

A REVIEW OF ARGUMENTS FOR THE USE OF COMPUTERS IN ELEMENTARY EDUCATION

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Introduction

In recent times, critical opinion has appeared concerning the use of computers by children and adolescents, specially in education at the primary and high school levels. In this essay, we begin by citing and summarizing some of the arguments given in favor of the use of computers by children and in education. Then we argue against them using some opinions which we consider to be non-standard.

Another approach and some more details on many of the issues covered here may be found in [8,9]. We also introduce here some new arguments.

Arguments in favor of early use

Let us introduce here some arguments for using computers in education, at home and in school, using citations.

T.Oppenheimer, in a recent article criticizing indiscriminate introduction of computers in schools, lists the following popular reasons for "computerizing our nation's [the USA] schools," [1]:

1. "Computers improve both teaching and student achievement."
2. "Computer literacy should be taught as early as possible; otherwise students will be left behind."
3. "Technology programs leverage support from the business community - badly needed today because schools are increasingly starved for funds."
4. "To make tomorrow's work force competitive in an increasingly high-tech world, learning computer skills must be a priority."
5. "Work with computers - particularly using the Internet - brings students valuable connections with teachers, other schools and students, and a wide network of professionals around the globe. Those connections spice the school day with a sense of real-world relevance, and broaden the educational community."

Let us now hear a strong fighter for the introduction of computers in education, who gives deeper reasons. We will cite him in chronological order. In his book "Mindstorms" [2], S.Papert writes:

6. "I began to see how children who had learned how to program a computer could use very concrete computer models to think about thinking and to learn about learning and in doing so, enhance their powers as psychologists and as epistemologists." [p. 23]
7. "I believe that the computer as a writing instrument offers children an opportunity to become more like adults, indeed like advanced professionals, in their relationships to other intellectual products and to themselves." [p. 31]
8. "Increasingly, the computers of the very near future will be the private property of individuals, and this will gradually return to the individual the power to determine patterns of education. Education will become more of a private act... There will be new opportunities for imagination and originality." [p. 37]
9. "... the computer may serve as a force to break down the line between the 'two cultures'

[humanities and science]. ... So in this book I try to show how the computer presence can bring children in a more humanistic as well as a more humane relationship with mathematics." [p. 38]

10. "LOGO environments are not [Brazilian] samba schools, but they are useful for imagining what it would be like to have a 'samba school for mathematics.' ... The computer brings it into the realm of the possible by providing mathematically rich activities which could, in principle, be truly engaging for the novice and the expert, young and old." [p. 182]

11. "The computer can be 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." [p. 186]

12. "Computation can be more than a theoretical science and a practical art: It can also be the material from which to fashion a powerful and personal vision of the world" [p. 210].

In his book "The Children's Machine" [3], Papert says:

13. "Across the world children have entered a passionate and enduring love affair with the computer." [p. ix]

14. "The introduction of computers is not the first challenge to education values". [p. 5]

15. "The computer graphics and the artificial creature projects give a glimpse of directions of change of School that move toward megachange." [p. 21]

In his book "The Connected Family" [11] Papert says:

16. "Across the world there is a passionate love affair between children and computers." [p. 1]

17. "The best uses of computers that I have seen in homes are so much better than what is being done with computers in most schools that I have come to see home computing as a major (perhaps *the* major) source of pressure for educational reform." [p. 15]

18. "... one of the big contributions of the computer is the opportunity for children to experience the thrill of chasing after knowledge they really want." [p. 19]

19. "What will children learn by making a game? They will learn some technical things, for example to program computers. ... They will develop some psychological, social and moral kinds of thinking. Most important of all in my view is that children will develop their sense of self and of control. For instance, they will begin to learn what it's like to control their own intellectual activity." [p. 47]

20. "... parents should recognize the need to build new kinds of relationships with their children and should see the computer as a vehicle for building, rather than as an obstacle to, family cohesion." [p. 79].

21. "... using the children's enthusiasm for computers as a basis for enhancing the family's learning-culture." [p. 79] "Computer learning experiences give the family a chance to become more aware of its learning culture and a chance to work at slowly (cultures never change fast) improving it." [p. 81]

Patterns

Examining these arguments, the following patterns emerge (at the end of each item we refer to the above arguments which apply to it):

- a) Computers should be learned and used as soon as possible because they will be essential for the individual in the professional working place (2,4).
- b) Students who do not master computers will not keep pace with their classmates (2).
- c) Computers are good tools for learning (1,8,9,19).
- d) Computers improve students' achievements (1,19).

- e) Computers accelerate children's development, mainly intellectual (6,7,19).
- f) Computers may provide a free environment for learning (7,8,18).
- g) Computers may promote social (and family) cohesion (20,21).
- h) Computers provide a fascinating learning environment, one that attracts children and young people (13,16,18).
- i) Computers provide for a challenge of traditional educational methods and values (11,14,15,17).
- j) Computers induce a certain vision of the world (12).
- k) Computers make it possible to learn without tensions and pressures (10,13,18).
- l) Computers (through the Internet) make students get interested in foreign cultures and people (5).
- m) Computers develop self-control (19).
- n) Computers may provide for a more humanistic teaching (9).
- o) Computers may enhance imagination and creativity (8).
- p) Computers may be used to make children conscious of their own thinking process (6,7,19).
- q) Computers provide for an individual way and pace of learning (8).

We want to add the following patterns that did not appear in the citations:

- r) Children have to learn computers otherwise they will be afraid of them at adult ages.
- s) Children who don't use a computer at home may develop psychological and social problems (e.g. a sense of inferiority).
- t) Through the Internet, computers make it possible for students to access all sorts of information not available through other means.

In the sequel, we are going to refer to the arguments as (1), (1,3) etc. and to the patterns as (a), (a,c) etc.

Critique of the patterns

- a. It is a big fallacy that children and young people have to learn computers now because otherwise they will fall behind in their future chase for professional jobs. Computers are becoming so easy to use and learn, on-line tutorials and helps are becoming so powerful that any person will be able to learn how to use computers very fast at any age. We believe that the use of computers will be part of on-the-job training, provided by the enterprises themselves. Just look at the millions of people now using computers without having had any special training before, sometimes just with some hints from other people (this is exactly the case with our spouses!). It is a fact that many adults are afraid of computers (r), but we presume this will not be the case with children that have been born after the introduction of personal computers: these have become so common as airplanes. How many people are nowadays afraid of flying a plane? Certainly a relative fraction of those that were, when planes were still not so common in our skies; furthermore, consider that there is a physical danger in flying, but apparently none when using a computer.
- b. This pattern applies mainly to the use of computers by children at home. Here we have to consider two cases: they are also used in school, and then there is no need to install them at home; or they are not used in school. In the latter case, it is necessary to consider if teachers are requiring something that only students with computers at home can do, for instance handing in an essay necessarily composed with a text editor, or looking for some information through the Internet. In these and similar cases, the teacher should be advised that it is not fair to discriminate students who can't have access to a computer. Moreover, if a parent considers that his children should not use computers, as we are trying to show here,

he or she should look for an appropriate school which does not use them in the educational process (at least at the elementary level) and does not require their use at home. We are aware that this is going to be increasingly difficult; we should fight for the existence of alternative schools, in these case those that are not for the use of computers in education before high school, as we will expound later.

- c. One of the reasons computers seem to be excellent tools for learning is the attraction they exercise upon children and teen-agers. But if we go deep into this phenomenon, it is possible to detect that this attraction is due to two main reasons: what we call "the cosmetics" and the "video game" effects. In the first case, users are attracted by the multi-media effects, such as fascinating pictures, sound and animation. In the second, by an excitement similar to that felt when playing a video game: the setting is perfectly, mathematically defined, and the user feels the power of complete dominance upon the machine. When the desired result is not reached - either not being able to force the machine to do what was expected, or not being able to discover by trial-and-error an appropriate command or sequence of commands -, the user enters a state of excitement, which stems from a purely intellectual challenge. We mean here a challenge which has nothing to do with a physical ability (such as those required in sports). The certainty that one will eventually discover the right way to do something with the computer attracts the user to such a degree that he forgets everything else, entering what we have called "the obsessive user state."

Thus, when used for educational programs, what attracts the child or adolescent is not the beauty or interest of the contents being learned, but these cosmetic and video game effects. One may object that a human teacher also tries to present each subject in a fascinating fashion. We would object that she would be using her own enthusiasm, and the knowledge she has of her class to present the subject in a nice way, which should be adequate to her students at their age and proper development, and certainly without forgetting the contents. In other words, the subject should be presented in a contextual form, adequate to the students in that class. An educational software does not have the possibility of "knowing" or deducing what is the student's context: what she or he has learned the week or even the year before, what has been happening around or in the world, etc.

An interesting question is this: what happens to a student that gets used to learning with computers? Is she going to tolerate a normal class without all those cosmetic and video game effects? How about the interest to read and study through books, and the concentration necessary for this activity? We conjecture that all these activities will be damaged by the use of the unique setting presented by computers. In other words, computers damage traditional learning methods. If this is good or not, is another question.

- d. Suppose this pattern is correct. Then one should ask: what kinds of achievements are improved by the use of computers in education? It is possible that students get better grades in multiple-choice tests in mathematics, but is this a good or a bad sign? The necessary logical thinking exercised while using a computer (recall that it is an abstract, mathematical, logic-symbolic machine) may improve exactly logic-symbolic thinking. We doubt that it improves other kind of mathematical thinking, and any kind of non-mathematical ones. In fact, the working space presented by computers is absolutely well defined. We consider that real creativity does not happen in well-defined spaces but in ill-defined ones, such as those involving handicrafts, art, humanities and social interaction. We conjecture that the development of logic-symbolic thinking forced by computers in fact hinders real creativity in non-logical, formal symbolic areas.
- e. We have no doubt that computers accelerate children's development. This is quite clear to us: forcing a virtual setting, a formal language (when issuing or choosing commands to any software) and a logic-symbolic thinking, computers force children and teenagers to physically and mentally behave like adults. It is absolutely non-natural for a child to sit on a

chair for long periods of time, if the child has no possibility of imagining, innerly fantasizing (this would happen while hearing a fairy tale, for instance). As with TV, educational software full of images leave no space for inner imagination. In fact, we conjecture that the capacity for forming inner mental images is damaged by the use of such software. Note that if this software is not rich in images, and consists essentially of texts, it will be so boring to a child or adolescent that it will not be used at all.

The acceleration of a gradual mental and psychological development, making the child innerly and outwardly behave like an adult, is in our opinion the worst influence exercised by computers. Obviously, we are of the opinion that there is a proper timing for every development in children and young people. Any undue acceleration produces some damage; in particular, we think that early intellectual activities tend to steal from the child her childhood, necessary for a balanced development, which should encompass physical, psychological, artistic, social and intellectual aspects. In this sense, we extend to any kind of computer usage Neil Postman's fears for the disappearance of childhood [4], which he concluded mainly from examining the impact of communication media. So pattern (e), which is praised by many authors, Papert in particular, is for us a counter-argument for the use of computers in education. Papert's position is absolutely clear, as in his following statement:

"The image of children using the computer as a writing instrument is a particularly good example of my general theses that what is good for professionals is good for children." [2, p. 30]

That is, in our opinion he does not recognize some essential differences existing between children and adults. He also does not see the damage one can do to children when they are handled as adults. His argument (6) seems astonishing: behaving like psychologists and mainly epistemologists puts a child into a clear adult state of consciousness.

- f. This pattern is based upon a conception that traditional schooling methods impose strict forms for behaving and learning, and this is damaging to the child or young person. We are absolutely against authoritarian teaching. But we are not against the exercise of a *loving* authority, such as that recommended to teachers using the Waldorf methodology [5]. This means that the teacher recognizes that children and adolescents need orientation and a firm guidance when necessary. Look at a child walking on a street, with her father or mother holding her little hand. How secure she feels! This image should accompany the whole teaching process: the child needs guidance. This means recognizing the child's or young person's needs, not imposing what is not proper or interesting for her. In this sense, we are against what has been called "libertarian education," a method where the child does in school whatever she wishes. This is exactly what Papert praises in his LOGO environment, because the child is programming the computer and has an open space to do whatever she pleases. In fact, for him the teacher is a mere "facilitator," not a counselor or orienting authority. He even praises the fact that in his environment sometimes children teach their teachers (he tells a story of himself facing this situation for the first time [11, p. 168]). In the elementary education environment, this looks to us as an aberration. The child should admire in elementary school the teacher's personality, feeling secure that she will be guided by the latter's experience through the wonderful mysteries of life. During high school, the student should admire the teacher's specialized knowledge. We think it is absolutely necessary for a healthy future social life that students of any age learn that there are limits to what they should do and how they should behave; probably too much freedom too early tend to produce insecure adults.

An interesting aspect of the use of the Internet in education is exactly the fact that it presents a "libertarian" setting: the user has the whole world under his fingers, and nobody is

orienting him what to fetch and to examine (unless only limited access to some sites is allowed - in this case we think that the experience is going to be so boring that the student will rapidly lose his interest). Only an adult should have the self-control necessary to impose self-limits, such as limiting the time of use, objectively looking only at what one has previously determined as the goal of the interactive session, and so on. A child is normally not able to exercise such controls; if she does, she is behaving like an adult, and has stopped being a child (refer to our comments on pattern (e)).

- g. The promotion of social and family interaction is due to the fact that a user may discover some new command or sequences of commands, or even a new site at the web and then shows it to the other people around. We find this social interaction extremely poor. Compare with a child playing ball with her playmates, or a family activity such as a conversation during a calm meal. One should ask: which one is a healthier, more natural, more intensive interactive setting? Which one really improves social relations? Note that the computer setting will only occur eventually in professional life; on the other hand, normal social interaction without the incentive of a machine will be the standard setting for the adult life. What do we wish to teach our children, being led to social interactions by a machine or through one's inner interest and pleasure in social life?
- h. We have already commented on this pattern. We recall that this attraction is a fake, provided by the cosmetics and video game effect of computers.
- i. Computers in fact challenge traditional educational methods and values. We fully agree with Papert that they are not adequate. But our diagnostics differ somewhat from his, and our solutions are totally different.

One of the problems with educational systems is that they are too abstract, at all levels, mainly in elementary and high school ones. Let us give here a typical example. In Brazil, children in grade 2 or 3 learn what an island is in the following way: "Island is a piece of land surrounded by water from all sides." This is a formal definition, and as such is devoid of life, leaving almost no space for imagination. Compare with a story told by the teacher, of someone whose boat sank and swam to a beach, then tried to go home and wherever he got there were more beaches or stones over the sea. This story should be enriched by all sort of details on what the person found, fruits, animals, and so on. It could be accompanied by a beautiful drawing made by the teacher at the blackboard using colored chalk. This drawing should exactly leave space for imagination, and not have all possible details as presented by a photo. This way the children may create their own inner images, and innerly participate of the drama felt by the hero of the story. They would create a live island in their minds; following the Waldorf Education method [5, after such a story the children would be asked to draw with crayons whatever they liked about the story (and here an element of freedom is introduced into the class), thus requiring some action to their outside, and not just absorbing with their intellects.

The excessive abstraction in learning activities make the students hate school. They just cannot identify themselves with what they are learning, because in general it has nothing to do with reality and their whole beings - it is mostly directed to their intellects. The simple fact that children and young people have to sit for hours hearing what the teacher says, without doing anything else than thinking, eventually breaking this process by writing on notebooks the abstractions and definitions they hear or read at the blackboard), is absolutely unnatural for young people. Observe children leaving a typical school: many times one observes something like an explosion, running around, beating each other, etc. This is an expression of their having absorbed the whole time and not being able to put out anything. Classes are in general not balanced, in a rhythm of inspiration and expiration, as organized in Waldorf Education.

What happens with computers in this sense? Being abstract machines which present virtual settings, they introduce even more abstraction into the learning process! It is astonishing that

Papert, who so well criticizes the traditional schooling system, does not notice that programming a computer, which is what his LOGO setting forces its users to do, is the utmost in abstraction. Programming a computer is using *only* a mathematical language, developing what is called in mathematics an "algorithm." But we want to stress the fact that any use of computers force abstractions. Any picture displayed on the screen has no reality; the computer does not present the reality of the human teacher in front of the class, of the whole class hearing the same subject, etc.

So, we agree that computers challenge the traditional educational methods, but not for better, on the contrary, for worse! Unfortunately Papert does not know that the traditional class setting may be deeply transformed, enriching it with a new way of regarding the students and the educational process. To begin with, teachers must recognize that the main attitude is developing an altruistic love towards their students. Secondly, they should regard their profession as a sacrifice: they should not force each student to be what they think is ideal (and abstract), but have to recognize what the student needs as an unfolding individuality. Thirdly, the teacher should have a deep knowledge of what is proper for each age and each group of students. This last factor is perhaps the most distinguished characteristic of Waldorf Education. WE presents a revolutionary educational method based upon the developmental model introduced by Rudolf Steiner. There are other such models, but none is so encompassing, taking into consideration all aspects of the human constitution as it unfolds according to the age of the young person. Fourthly, the teaching should be directed to the students as whole individuals, and not just as intellectual brains. In other words, actions (willing) and feelings should be so much cherished and developed as good thinking. In fact, WE stresses that during elementary school, teaching should be oriented through feelings, mainly through artistic activities and an artistic presentation of any subject (even mathematics!). At normal high school age students start looking for purely conceptual explanations of the world; it is at this stage that the WE method presents subjects in abstract, formally rigorous ways, as required by scientific theories, - but always in relation to the real world, and not as pure intellectual abstractions.

We have stressed here the WE method because it is an established one, in existence since 1919 and in practice in more than 700 schools all over the world (more than 100 in the USA and Canada). It is astonishing that proponents of radical changes in education, such as Papert, ignore such a revolutionary change which preserves the traditional school setting with human teachers, classes, and so on. In [6, 9], we have expounded our ideas and proposals for the introduction of computers in education, at high school level, inspired mainly by WE.

Summarizing, yes, we have to radically change the educational process, but this change is not a technological one, it is a humane one. It is sad to see so much hope put on computers as saviors of the educational system, when we see that it represents the continuity of its main problems.

- j. We agree that computers induce a certain vision of the world (j). Unfortunately, for us this vision is absolutely inadequate for children and teenagers. It is not a humane vision, it is a machine, a technological vision. Schumaker, the reknown author of "Small is Beautiful" has called the attention to the fact that science and technology have tried to solve the problems of the world. Nevertheless, what one hears and reads is most frequently "questions of survival" - problems produced by technology or technological points of view of society [7].

We would like to call here the attention to the fact that computers require the exercising of a particular kind of thinking, leading to commands which we may give the machine, and which it is able to interpret. In other words, when issuing commands to any software we are forced to think in such a way as to make it possible to introduce those thoughts into the machine. In particular, any program is of such a class. We call this type of thinking

"Machine-Thinking." When exercising it, we reduce our wide thinking space to that defined (and accepted) by the machine. Obviously, this has an influence on the way the person thinks, because humans are continuously incorporating and being influenced by their experiences (the reader of this paper is not going to be the same after having read it; the author expects that the transformation has been for better!): the tendency is to think in a logical, unambiguous way, and expect everything in the world to be abstract, deterministic and foreseeable as computers are. We fear particularly the deep influence this attitude may have upon children and young people, who are precisely developing their way of regarding the world.

- k. This pattern uses the fact that computers may be programmed never to censor, being always available for new experiments. We are also against a teaching method that produces tensions and pressures, as the typical ones with grading systems, flunking, admonitions for a deficient academic accomplishment, etc. The problem is that this may be changed in a traditional setting, as WE has been demonstrating for decades. In fact, the system does not assign grades, which are pure abstractions - in Brazil, the grading system goes from 0 to 10; what does a 5 in a test (in general, the minimum to pass) mean: the student knows half of all topics or half of each topic? One sees how ridiculous it is to handle real people in a pure abstract fashion. WE has demonstrated that a new kind of learning may take place in a classical setting - this change does not require any machine, on the contrary. It requires a more humane approach to education, and not a technological one.
- l. One of the arguments in favor of the use of computers in education is their application in the Internet, making it possible for students to exchange fast mail with people or students in foreign countries. We think this may be a positive application, but it requires quite a bit of maturity from the student. So, we would recommend the use of the Internet only at the last year of high school. Lowell Monke, who teaches in a high school in the USA, has once made an interesting observation: his students, leaving his class on computers, faced foreign students leaving the front room, from a class in English as second language. He noticed that no one of his students addressed a foreigner. So one may think: shouldn't we teach our students how to get interested in real people, developing their social interest and sensitivity, instead of giving them the opportunity to engage in a conversation with a virtual person living in another country? Is this contact perhaps a palliative to real person-to-person interaction, eventually producing an anti-social attitude, instead of the opposite one? Furthermore, what is more important, exchanging a probably eventual futile conversation or seriously reading some description of the foreign country? Our recommendation in this respect is that such Internet contacts (to be carried only by high school students) be always carefully programmed by teachers, who should continuously follow what happens.
- m. We think that, much more often than developing self-control (m) computers develop lack of discipline. Let us make a simple comparison. When handwriting a letter or typing it with an old-fashioned typewriter, a person has to exercise a tremendous mental discipline. In fact, the possibilities for making corrections are extremely limited; a neat format is only reached through painful observation and control on how the lines are being written. Now compare with the use of a text editor. The user does not have to pay almost any attention, because she will be able to change everything, move paragraphs or phrases around, and obtain a neat print just by choosing appropriate commands or icons. She doesn't even have to pay much attention to spelling and grammar, because correctors will detect most of her mistakes and suggest corrections. The result of this lack of need for paying attention is, in our opinion, an invitation for exercising lack of discipline. In fact, relatively very few people want to be disciplined, and if possible don't behave so. This is even more typical when developing a program. Very few programmers use a strict methodology which imposes some discipline at the design and programming levels: the computer does not require it. The result is that almost all programs are big mysteries: the "year 2000" problem is derived exactly from this lack of discipline. If the programmers would have documented decently their programs, and

had chosen appropriate names for the variables containing dates, the changes would be quite simple. The big problem is to discover which variables contain dates. Moreover, it was poor programming practice saving 2 bytes (or even not saving anything, depending on the format used for the date variables) for each year: this was a typical optimization in the wrong place. All this is due to one essential characteristic of computers: it is possible to badly develop (software) products which work fairly well. The problem occurs later, when they have to be adapted or maintained.

But, suppose computers indeed develop self-control. In this case, what happens with children is that they are again forced to act like adults. Nobody would expect a child to exercise the type of self-control needed to use a computer in a decent fashion (this includes properly choosing the adequate web sites to be examined).

- n. In our opinion, computers represent the opposite to a more humanistic teaching. This should be provided by humans, and not by machines. The first rules for a humanistic teaching is loving and respecting students. No machine can exercise such soul activities. We were very impressed that Papert does not mention the fact that teachers should love their students - this is obvious, because he would not be able to apply it to computers. It is also impressive to find apparently only one mention of the word "love," actually in his two latest books, in fact at their beginning: those cited in items 13 and 16 above (the latter is a grand opening to that book). We consider the phrases "love affair with the computer" and later "between children and computers" to manifest a frightening vision of the world. If humans start dedicating their love towards machines we may expect terrible social attitudes, probably worse than those practiced during this century's wars. Moreover, speaking about a "love affair" with a machine is not just obscene, it reveals a fundamental viewpoint prevalent in his three books: humans are just machines. In our opinion, humans are not machines - neither animals, but this would lead us too far from our main subject.
- o. As we have expounded when criticizing item (d), our opinion is the opposite to this pattern: computers do not enhance imagination and creativity, on the contrary, they impair them. Let us here cite a type of software which many people consider connected to creativity: drawing programs. To really understand that the creativity exercised with their use is extremely limited and in fact non-artistic in a deep sense, it is necessary to compare it with real painting. Here, nothing is fixed. For instance, colors are mixed in an intuitive, not formal way, and only after putting them on paper or canvas one can see the result. On the other hand, a drawing program gives *exact* colors, in fact formal ones, because they are the combination of intensities of red, blue and green measured each in a formal scale of 0 to 255. If one colors a certain region using a certain color (from a formal palette or combining the three numbers), the result is a uniform color, something impossible to obtain with real paint: the pressure on the brush, the texture of the surface, the humidity, all this influences the result, making the process a rather intuitive, that is, non-formal one. Only with personal experience it is possible to understand what we mean here. For further considerations and details on computers and art, please refer to [8].

A child may reveal a high sense of improvisation and discovery when using a computer. But should we call these qualities "creativity?" In fact, what the child is doing is to combine previously logically defined functions. Creativity in science (except perhaps for algebraic Mathematics), arts and in the social life means for us devising absolutely new ideas or objects which are not just a combination of previously known patterns. Recall also what we have already said: real creativity is exercised in ill-defined working spaces (that's why we excluded Mathematics, albeit recognizing that there is also some sort of – limited – creativity in this field).

- p. If computers may make children more conscious of their own thinking process, this would mean that those children would be forced to be as conscious as adults. Children should not

have the same degree of self-consciousness as adults. In Brazil, the legal full adulthood is attained only at age 21. An ancient wisdom is expressed here: it takes that long for a young person to become fully self-conscious and be assigned free will and self-responsibility. Self-consciousness is only exercised through thinking, so what computers would be doing here would be to contribute for the elimination of childhood and "teenagerhood." See our comment to (e).

- q. Individual ways and paces of learning are fine for adults. But it is an aberration to say that children and teenagers know what is best for them, and may decide what and how they should learn. Again, this freedom is desirable for adults, but when induced into children, it makes them insecure and leads to eventually wrong decisions. We adults have to assume the responsibility of guiding them, and that's exactly what they expect from us. Traditionally, in Brazil or in Europe high schoolers don't have the possibility of choosing elective subjects. All of them have to study Math