Can we Integrate Logo into the Regular Mathematics Curriculum and Still Preserve the Logo Spirit?*

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Logo is at a turning point in its history. Certain crucial choices must be made in order to assure the development, if not the survival, of Logo in the current educational system. On the one hand, Logo still needs to penetrate more deeply into the educational milieu, multiplying its agents and its contributions. On the other hand, certain measures must be taken to ensure that the fundamental link between Logo and mathematics be maintained and strengthened. This article examines the extent to which the current trend favoring the integration of Logo into the mathematics curriculum responds to these needs

Some developmental trends in Logo environments

It has now been nearly fifteen years that Logo has been around and in use in primary schools for the purpose of creating educational contexts that favor the development of mathematical thinking. Although it would be an exaggeration to say that the implementation of Logo is currently undergoing a crisis, it would not be farfetched to suggest that the time is at hand for a redefinition of Logo environments. On the one hand, important developments have occurred that have allowed the emergence of extended Logo environments, but on the other hand, fundamental questions have arisen concerning their very survival in the educational system

Indeed, there is clear evidence that Logo has already gone and is still going through important developments. Logo-Writer and Lego-Logo, to name but two recent innovations, are newly developed tools that have helped Logo to reach out into the educational environment [Weir, 1987]. In the last decade not only have we witnessed the increasing technical sophistication of early Logo but, more importantly, we have also seen Logo linked to different kinds of abilities that were not easily accessible to it initially: writing, mechanical and physical abilities, both with theoretical and practical applications [diSessa, 1982; Weir, 1987; Weir, in press]. With this trend Logo tends to be more and more multidisciplinary, slowly infiltrating its way into new fields after its initial start in programming and mathematics.

Parallel to this phenomenon of outward expansion, another kind of expansion can be observed, a more inward and subtle phenomenon, namely, the development of cleaner and clearer connections with the mathematical world. Such authors as Hoyles & Noss [1987b], Hillel, Kieran & Gurtner [1989] and Gurtner [in press] have recently underscored the pernicious possibility of children doing Logo without ever really getting in touch with mathematical entities or mathematizing their activities. There is today an important current that favors a closer and clearer link to mathematical thinking. It is no longer enough to make loose associations between Logo and problem-solving abilities or mathematical reasoning; special care must now be taken to assure direct and solid connections with authentic *mathematical* types of solutions

In its quest for a rapprochement with the mathematical domain, there is more and more contact between aspects of Logo and elements that are already covered by the traditional mathematics curriculum. A review of the literature points to an increase in the nature and in the frequency of this interaction. The extent to which these new liaisons with traditional mathematics can be beneficial to Logo environments — or could constitute dangerous liaisons — is an important question that needs to be clarified in a general discussion of Logo's role in the evolution of the educational process. From now on, whatever happens to those Logo environments that are designed for developing mathematical abilities will be of major importance in determining the future fate of all Logo environments in the educational system.

The relation between Logo and the traditional mathematics curriculum: a risk or an opportunity?

Simply stated, *the risk* of making the ties between Logo and traditional mathematics tighter and tighter is that Logo could be gobbled up by the traditional approach. This is often called the recuperation phenomenon. The old system annihilates an innovative approach by slowly adapting it to its own. Logo would then be treated, for example, as one exercise among others, an element of the curriculum mechanically "covered" by the teacher, which is what often happens to other mathematical topics. More tragically, the Logo spirit and philosophy would be muzzled for many years to come. Were Logo to be so ensnared, all hope would be lost for Logo to be an active agent of change in the learning and teaching of mathematical thinking.

On the other hand, *the opportunity* that arises from forging closer ties to the traditional curriculum would be to fulfill some current needs observed in Logo environments. The insertion of Logo into the mathematics curriculum could foster, for example, a real mathematical spirit and context when doing

Logo; it could favor too the evolutionary role of Logo in contemporary education Let us examine this opportunity and how the risks might be minimized

THE LINK TO THE MATHEMATICS CURRICULUM: A WAY OF MATHEMATIZING LOGO

As stated above, difficulties sometimes arise in bringing children to think mathematically in Logo environments Gurtner [in press] uses the metaphor of a tunnel to express how the characteristics of Logo situations sometimes make "students miss nice viewpoints on mathematics and geometry". He asks that windows be opened in the Logo tunnels in order for children to have a perspective on related realities while working on specific Logo tasks At the same time, Gurtner notes the need for bridges that permit students to go readily back and forth between Logo actions and basic mathematical principles, laws, or notions In order to avoid progressive isolation, the Logo context needs to be consolidated and enriched by significant links to the field of mathematics. As Côté [1989, 1990] has emphasized and demonstrated in his work on a new microworld that he calls "the two turtles" — "les deux tortues" — many connections can be made to concepts that are already part of the primary and secondary mathematics curriculum [see also Hoyles & Noss, 1987a; 1987b] Thus, from a general point of view, links with traditional mathematical content could be beneficial to the Logo curriculum by maximizing the opportunities of mathematizing children's processes while working on Logo situations.

In a way, Hoyles & Noss [1987a] de-dramatize the necessity for Logo to link up with mathematical concepts The whole of mathematics teaching seems to suffer from a similar but stronger malaise: "the separation of any sort of meaningful activity and the separation of pupils' conceptions from their formalization" A first response to such a malaise resides in a general awareness of the need for links, concrete and abstract, in whatever problem-situation is being worked on. Many authors [Hoyle & Noss, 1987a; Côté & Kayler 1987; Gurtner, 1988; Hillel et al., 1989; Côté, 1989, 1990] have proposed the creation of mathematical microworlds as an interesting solution to this particular problem for Logo and to the more general problem of mathematics education. The microworld notion can, of course, present subtle differences of definition from one author to the next, but what is most important is the idea of working on a specific topic from different points of view and with different kinds of tools (computer, paper and pencil, ruler, compass, etc.) If that were done for all pertinent mathematical concepts (number, measure, area, variable, function, etc.) the future of Logo environments and the future of mathematics teaching would be in better hands! In sum, the confrontation of Logo with the mathematics curriculum could be beneficial to both, but especially to the propagation of Logo, given its renewed chances for influencing the whole of mathematics teaching

THE LINK TO THE MATHEMATICS CURRICULUM: A WAY TO SUPPORT THE EVOLUTIONARY ROLE OF LOGO

Historically Logo has now reached the point where progress in its evolutionary role relative to the learning and teaching of mathematics is, more and more, in the hands of the teachers. In the beginning Logo was actively supported by a nucleus of keen teachers and by a lot of researchers. Then after a short period of adaptation, which in many cases brought along better infrastructural school support — more equipment, direct support in class, better information and training — a larger group of teachers became active in Logo. Today with Logo having more direct links to a content that is known and judged important by teachers, a larger group could become positively involved with the Logo approach Through successive waves of pedagogical changes that step-by-step embrace an ever-increasing pool of active agents Logo can now have its evolutionary influence on the educational process This process is not, however, without risk How can one guarantee that the spirit and crucial goals of Logo will not be lost in a phase of implantation and adaptation in the school curriculum? If adapted to parts of the mathematics curriculum and if adopted by a larger number of teachers, variations and modifications in Logo environments will necessarily occur. Under what conditions are they going to be judged acceptable by the Logo community? In a nutshell, what appears essential in implementing Logo in the school is not the form of presentation but the spirit in which it is presented, and the maintenance of specific pedagogical goals in whatever modality is chosen.

The growth of variety in employing Logo: what counts?

What evidence do we have that what counts in the ways of deploying Logo is the nature of the goals rather than the external means of presentation? An apparently "good" way of presenting a subject matter does not guarantee that important goals will be respected. It is not, for example, because Logo is offered in an open non-directive environment that such developmental goals as the acquisition of autonomy, mathematical knowledge and thinking skills are necessarily attained. Nor is it because Logo is offered in a relatively structured environment that such goals are *not* attained. As ecologists like Bronfenbrenner [1979] and Garbarino [1982] have said: it all depends! It depends on the nature of the context, and mainly on the nature of the actions and interactions that occur in each given context

There is a wide variety of contexts in which Logo is offered today. A supervisor can choose basic Logo or opt for an expanded version such as Lego-Logo. It is possible to focus on visual art, physics, programming and/or mathematics The working context can be open, that is, centred on children's projects; or it can be structured such that the situations are all chosen in advance and have specific aims; or it can be semi-structured where the two approaches alternate. Although it was once seen as heresy to do Logo in a way different from what Papert [1979, 1980] first proposed, many now see varying the kinds of implementation as an assurance of Logo's future and of the educational environments in which it has been implanted. The variety of proposed contexts — open, semi-structured, or structured — is by far the most important development observed today. Transforming the initial open and child-centered approach into contexts with particular projects aimed at developing specific abilities may indeed present risks, but that will all depend on the pedagogical approach accompanying the proposed changes.

Moreover, given the risk, as described in Lemerise [in press], of seeing Logo "denaturalized" — due to the mere existence of Logo's connection to educational approaches — the best way to counter this risk is to transform it into an opportunity. This can come about by proposing sound and varied environments that respect the fundamental tenets of the Logo philosophy. Hoyles [1985a, 1985b] and Hoyles & Noss [1987a] have described some necessary conditions for an adequate integration of Logo into the school mathematics curriculum by maintaining, in particular, the opportunities for exploration, experimentation, reflection and discussion. Weir [1987] and Côté [1989, 1990] have argued that exploration and experimentation can also occur in a structured environment ("structured exploration", "structured discovery" are expressions now often found in their writings). Finally, research by Lemerise [1990, in press] and by Hoyles & Noss [1987b] has showed that a structured approach can facilitate the realization of many of the goals put forth by proponents of Logo, namely, the identification, use, and mastery of abilities linked to specific mathematical notions.

In conclusion, given that the fundamental goals of the Logo philosophy can be preserved in many different contexts, variety in Logo environments appears to be more of a strength than a weakness. Developmentally speaking, rigidity is usually more deadly than flexibility, so it is more than time to offer a wide variety of sound Logo environments to children. The contemporary goal of "mathematizing" Logo environments and opening them up to a variety of applications can now be reached without sacrificing the spirit of Logo.

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Of the many forms of false culture, a premature converse with abstractions is perhaps the most likely to prove fatal to the growth of a masculine vigour of intellect.

George Boole
