Redefining Childhood: The Computer Presence as an Experiment in Developmental Psychology

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I.

Since it is not possible to discuss everything at once, I shall make a number of assumptions about the penetration into society by computers in the next n years, where n might be 5, 10, 15 or some other similar number. The first assumption is banal: the diffusion of personal computers into private life will grow more than linearly as prices come down, computational capacity of small machines goes up and available services and software grow in quality and quantity. The second assumption is a slight extension of the first: substantial numbers of children will have the opportunity to use the computer in the mode I call "computer as pencil," that is to say emulating the quality of the pencil as a familiar, freely available object that can be used for many purposes such as writing, drawing, scribbling, doodling, calculating, chewing and so on. Children will use personal computers in the same spirit -- but more so since the computer can do so much more. The third assumption almost follows from the second: the activity now called "programming" will become so continuous with all these others that no one will think of asking such questions as "will people actually program the computers or just use canned programs." Finally, I assume that together with the diffusion of the physical presence of the computer will come an ultimately much more important cultural presence: ideas, language, metaphors, relationships and aesthetics drawn from the world of computers will become common currency. The last two assumptions are discussed further in my book *Mindstorms: Children, Computers and Powerful Ideas* (Basic Books, New York, 1980) and in Sherry Turkle: "Personal Computers and Personal Meaning" elsewhere in these proceedings.

II.

My intention here is to use these assumptions to provide a context for a fresh discussion of a set of questions about the roles of "nature and nurture" in human development. For the lay public the most salient of these questions bear on the differences between individuals.

Some children seem to be bright, quick and successful in everything they do. Others seem to be dull, slow and doomed to failure. Everyone has a personal stake in thinking about (or in refusing to think about) the extent to which these differences are laid down in the genes and are therefore "essential" properties of the individual rather than the products of the conditions of upbringing. Many theoretical psychologists see as more fundamental questions about the regularities on which the individual differences are variations. Is there a universal "natural" pattern of development? Could the development of children follow a very different course in a different "learning environment?"

Theorists hold very strong opposing views on the existence of cognitive universals and on their nature. Jean Piaget, the world's most influential authority on intellectual development, sees regularities as the results of general laws that govern the growth of intelligence, laws of epistemology rather than of biology. The linguist Noam Chomsky disagrees vehemently: he takes the growth of physical organs (for example, the heart or the kidneys) as a model for the determination of specific "mental organs" (for example, language) by specific, biologically-laid down designs. Others are skeptical about the reality of universals. I shall not attempt here to resolve these multiple differences but rather to suggest that careful observation of the consequences of the diffusion of personal computers into society might provide some very surprising new data relevant to these consequential issues.

Much of the argument about nature vs. nurture is ideological and dogmatic. Some of it is highly theoretical, even metaphysical. But here I am interested in how the arguments draw on factual evidence. I shall suggest that this evidence appears in a very different light when reconsidered in the context of the computer-rich future I am postulating. The most commonly used paradigm attempts to study the developmental patterns of children growing up under very different conditions, for example, in very different cultures.

Thus, linguists, anthropologists and psychologists have scoured the world making comparisons between patterns of language and thought in societies as apparently different as the industrialized, urban, literate sectors of America and the few societies of hunters that have survived in Africa. Striking similarities have certainly been found. But the interpretation of such findings is always under the shadow of the "parochial fallacy," which consists in exaggerating the uniqueness of every aspect of one's own ways and therefore thinking that everyone else must be "totally" different. It is parochial to exclude the possibility that despite their differences the culture of New Yorkers and the culture of Bushmen might not be the same in just the one or two critical respects that really matter.

Indeed, I believe that the "computer cultures" of the future will be different from all "precomputer cultures" in respects that are more likely to impinge on very young children than the differences between New York and the Kalahari Desert. My thesis is not that this *will* necessarily lead to fundamental changes in the way children develop. I do not see how anyone could possibly know that. My thesis is more modest. I shall present examples to illustrate a number of ways in which the computer presence stands out from other cultural differences in its potential relevance to changing patterns of intellectual development. By showing how it *might* lead to changes in the way children develop I shall be supporting the idea mentioned above that the diffusion of personal computation will turn the coming years into a giant experiment in developmental psychology carried out on a social scale, perhaps the only scale on which such experiments can be meaningful. In each of my examples the computer plays a very different role. Thus I hope that the discussion can serve the secondary purpose of providing a view of the variety of ways in which computers can affect the process of intellectual development.

III.

In the first example, the role of the computer is conceptual. The factor that will influence the development of children is the diffusion into their culture of computational concepts. The physical computer enters the picture as a carrier of these concepts. What I mean by these phrases will become clearer as I develop the example after a necessary digression on some of the remarkable discoveries Piaget has made in his life-long study of the development of children's thinking.

The most immediately impressive of Piaget's many contributions to knowledge is a large set of experiments that uncover important but previously unnoticed intellectual activities of children. Prominent among these is Piaget's demonstration that every child independently rediscovers a number of laws of conservation analogous to, but different from, the more formal conservation laws that have played such an important role in physical science.

Lie out on a table a row of eggcups each containing an egg and ask a child of four whether there are more eggs or more eggcups. The child will say "no" or "the same" or otherwise communicate the obvious and "correct" answer. Many children will also let you know that this is a stupid question, as if to say, "Of course they are the same. Who do you take me for?" But now remove the eggs from the cups. Spread the eggs out in a longer line than the original row and bunch the eggcups together as a small compact cluster. Ask the same question: "Are there more eggcups or more eggs.'" This time the answer is very likely to be "more eggs" with the same tone of "of course ...who do you take me for?"

Piaget has often been interpreted as showing us what children "do not know" and educators have taken on the task of "filling in" the cognitive deficiencies he has revealed. In my view this interpretation stands Piaget on his head for he is really the theorist of what children can learn by themselves without the intervention of educators. If you wait a few years and come back to ask the same child the same question you will eventually get the "adult" answer, namely that there are as many eggs as egg cups whether they are spread apart or bunched together. In Piaget's language the child will have acquired (I would say discovered) the conservation of number.

This discovery marks the entry of the child into an intellectually rich life period during which many other impressive mental feats will be achieved without assistance from adults. Indeed, these feats are so impressive that one is tempted to see the child as now thinking like an adult and obviously fully competent at thinking about sets of things. But Piaget has some more surprises in store for us.

Place in front of the child a large stock of beads of five or six different colors. Explain that a red and a green bead form a family, a blue and a purple form another family and so on. The child will easily grasp the idea you referred to in your college algebra course as taking all the combinations of 2 colors from the set of 5. In fact the child will have no trouble understanding the idea of families of 3 or of 4 colors. But if you now ask for all the families to be constructed, you will find that very few children younger than 10 or 11 can do this systematically and accurately.

Why should the combination task be more difficult than the conservation? It is not too difficult to make up explanations of every kind in the psychologist's repertoire. The difference is systematic enough to argue that there is a neurological or other maturational factor. Piaget himself explains it by the fact that the children use a different and more complex kind of logic in order to solve the problem. One could argue that children are not as motivated to think about this kind of problem. Without necessarily questioning any of these explanations, I wish to offer one of a different kind.

I observe that the combinatoric problem is really a problem in programming (rather than in algebra or in formal logic.) A simple program that has a small bug is structured by the idea of using nested loops: the inner loop cycles through all the colors for each step in the next loop out, which in turn cycles through all the colors ...and so on. The bug is a familiar one: objects are counted more than once. For example, in the case of two colors blue-green and green-blue appear as different families. One way to deal with it is to debug the program. Another is to run the buggy program and then use a second pass program, a filter that removes the duplicates.

Now we come to the point of the example. The description of the program uses quite a few ideas that would be quite familiar to anyone who has spent time in a "programming culture" but which are so alien to the general culture of our society that they do not even have names unless one counts the beginnings of a diffusion of words (such as "program" and "bug") from the nascent computer culture. My conjecture is that this diffusion of computational concepts will accelerate and reach down to increasingly lower ages as the state of affairs postulated in my initial assumptions becomes real. If children grow up surrounded by computers and a computational culture, it seems quite plausible to me that they will find such problems as forming families of beads perfectly concrete and be able to carry them out as early as they discover the conservation of number. And if computers become really important in their lives, they may develop the computational concepts even earlier than the numerical, thereby reversing what has appeared to be a universal of cognitive development.

IV.

In my book *Mindstorms: Children, Computers and Powerful Ideas*, I place the relationship between conservation and combinatorics in a theoretical perspective based on a somewhat personal interpretation of Piaget. I read Piaget as the theorist of children as the builders of their own intellectual structures. But they need materials to build with and the culture is their source. When the culture is rich in relevant materials they build well, stably and early. When the culture is poor in materials the building is impeded.

ALL present day cultures are rich in materials relevant to the construction of the kind of knowledge that underlies conservation of number. Most are particularly rich in examples of 1-1 correspondence. Mother-father, shoe-foot, foot-foot and the many other things that come in pairs. I see all this as "material" for the notion of number. But the present day cultures are poor in everything to do with procedure and process and in many other things related to computation such as all the aspects of self-reference and Godel coding so beautifully discussed in *Godel Escher Bach* by Douglas Hofstadter. Children build slowly, shakily or not at all where the natural form of the intellectual structure would use these "materials." Thus a common element of all hitherto existing cultures gives rise to a developmental universal. But the idea that there could be a computational culture shows that the "universal" is an artifact of history and not of human nature.

V.

Reversing the order of development of conservation and combinatorics would bring into question much contemporary thinking in developmental and educational psychology but might not even be noticed by lay people. As a second example I explore a conjecture about a change that would be immediately visible to everyone: I believe that the computer presence could close the gap between the acquisition of the spoken and the alphabetic language and then reverse their order in the sense that mastery of writing might grow faster than mastery of speaking.

I use the phrase "alphabetic language" to avoid the ambiguity in the word "writing," which sometimes refers to the physical act of handwriting and sometimes to the intellectual activity of composing text. This ambiguous reference is a relic from a previous age whose primitive technology tied these two meanings to one another. For adults, the typewriter has already separated them in practice: most writing in the intellectual sense is no longer done in handwriting. But for children beginning to learn alphabetic language the pencil has remained the dominant technology. I shall mention two reasons for my belief that this will change.

The first reason is a very minor one. Hitting keys is a less complex manual skill than calligraphy and so more accessible to the very young. But if this were a major factor the typewriter would long ago have made writing accessible to infants.

My second reason is weightier. The major reason why children do not write at the same age as they learn to talk is social. Stated most simply it is that talking is an important part of the most important activity of an infant relating to other people - while writing serves no purpose at all in a child's life. (Indeed, it serves very little that could be called a "personal purpose" in the lives of most adults!) My expectation of change is based on a vision of how the computer presence will enter the fabric of the child's life, becoming in a very real sense part of the culture. A simple vignette may begin to explain what I mean Coleta Lewis, a nursery school teacher at the Lamplighter School in Dallas, Texas, wrote a number of programs to enable three-and-four-year-old children to manipulate brightly colored objects on a computer screen by hitting a small number of special keys (marked with arrows to indicate directions of movement and colors to indicate color change.) The children loved playing these games. But they soon noticed that the teacher was playing a more complex game. She could change from one game to another by typing something at the keyboard. They asked to be allowed to do this too. Ms. Lewis is a gifted teacher and immediately saw a great educational opportunity. Very soon the children were pecking their way about the whole keyboard spelling out the LOGO commands that would interrupt one game and set up the next. They were on their way towards two new worlds of intellectual endeavor: writing and programming.

I remarked above that writing serves no purpose in the lives of young children. The children in Ms Lewis' class found several very important uses for it. First, it allowed them to produce effects on the computer screen. Second, it gave them a sense of power and control over the machine. And third, it allowed them to achieve one of the principal desires of children: to master what was perceived as an adult activity. These uses of the computer overlap one another, but all should be recognized as parts of the complex ways in which the incident could be a harbinger of much more extensive change the computer might bring into the lives and the desires of children.

It is easy to project a future in which typing at a computer keyboard could open doors to vast worlds of unlimited interest to children. These could be worlds of games, of art forms, of access to libraries of video material and of communications with distant people. There can be no doubt that under such conditions children of three would master many constituent skills of "writing." We have already seen that they can easily learn to find their way around a keyboard, to spell words and to use a simple formal syntax. And in addition to "skills" they are building up meta-linguistic knowledge whose absence may be a serious obstacle to many children's accession to writing. For example, many children of five and six do not have a clear notion of the word as a constituent of language: it is possible to speak without any such explicit notion. Finally, and perhaps most important of all, they are developing a relationship with alphabetic language whose affective content is very different from the usual one. The most serious obstacle to learning to write is the alienated relationship to writing that most people form early and few ever change. The spoken language *feels like* a natural thing, a part of the innermost core of the self. People who have become intellectuals and writers have usually developed a similar relationship with writing and find it hard to appreciate that for most people the written language feels like something external, foreign and artificial.

All this does not by any means prove that two-year-olds will be writing electronic letters to their friends and grandmothers. But it does open doors to fresh speculation about what might happen as society moves into the great cognitive experiment that has scarcely begun.

VI.

When I talk about these themes people often ask in an antagonistic tone: "But why do you want children of two to write?" The question demands two very different answers.

The first answer, which touches on the need for a fundamental change in attitudes toward educational change, is simply that "want" has nothing to do with what I am saying. I am speculating about what is likely to happen as computers diffuse into the life of the society.

Educators are used to thinking of change as something that happens with great difficulty through a cycle of proposals, edicts and implementations. In areas such as young people's knowledge of sex and drugs it is obvious that some changes happen very easily and have nothing to do with proposals. In areas such as knowledge of reading, writing and mathematics educators have been able to hold onto the prevailing models of change because in reality there hasn't been any change. But this is what is different about the coming period. The computer is happening; whether educators accept it or not. Their choice is not one of deciding that it is good and should happen or bad and should not happen. Their real choice is either to recognize the trend and try to influence it or to look the other way until it has happened without their input.

My second answer to the question "Why do you want children to read so young?" is more fundamental. I believe that children are placed at risk psychologically by the fact of living for so many years with a sense of inability to appropriate this thing, the alphabetic language, that surrounds them, that is so important to adults and yet so inaccessible. I believe that the resulting; frustration contributes to the sense of impotence, of being infantile, of being limited in what one can learn that, in so many cases, gradually erodes children's native positive attitude to learning eventually creating the "learning problems" that beset almost all children in school.

VII.

The infantizing effect of exclusion from writing is part of a much more general state of impotence and dependency on adults. Piaget has taught us to appreciate the extent to which children build their own intellectual structures. Adults do not provide the knowledge they need to do this: it is found by exploration of the many worlds (eg. the physical, the social and the linguistic worlds) in their immediate reach. But for any knowledge about the world beyond their immediate reach children are totally dependent. They cannot read. They cannot go to a library or use a reference book. Occasionally they may get a glimpse of a bigger world from television. But TV in its classical forms does not allow children to get the knowledge they want *when they want it*. It does not undermine, but rather increases, the state of dependence.

The computer is very special in its potential for changing this dependence. Through it children may come to have a degree of access to knowledge that boggles the imagination. The combination of personal computers, high density video storage and high bandwidth communication channels will make it possible for every child to have access to much more and much more varied knowledge than the most expert scholars do now. I shall talk about two possible positive consequences that this might have and about one danger. The first of the two benefits is that children will have so much more to build with. The second is what I have been stressing here: more important than having an early start on intellectual building is being saved from a long period of dependency during which one learns to think of learning as something that has to be dished out by a more powerful other. Children who grew up without going through this phase may have much more positive images of themselves as independent intellectual agents. Such children would not define themselves or allow society to define them as intellectually helpless.

The danger I mentioned is the flip side of this idea that there may grow up a new image and a new self-image of children as less dependent. I cannot convince myself that this prospect can be envisioned with complacency. It may have the most tremendous positive effects on the learning ability of future generations and at the same time destroy what we consider to be most human. It is easy to fantasize a scenario in which it gives rise to an epidemic of psychosis.

VIII.

My purpose here is neither to outguess the future nor to argue that computers are good or bad for children. I am suggesting that as it moves into the epoch of the computer culture, our society is embarking on a momentous experiment in human developmental psychology. What is at issue is the nature of childhood and its role in the construction of the adult.

In each of the past two generations science allowed mankind to put its future in jeopardy by meddling with previously inaccessible corners of nature: the inner structure of the atom and the inner structure of the gene. The promise and the threat of the computer presence is intimately linked to the opportunity it offers us to meddle with the nature of childhood.

My examples of what children might do in a computer rich world are meant as thought experiments to show the fragility of the accepted models of childhood, of what children can do and what they cannot do. The recommendation to which they lead is that we begin right now to monitor such changes and to mount experiments in which the encounter between children and the computer presence can be varied sufficiently to allow more informed thinking about these issues than has up to now been possible.