

WILL LOGO ENVIRONMENTS REALLY IMPROVE EDUCATION?

IN the last few years there have been a lot of books, papers and talks dealing with computers in education, often with a poor, if any, pedagogical background, but nevertheless recommending an extensive use of computers in classrooms. In order to understand this phenomenon better, one has to take into account some possible vital interests (which are, in part, not objectionable from the first) promoting this movement:

- a. The educational system is a considerable market for producers and sellers of computer hardware, software, and accessories (especially books).
- b. It is advantageous for the military, government administrations, and the business world, when pupils, as well as their parents, get accustomed to the computer (and eventually computer networks).
- c. There are groups in the computer science community who want their field to be rounded off by an appropriate school subject.
- d. Research on AI (Artificial Intelligence) has an imperialistic behaviour (Turkle 1984) towards the humanities.
- e. A lot of educators who have a microcomputer of their own joyfully make their hobby a job.

Seymour Papert's book *Mindstorms* (1980) is one more praise of the computer's boon for education, but it is outstanding in several respects: It has got a pedagogical basis; its claims for changes as well as its promises are extremely far reaching; its target group are, at first, young children (from the age of 4). At a first glance, the arguments (involving a wide range of humane sciences) appear conclusive; there are keen observations about the contemporary (American) school system, a legible outline of Minsky's and Papert's theory of cognition (well appreciated e.g. by Jahnke (Ed. Stud. 1983, 87), and Otte (foreword of German hardcover edition 1984)), some good rhetoric etc. The phrase 'Logo philosophy' (named after the programming language 'Logo' which is the carrier of the educational revolution as envisaged by Papert) was invented, and there are a lot of people who believe in it.

It started infiltrating American elementary schools, but although it has been criticized ever since it came up, it was apparently not taken seriously enough by professional educators (as well as the whole challenge of computers to education), and before 1984 there existed practically no literature on that matter containing comprehensive criticism. Then there was a whole issue of Teachers College Record devoted to the subject with a sensible introduction by Sloan (T.C.R. 1984, 539), and several of the articles treating the 'Logo philosophy' explicitly.

In Germany we also had some papers: Müller (Beitr.z.Math.Unt. 1984, 251), von Hentig 1984, Bauersfeld (Inst.f.Did.Math. Occ.Pap. 56, 1984).

Köhler (Math.Nat.Unt. 1985, 1, 65), and again some particularly on *Mindstorms*.

Dreyfus/Dreyfus (T.C.R. 1984, 578, and forthcoming book) question the effectiveness of contemporary AI with respect to the computer's proposed role as a tutor and the sufficiency of that kind of merely analytical thinking that the child is supposed to acquire by using the computer as a tutee. They query Papert's assertion that programming with Logo would enable the child to choose, according to a given situation, the appropriate style of thinking (also: Brown (Math.Teaching 107 (1984), 43), Davy (T.C.R. 1984, 549)). Bussmann/Heymann (Zentr.bl.Did.Math. 1985, 76) try to reconstruct the educational theory contained in *Mindstorms* find some inconsistencies, and draw conclusions similar to those outlined in this paper which is based on a analysis of Papert's methodology and curricular implications (cf. also Davy).

I believe focussing on these topics to be useful, as this provides a possible basis for evaluating a lot of arguments which can be found all over the literature mentioned in the first paragraph. One of the favourite patterns is to substantiate the need for a certain positive view of the computer (fitting the following conclusions) by comparing it with some wellknown technical device such as the automobile, then to deduce that this requires proper activities in schools (like programming), and at the same time to ignore all the shortcomings connected with that device, because inferences from the past cannot be drawn, as the computer is an absolute novelty.

PIAGETIAN LEARNING IN LOGO ENVIRONMENTS

Papert designs the scenario of a 'Piagetian learning in Logo Environments', organized like an idealized version of Brazilian samba schools, at least like he perceives them, resuming - without mentioning it - old traditions in pedagogy, e.g. the reformatory ideas of Gaudig, Dewey, and many others since then, and wellknown principles of modern mathematics education, such as learning procedural mathematics in projects by action and discovery. According to Papert, institutional, social, psychological, cognitive, and other obstacles to this vision belong to the pre-computer culture and will be removed by basing future learning on the computer, strictly speaking on Logo, resp. on its subsystem 'turtle geometry', or on systems still to be developed. His goal is a 'new learning' (as in the subtitle of the German edition) promoting children's insights into mathematics, their problem solving ability, and the reflection of their own cognitive processes. This all shall be achieved by applying or experiencing certain techniques (like debugging, interactivity, modularity, recursion) when programming with Logo and transferring them into problem solving strategies for other domains, in particular for 'epistemological' activities, which, finally, shall bridge the gap between the sciences and the humanities.

Papert underpins the attainability of this ideal by essayist reports about some ten children, all with intense learning or motivational

defects, which were all cured by a several months stay in 'Logo environments', which means that afterwards most of them liked mathematics. As can be found in a lot of papers on educational research, Papert, too, disregards the influence of variables like 'expenditure of time and means', 'degree of attention to each child', 'character of innovation', 'disposition of teachers', 'selection of the sample', 'suitability of the content' on his 'findings', and contrasts his ideas with (a miserable version of) everyday mathematics education (in American schools).

Furthermore, 'Piagetian learning in Logo Environments' is, on principle, connected closer with conventional education than with learning in natural cultural environments, as there is still a system established for the purpose of teaching and there are didactical goals imposed on the pupils. Still Papert talks about the vanishing of schools (in a way similar to Illich 1970) - fully ignoring the dependence of the educational system(s) on economical, social and political conditions. (He does not explain how 'Logo environments' should make them change properly; some speculation about an idyllic computerized future society can be found in Haefner 1982.)

Neither does Papert try to justify his goal of turning children into 'epistemologists' (he even welcomes an accelerated loss of childhood possibly coming along with the 'epistemologist' activity), nor does he question its attainability. He seems not to be aware of the slight but essential difference between thinking about some mathematical content (learning mode) and thinking about this content ('epistemologist' mode). While, for example, in a typical multi-stage process of concept formation there is on each stage always only one single reflection of the stage just left behind, the 'epistemologist' mode always involves a two-fold reflection, hence is much more demanding intellectually. What is more: according to Papert, the two modes (which experienced educators would call incompatible; see Brown) shall be operated in simultaneously. And, it is young children with little practice in learning and reasoning who shall do so.

They all shall learn mathematics (cf. also Papert (Int.J.Math.Educ. 1972, 249)). As a mathematician Papert is not bothered by such problems as legitimization or genuine applications (for some contrast see Fischer (J.Math.Did. 1984, 51)), but pleads for 'turtle geometry', since it fits Logo and is just another mathematical theory like 'pencil and paper geometry' (whose power he heavily underestimates, as Jahnke points out). 'Turtle geometry' is plane geometry with line segments, and on a higher level it can be interpreted as intrinsic differential geometry (see Abelson/diSessa 1981). As such it is not suitable for the vast majority of school children, since it involves the omission of nearly the whole field of experiences in elementary geometry, connected with the practical use of geometric forms in real world, which can and should be made in conventional geometry courses (cf. Bender (B.z.M. 1983, 8)).

For doing geometry in the long run, children have to take a stand-point at a distance, and for that the body syntonicity of the turtle

(which the original robot turtle may have had literally, but which the screen turtle has only in a desensualized manner) is rather hindering. E.g., in 'turtle geometry' the circle is defined as the fuzzy image of a sequence of line segments, related to the transitory track of a person walking in a circle (where from has that person got the idea of a circle?) instead of to a wheel, for instance. Questions already very simple (is the circle a closed curve? has it a center? what is a center? how to construct a triangle? how does a real geometric form satisfy its purpose? etc.) require the local point of view to be given up (Richenhagen (I.D.M. O.P. 66 and J.M.D. 1985)). Not surprisingly, most of the examples given in literature for what children can learn are drawings of concrete or abstract, symmetric or non-symmetric objects.

Making the turtle draw a house, dancing to the rhythm produced by a computer, inventing a poem or some graphical art with the help of a random number generator, dealing with language by programming, or using a wordprocessor are not the type of creative activity a humanist, writer, artist or educator in these fields wants children to adopt, and a vast majority of teachers reject such technology oriented attempts for taking in their subjects (for profound criticism cf. Sardello (T.C.R. 1984, 631)).

HOW ABOUT PROBLEM SOLVING ABILITIES?

First, some of those techniques mentioned above can be treated as categories of theory of cognition, but, of course, Papert's 'society of mind' is only one approach among others to understand cognitive processes. Second, these techniques make up a distinguished programming style which is appropriate for certain classes of tasks. However, Logo is not used in professional programming, because it is too slow, most programmers are accustomed to other languages better processing input and output, and its recursive call of functions conceals the flow of the programs (at least for non-experts). Third, these techniques are ascribed the power of making the programmer develop heuristics for general problem solving, which turns them into pedagogical ideas justifying the use of computers according to the 'Logo philosophy'.

But unlike Papert claims, debugging is a principle applied by everybody everywhere, in programming as well as in everyday situations (including classrooms), as long as it is economical. Only if mistakes are too numerous or significant, the work on a problem (including computer programs) is done over completely. Like the solution of any problem, a program is either right or wrong, in that it either works as demanded or not, and sometimes the problem solver can tell by him/herself (which admittedly will occur more often if the solution is a program), sometimes he/she cannot.

If the principle of recursion is really incorporated by a person, it may lead him/her to ignore physical boundaries (in extreme cases: confound computer worlds with reality) or stages in cognitive (or other) structures. Papert himself delivers involuntarily several examples: for him

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'powerful ideas' comprise mostly mathematical theorems, whose power 'the child learns to enjoy and respect', but he/she 'also learns that the most powerful idea of all is the idea of powerful ideas'. By using the notions 'idea', 'thinking', or 'learning' recursively, he jumps light-footed from one object domain to another thus leveling essential structural differences.

The concepts 'modularity' and 'interactivity', finally, can be experienced by programming in a rather reduced manner only, which may not be sufficient for real physical or social situations. Of course, juggling (one of Papert's illustrative examples) can be analyzed in terms of a programming language using those principles, but, structurally, juggling is a decidedly primitive situation consisting of a few simple rules. And even this requires much more than just programming, namely, some motivation, perseverance, dexterity, and possibly a fairly good teacher. The extensive use of the computer, as suggested by the 'Logo philosophy', bears the tendency to replace reforming an activity with programming it - a perfect symptom of psychopathy, as Sardello puts it.

In comparison with those necessary, desirable, or possible social, emotional, artistical, cognitive, sensory, physical, etc. experiences in a child's cultural environment (including school), those experiences which are possible when programming a computer are rather poor. For all the authors mentioned this is a main point of criticism. When working with a computer the child becomes confronted with just one or several more 'domains of subjective experiences' (Bauersfeld 1983), resp. 'microworlds' (Lawler (Cogn.Sc. 1981, 1)). Any content from one such 'domain' is not transferred to some other automatically; these transfers have to be taught, too; and even then they are still hard to accomplish, if at all.

The conception of microworld used by Papert has not got the power to describe children's ideas connected with their activities, since to him it merely means some mathematical theory (often with some background in physics) which they shall study, in particular by varying its axioms. The notion of 'Piagetian learning in Logo environments' gives rise to another misconception: first, 'Logo environments' is not the expression for friendly furnished rooms with a lot of materials for the learning of and with Logo, but it is a technical term for the computer equipment which is necessary for the programming language 'Logo', and Papert obviously uses it in both meanings without differentiating.

Second, his adoption of Piaget's theory is rather unorthodox, as he evolves an essentially different view of the cognitive development of children and how to influence it (cf. Bussmann/Heymann). The reference to Gallwey's (1976) theory of learning tennis (after all one of the sources of his learning theory), again seems to be a total misunderstanding on his part (according to Dreyfus/Dreyfus).

Perhaps stylizing samba schools as prototypes for future classrooms is just another suggestive rhetoric; and rather the subcultural community of AI researchers, computer hackers, etc. working in the laboratories of Massachusetts Institute of Technology (MIT) and those connected to

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them by computer networks (as described by Turkle) seems to be a proper model. But this model would appear less pleasant and would point directly to its own main shortcoming: its need for extraordinary people.

LOGO, A TOPIC FOR PRIMARY GRADES?

Meanwhile, 85% of all American schools have computers, and regardless of the extent of use, while Logo is rarely found in highschools, it is the prevailing programming language in elementary schools. (Rezanson/Dawson (M.T. 110 (1985), 5) name some psycho-sociological reasons for this success). According to a lot of reports, it is often like in the old days of 'new math': Logo is a topic for the primary grades, treated, by pupils as well as by teachers, as one more subject besides arithmetic, geometry, sciences, reading, writing, and others, not meant to be extended. It is overlooked that Logo, unlike those other subjects, has no roots in culture or nature, but is a system of artificial rules invented by some human beings at a certain time, fitting a special technology, being changeable, or even removable, without loss of meaning. In all those reports about children working with the computer for a long time ('exploring microworlds') or talking to other children stimulated by the computer ('sharing their ideas') one does not get to know, what they actually learn (let it be facts, concepts, algorithms, or skills) besides programming. In classrooms dominated by 'Logo environments' there seems to be a lack of content related goals (criticized by Cuffaro (T.C.R. 1984, 559) and Sardello); and in the long run they may even fail to fulfill their objective purpose, i.e. keeping the children occupied.

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REFERENCES

- [1] Abelson, H. and A.diSessa: *Turtle Geometry* , Cambridge, Mass. 1981.
- [2] Bauersfeld, H.: *Subjektive Erfahrungsbereiche als Grundlage einer Interaktionstheorie des Mathematiklehrrens und -lernens*. In: Bauersfeld, H. et al. (eds.); *Lernen und Lehren von Mathematik*, KÖln 1983, pag.1-56.
- [3] Bauersfeld, H.: *Computer und Schule - Fragen zur humanen Dimension*. Occasional Paper 56, IDM Bielefeld 1984.
- [4] Bender, P.: *Zentrale Ideen der Geometrie für den Unterricht der Sekundarstufe I*. In: Beiträge zum Mathematikunterricht 1983, pag.8-17.
- [5] Brown, S.: *On Mindstorms*. In: Mathematics Teaching 107, (1984), pag.43-46.
- [6] Bussmann, H. and H.W.Heymann: *Revolutioniert die 'Schildkröte' das Lernen? - Rekonstruktion und Kritik der Bildungsutopie von S.Papert*. In: Zentralblatt für Didaktik der Mathematik 17, 76-83 (1985).
- [7] Cuffaro, H.: *Microcomputers in Education. Why Is Earlier Better?* In: Teachers College Record 85, 559-568 (1984).
- [8] Davy, J.: *Mindstorms in the Lamplight*. In: Teachers College Record 85, 549-558 (1984).
- [9] Dreyfus, H.L. and S.E.Dreyfus: *Putting Computers in Their Proper Place: Analysis versus Intuition in the Classroom*. In: Teachers College Record 85, 578-601 (1984).
- [10] Fischer, R.: *Unterricht als Prozess der Befreiung vom Gegenstand - Visionen eines neuen Mathematikunterrichts*. In: Journal für Mathematikdidaktik 5, 51-85 (1984).
- [11] Gallwey, W.T.: *Inner Tennis: Playing the Game* , New York 1976.
- [12] Haefner, K.: *Die neue Bildungskrise. Die Herausforderung der Informationstechnik an Bildung und Ausbildung* , Basel 1982.
- [13] Hentig, H. v.: *Das allmähliche Verschwinden der Wirklichkeit* , München 1984.
- [14] Illich, I.: *Deschooling Society* , New York 1970.
- [15] Jahnke, H.N.: *Technology and Education. The Example of the Computer*. In: Educational Studies in Mathematics 14, 87-100 (1983).
- [16] Köhler, H.: *Computer als Herausforderung - zur Sklavenarbeit?* In: Der mathematische und naturwissenschaftliche Unterricht 38, 1-9, 65-73 (1985).
- [17] Lawler, R.: *The Progressive Construction of Mind*. In: Cognitive Science 5, 1-30 (1981).
- [18] Müller, K.P.: *Stud die Computer oder die Computerfachleute eine Gefahr für die Schule?* In: Beiträge zum Mathematikunterricht 1984, 251-254.
- [19] Papert, S.: *Teaching Children to be Mathematicians Versus Teaching About Mathematics*. In: International Journal of Mathematics Education in Science and Technology 3, 249-262 (1972).
- [20] Papert, S.: *Mindstorms. Children, Computers, and Powerful Ideas*. New York 1980, German Basel 1982.
- [21] Rezanson, F. and S.Dawson: *The Logo Cult*. In: Mathematics Teaching 110, 5-7 (1985).
- [22] Richenhagen, G.: *Kinder, Computer und Mikrowellen - Bemerkungen und Fragen zu Seymour Papert's 'Mindstorms'*. Occasional Paper 66, IDM Bielefeld 1985, forthcoming in: Journal für Mathematikdidaktik 6 (1985).
- [23] Sardello, R.G.: *The Technological Threat to Education*. In: Teacher College Record 85, 631-639 (1984).
- [24] Sloan, D.: *On Raising Critical Questions about the Computer in Education*. In: Teachers College Record 85, 539-547 (1984).
- [25] Turkle, S.: *The Computer Culture* , New York 1984.