means we have for giving it poetical, cultural and personal-human dimensions which are a necessary condition for it to be accepted and absorbed in a natural and easy way by billions of children. So I shall turn back to computers and mention some of the ways in which they can play this poetogenic role.

How can we establish a link between mathematics and beauty? For those of us who become (through who knows what lucky accidents) mathematicians this bridge has become strong enough for us to see the deepest beauty in abstract mathematics itself. But if we are not to rely on accidents we need the means to link mathematics with aspects of beauty which already touch the aesthetic sensibilities of the non-mathematician. Two outstanding examples of such links are computer graphics and computer generation of music. And so we have struggled, with gratifying though not yet complete success, to make these activities available to children in forms which make the connection between mathematical content and aesthetic form quite transparent. One such route is again Turtle Geometry. The Turtle can be commanded to crawl on a Television screen, leaving a trace as it goes. The increased mastery of geometric principles is immediately a source of power (of "MATHPOWER") to produce valuable results, in the form of dramatic designs and (especially) of animation, a dimension of drawing not usually available to ordinary people.

The fact that the computer enables geometry to produce results to which the child feels an immediate reaction of pleasure and pride establishes one of many points of contact with the Samba School. Another, no doubt ultimately related but superficially different point of contact is the way in which computer graphics can appeal simultaneously to young and to old. Very often the same product can be appreciated by novices and experts. This common sharing of appreciation between child and adult is one of the glues that makes our society'es culture hang together. Indeed, it happens frequently in some areas: in art forms particularly, in jokes and in the admiration of heros. But it happens very rarely in mathematics! And surely this is a big factor in the general rejection by our society at large of mathematics which is very much not felt as part of the culture.

Surely I have said enough to make the point that formulating the task as design for education in a technologically rich future leads very quickly into areas of research which are totally neglected, indeed quite unsuspected, by the community of professionals in"education research and innovation." There must in the world be tens of thousands of people struggling to understand what happens in a classroom where children are asked to do sums with pencil on square paper. Some of them try to improve matters by having the children do the same sums on computer terminals. I do not think it is my business to criticize or judge the value of all this. But I cannot help being overwhelmed by the fact that there must be ten thousand or more people doing that for each one person who has the other kind of design process of which I have tried to give you a glimpse. And I suggest that what happens in ten years depends very sensitively on whether our society decides that it can afford a small shift in this ratio. So perhaps the problem is more political than technological. And if the political aspect depends on how well we can convey on alternate vision, then perhaps it is even more poetical than political.