THE SOCIAL SHAPING OF LOGO

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Abstract: "Logo" is the name for a philosophy of education and for a continually evolving family of computer languages that aid its realization. Developed in the US in the late 1960s, it became the material embodiment of a radical educational philosophy and a potential vehicle for the transformation of education. In the early 1980s, Logo was introduced into mainstream education in both the US and the UK. Within an increasingly conservative social and political context with different education policy priorities, Logo was gradually stripped of its radical potential, marginalized and, where it survived, remoulded as harmless to the mainstream educational system.

This paper draws on empirical research which explored the evolution of Logo between the late 1960s and the late 1990s. The paper focuses on the social processes involved in the initial development and evolution of Logo. It shows that these processes were heavily contested. It demonstrates that Logo was the product of complex social, technical, political and economic decisions, and the product of negotiation shaped by the concerns of the social players involved. It shows that the evolution of Logo was not linear or even primarily technical. Rather, that it was a seamless web in which the technical was interwoven with the social, economic and political in ways that illustrate the dialectical interaction between historical contingency and the intentions and aspirations of individuals and communities.

Keywords: Educational technology, educational computing, sociology of technology, sociology of education, social studies of technology, ICT in education, educational change.

INTRODUCTION

'Logo' is the name for a philosophy of education and for a continually evolving family of computer languages that aid its realisation (Abelson, 1980, p.1). Specifically designed for and dedicated to education, Logo was initially developed during the post-Sputnik era of reforms in US education as an alternative to the prevailing technocentric and behaviourist notions of computer-aided instruction (Agalianos, Noss and Whitty, 2001; Johnstone, 2003).

This paper focuses on the social processes involved in the production and evolution of Logo. It draws upon prior research (Agalianos, 1997) that demonstrated the variety of ways in which the development and evolution of Logo was socially shaped, as it locked into

institutional arrangements and reflected elements of the prevailing social relations in and around the particular contexts of its production, implementation and use. An earlier paper drawing on this research discussed the ways in which Logo was received in mainstream education systems and was implicated in the politics of educational innovation in the US and the UK at a time of conservative restoration (Agalianos, Noss and Whitty, 2001). This present paper, in addition to looking into the ways in which Logo was received in real classrooms, focuses on the complex interactions between several social players that influenced the evolution of Logo. These include the activities of the research teams involved and of mediators like government departments and the domestic the microcomputer industrial lobby. This paper can be seen as a case study against notions of technological determinism. It shows that, in the initial development and evolution of Logo, the technical and the social were bound up together in a process of mutual influence, each shaping the other and in turn being shaped. It demonstrates that Logo was not only the result of scientific progress but also of complex interactions and negotiations among diverse social groups, and that technologies do not follow some predetermined and inevitable course from their context of production to their context of use.

The project[1] on which this paper is based adopted a cultural studies approach to the social shaping of technology[2] which emphasized the need to address all the phases in the cycle of innovation from research and development to the implementation and use of technological artefacts. The project appropriated and extended the 'cultural circuit' model initially developed by Richard Johnson at the Birmingham Centre for Contemporary Cultural Studies (Johnson, 1983, 1986)[3]. The new model made an analytic distinction between five 'stages' (or 'moments') in the lifetime of a technological artefact: production, text, marketing/economics, context, consumption (see Agalianos, 1997).

LOGO AND THE PENDULUM SWING.

The first version of Logo was developed in 1966 by Seymour Papert, Daniel Bobrow and Wallace Feurzeig at the Educational Technologies Laboratory of Bolt, Beranek & Newman (BBN), an R&D company in Cambridge, Massachusetts.[4] Its initial developers believed that the new language (which has subsequently been extensively modified and has become instantiated in many new and different forms – some of which use only the design/pedagogic/epistemological ideas of Logo and not the technological infrastructure) was much more than a procedural programming language for the teaching of mathematics. Certainly, for Papert, it was the material embodiment of a radical educational philosophy which had been developing alongside (and sometimes in tension with) the technological artefact itself. Thus Logo was seen by some of its producers as a potential vehicle for the transformation of education.

In the first few years of its development, particularly since schools did not yet have microcomputers, Logo remained a research idea shared among a number of research centres around the world interested in education. During that time, a number of school-based research projects were set up and versions of Logo were experimentally tested in a small number of atypical (not mainstream) elementary and secondary schools involving only a very small number of teachers.[5] By the early 1980s, Logo was no longer a marginal, private experiment. Following the introduction of microcomputers into schools, it became available to a large number of US and UK mainstream classrooms. At the same time, the publication of Papert's book *Mindstorms* in 1980 made Logo (and its philosophy of education) known to a world-wide audience and offered an alternative, radical vision for education which caught the imagination of a large number of educationalists. Within months of the publication of *Mindstorms*, pro-Logo and anti-Logo lobbies had developed on both sides of the Atlantic. The book appealed to a number of 'progressive' teachers who, echoing

the revolutionary 1960s and 1970s, were still looking for ways to bring about radical educational change. To those teachers, Logo was more confirmation than revelation; it was not a new movement itself but, rather, an expression of already existing ideas connected to their social and political radicalism. Excitement was significantly higher in the US where, in many cases, Logo was seen as a panacea for the ills of an educational system in crisis (see Kozol, 1967; Postman & Weingartner, 1969; Holt, 1969). A large number of (mainly elementary) schoolteachers were said to have caught the 'turtle fever'[6] (see Johnstone, 2003). A community of radical teachers emerged and Logo became their symbol, a metaphor for using the computer to break out of the traditional ways of doing things in schools.

In this context, the introduction of Logo in US and UK schools was initially not a centrally organised educational reform: it was a grass-roots innovation, which was employed as a way to change existing educational arrangements and orientate them towards child-centred and open-ended exploratory learning. However, soon after this initial, unofficial and semi-autonomous phase, Logo was included in the official school policies of both the US and the UK. From an experimental tool in the classrooms of dedicated enthusiasts, Logo became 'part of the curriculum'. This marked the beginning of a shift away from Papert's original intentions of 'educational megachange' (possibly but not necessarily bypassing school) towards evolution rather than revolution.[7]

However, the introduction of Logo in mainstream education in the early 1980s as an attempt at radical educational reform happened within an adverse political climate that discouraged progressive, open-ended approaches, and favoured hegemonic 'technical fixes' rather than social interventions in education. In another study (Agalianos, Noss and Whitty, 2001), we give a detailed account of the ways in which the conservative restoration was effected. In this context, the 'Logo philosophy' for education and its methods were incompatible with the

culture of most mainstream schools and the educational reform priorities of the 1980s. Although a significant part of Logo's radical messages were still there at the time Logo reached mainstream schools, the changing conditions of the 1980s meant that the possibilities of activating those radical messages were reduced. By the mid-1980s, a pervasive backlash against Logo was already in place in the US, where Logo was beginning to be denounced as having failed to deliver what it promised. Where it survived, Logo was marginalised, remoulded as harmless to the mainstream educational system, recast as 'a drawing tool' rather than as any kind of catalyst for rethinking the content of what was taught. It was added to the long list of attempts at fundamental school change that were adopted in many classrooms and yet, over time, were either marginalised into incremental changes or slipped away leaving few traces of their presence.

THE EARLY DAYS OF LOGO

Logo started largely as a language-manipulation (or list-processing) language, which was originally intended by Feurzeig (1967:87) to be used by students not only for mathematics but also for understanding the grammatical structure of language.[8] Beyond these two areas, a number of other applications of the language were soon explored, in areas that included science, music and special needs. In its early days, it was far from clear what the main use of the new language would be; there was a range of possible areas of application. Wallace Feurzeig, the leader of Logo's initial development team at BBN, remembers:

> Initially the interest was not only mathematics. I named it 'Logo' from the Greek 'λόγος' [logos] which means a word, a thought, the idea, but word is very prominent. And the notion was that computers were not just for doing science or math technical kinds of things; they could be used for language, for music, for all kinds of things, that computers would be interesting to people in various ways. We were interested not only in mathematics but other areas, too.

The initial development of Logo was linked to a radical view of educational change that held Logo as a tool for constructivist learning and as a potential vehicle for the transformation of education:

> We had the hope that this would be transformational ... we were interested not only in mathematics .… And the thought and the hope was that this was going to really revolutionise education. It was a very, very different view about what computers and programming and kids were all about from what people were doing with other technologies like CAI or with BASIC ... the hope was that Logo would really get kids to think in a more fundamental way about thinking in all kinds of contexts, to become strategic thinkers, to become more involved in designing and building of knowledge. (Feurzeig, interview)

This view of Logo as a potential vehicle for an educational revolution was shared by all those involved in its initial development, but to different extents. Within the research team two distinct positions gradually formed on what the language should be applied to and the position of the language in relation to the curriculum and existing school structures.

REFORMERS AND REVOLUTIONARIES

Some members of the early development team expected that Logo could be used throughout the curriculum from elementary school through college and graduate school to augment courses, to provide new kinds of experiences, and to enable students to engage in many different areas instead of simply studying about them. From this perspective, Logo was seen as an appropriate interactive tool to help children engage in formal thinking very early, but within the existing school reality. George Lukas,[9] a member of the BBN Logo team at that time, recalls:

> We were interested in augmenting the curriculum at lots of different levels ... as opposed to the idea that Logo was a revolutionary new idea which would be the centre of the curriculum. (interview)

According to this view, a necessary condition for the success of innovative Logo activities would be the creation of an appropriate 'Logo culture' among teachers, teacher training, curricula and teaching materials. Some tension developed within the team in relation to this:

> We began to have some so-called 'teaching clinics' around 1967 or 1968. There was also a kind of funny attitude on the part of some people that one should not be providing a great deal of curriculum material to support the work because the teachers would tend to use that slavishly instead of getting in the spirit of building what was needed at the time more circumstantially and so on. It was almost religiously thought by some to be just the wrong thing to do. (Feurzeig, interview)

In this sense, the reformers within the team tended to view Logo as something with great potential which should be introduced into schools and assist grassroots educational change from within. They were more interested in projects that would be more acceptable within existing structures, tending thus to see Logo penetrating traditional schooling through a process of evolution rather than revolution.

Supporters of the *revolutionary* perspective (including Papert himself) tended to adopt a fundamentally different view of Logo as something that was incompatible with the existing forms of schooling. For them, Logo was an anti-school project, something which was different and, in fact, against school in its traditional form:

> At a certain point I did not think of school as saveable, I didn't think that school was a proper learning environment. ... Originally in my head it [Logo] was an anti-school thing. ... Logo was the cleanest example of an anti-school use of the computer, of a use of the computer very different from anything that happened in the school. (Papert, interview)

From this 'de-schooling' perspective, the revolutionaries -- instead of focusing on the ways in which computers and Logo could make traditional teaching more efficient or attractive – saw Logo as a computer environment where children should be encouraged to do things in completely new ways. Rejecting traditional approaches as conservative and alienating, the revolutionaries pressed strongly in the direction of more heuristic, intuitive, qualitative and

experiential approaches for making connections with mathematical and scientific ideas. They argued that children could use Logo to learn through discovery methods, pursuing their own goals and ideas. Rather than viewing Logo as a new tool within the existing curriculum, they saw it as a revolutionary anti-school idea which could potentially bring about radical change in existing perceptions of schooling, teaching and learning, and more generally in society and culture. In this sense, their claims for Logo were overtly political and iconoclastic in a way that was more extreme, confrontational and uncompromising than the radicalism of their reformist colleagues. Logo for them was an alternative project outside existing school systems.

THE MOVE TO MIT AND THE ROLE OF THE NATIONAL SCIENCE FOUNDATION (NSF)

Evidence suggests that this division of perspectives between reformers and revolutionaries within the initial Logo development team was one of the reasons why a number of 'revolutionary' group members followed Papert to form the MIT Logo group in 1969. A member of the early group remembers:

> Because Papert really had a very different idea of Logo. [Our idea] about Logo was that it would be a curriculum component that would provide a laboratory setting in which students could do many things that they couldn't do otherwise. While his [Papert's] idea about Logo was that by explaining something to the computer the student really understands it. And of course the method of explanation to the computer was via a Logo program. And so he felt that Logo would replace everything and also his emphasis was curricula based on Logo. We were pretty much against that. (Lucas, interview)

In 1969, Papert founded the MIT Logo Lab within the MIT Artificial Intelligence Laboratory.[10] Within the powerful institutional context of MIT, the Logo Lab continued research on Logo while, at the same time, the BBN Logo team remained small and short of the necessary resources (mainly grants from the US National Science Foundation).

The fact that BBN was no longer credited with NSF funding for Logo research after the MIT Logo group was formed meant that a particular direction in Logo's development (the approach of the MIT Logo group) was being supported at the expense of the BBN approach. In this sense, NSF funding became a decisive element and the NSF an important social player in the development of Logo. The fact that BBN[11] was not a university involved in education projects made it very hard to get any funding from the NSF:

> The tradition was funding universities. BBN was suspected as being a money-grabbing kind of place rather than pure as a drift of snow like universities! So he [the Head of the Office for Computing Activities of the NSF, Dr. Milton Rose] said: 'Why should I fund you? You are not a university'. (Feurzeig, interview)

Under these conditions, obtaining NSF funding (or personnel assistance) for Logo research became almost impossible for BBN. Especially after the introduction of Logo into schools in the early 1980s, BBN was not funded by the NSF for research projects in education, in contrast with the MIT Logo Lab, which was part of a university. George Lukas remembers:

> Because basically if the NSF had the choice of giving money to a college or to BBN, the college would be much preferred. (interview)

As a result of this decision, Logo research at BBN continued with very limited resources. At a time when a significant ideological gap existed between the two research groups, the NSF funding cuts meant that the approach of the MIT Logo Lab was the official choice of the NSF:

> We didn't know where to put our technical effort because we were so limited. We never got funding, we were never as successful as MIT, we never had more than four-five people working on the project, so capabilities were limited ... so part of the reason why we fell behind [MIT] was because it took so long for us to get the software out. (Lukas, interview)

In the early 1980s, it became almost impossible for BBN to obtain funding either for Logo research or for dissemination of Logo in schools; this was considered to be exclusively the job of universities and also (later) of places like the Education Development Center (EDC).[12]

While Logo was increasingly becoming a school matter, the BBN Educational Technologies Department was obliged for reasons of survival to look for different areas of activity, with Logo research doomed to remain a minor activity.

The exclusion of BBN from the game meant that Logo research would continue in a certain direction (that of the MIT Logo Lab) and that the BBN approach would be closed off. From a social constructivist point of view, a question arising at this point is whether Logo-the-product would have been different had BBN been given the resources to continue research on Logo. We do not know. What we do know is that BBN's limited access to NSF funding for Logo meant that, for good or ill, a particular perspective on Logo was being closed off as a result of the influence of a powerful social actor (the NSF).

The influence of the NSF in the shaping of Logo would also be visible a few years later, when the MIT Logo group itself suffered significant funding cuts. Permeated by a conservative preoccupation with academic results from standardised tests, which were the fashion of the day, the NSF put enormous pressure on the Logo group to provide 'evidence' of the educational benefits from Logo in those terms. But, throughout the 1970s, the MIT Logo Group were critics of standardised testing as a way of determining people's intelligence and educational achievement. Although they agreed that standardised tests might indicate something about people's perceptions of particular subject areas, they did not think that these tests were a measure of a person's understanding. They vigorously opposed standardised tests and grades, while still expecting that children in a Logo computer culture would show an improvement in their standardised tests of reading, language, arts and computational skills. The Logo Group rejected the traditional testing methods of evaluation, which the NSF advocated, as unable to indicate anything really worthwhile about what

students were learning. John Berlow, the person who worked closely with Seymour Papert as editor of *Mindstorms*, recalls:

> Seymour was pretty principled when it came down to testing and things like that, he really refused to go along with that. (interview)

As a result, the MIT Logo project suffered significant funding cuts by the NSF and downsized in 1977 on the grounds that students who had done Logo did not score higher on standardised tests. This pressure of the NSF to test whether Logo was leading to generalised problem-solving enhancement is an example of a struggle over the meaning of Logo. It illustrates how the mathematics education community at the time re-constructed Logo to answer its own concerns, but was overshadowed by the need to exhibit improved scores on 'problem solving' (see Noss & Hoyles [1996:180-81], for a full discussion of this phenomenon).

THE STRUGGLE OVER THE MEANING OF LOGO WITHIN THE MIT LOGO LAB

Within the context of the MIT AI Lab, a large number of researchers with diverse backgrounds and interests were gathered around Seymour Papert, most of them computer scientists and engineers who had an interest in education, rather than educationalists who had an interest in computer science. A short time later, a number of non-computer scientists also joined the Lab, such as the psychologist Edith Ackerman, John Berlow and people from the world of education like Paul Goldenberg and Daniel Watt.

Within this context of diversity, the simple division between *reformers* and *revolutionaries* was reconstituted in a new and different form within the MIT Logo group itself. The fundamental disagreement over the degree of radicalism and departure from traditional

schooling structures was re-contextualised, creating some tension within the MIT Logo group. John Berlow remembers:

> Within the Logo group the people who were kind of MIT hackers[13] -- and Seymour too – they were the kind of people who were more purists in a sense of being more radical about it [Logo] and really wanted nothing to do with school systems; they just wanted to do alternative kinds of projects. But then there were people in the group like Dan Watt, who was a teacher, and Sylvia Weir ... who were more interested in the kind of project design that was more acceptable by conventional standards ... and Seymour was really very, very opposed to that kind of approach. ... So there was a kind of deep conflict that way. (interview)

An example reflecting this tension is the gap that arose between those members of the group who prioritised technical development and those who were in favour of dissemination in schools. It was the tension between how much effort to put into building more technically advanced Logo computer environments as against the effort to spread the existing product and the ideas around it into schools. Henry Lieberman,[14] a young computer scientist at that time who was initially involved in 1971, recalls:

> One of the major currents of tensions was over how much effort to put into developing the computer systems versus just trying to get it out into schools and not worrying too much about updating it. ... My personal preference was always more on the research side; I always thought that we should put more effort into developing new things. (interview)

Evidence suggests that the NSF was significantly involved in the resolution of this tension by putting pressure on the group to make sure that existing Logo implementations would spread into schools and would be tested as soon as possible, rather than that new technical developments would be supported.

At a later stage, personal dynamics played a role in the struggle over the meaning of Logo within the MIT Logo group, having an impact on important decisions that would shape the future of Logo. For example, evidence suggests that some members of the group who were neither mathematicians nor computer scientists (and who had priorities other than the

technical development of Logo) at times felt quite uncomfortable within the group. A member of the group remembers:

> … a lot of people emerged very hurt from that, because we could not work it out, there were terrible power struggles. People were forced to drop out, people stayed in but emotionally dropped out, people took power, people lost power ... there was anger and hatred under the surface and we needed to resolve this ... it was too much pain and problems, more than I had anticipated, and it couldn't be resolved ... and that's why people had intelligently suppressed it. And when it started to happen, people started to cry in our group meetings and yell at each other, and really let it out, and Seymour asked [name] to find a therapist to come and give us group therapy ... It didn't work ... He talked to us individually but not as a group ...The problems were very deep. There was a lot of competition for Seymour's attention and we could never agree on the structure. ... One of the big casualties was [name] who really did get pushed out as a result of that process and that was a big loss to the community. (confidential interview)

Additional tension arose sometimes over specific technical decisions, for example, the precise syntax or functionalities of individual commands, or the importance of Logo inheriting all of its intellectual antecedents from its parent languages (LISP-SCHEME). Logo was a technical as well as educational breakthrough, and such developments do not take place without substantial questioning and contest. To those people in the group who were giving primacy to the use of Logo for mathematics, the 'purity' of Logo's inheritance was, for example, a key aesthetic of Logo. However, such elegance was sometimes seen to be achieved at a price: some felt it could compromise its learnability. In this sense, the existence of two competing aesthetic priorities (learnability and the integrity of the knowledge domain) marked the development of Logo.

This tension about Logo being a 'mathematically clean' versus an 'easy to get at' (Papert, interview) programming language was most demonstrably reflected in the debate about syntactic uniformity. The struggle to maintain a uniform syntax for Logo was a reflection of the debate about whether the programming language should be like a mathematical system (where things are very systematic and consistent) or like a natural language where all sorts of different idioms are possible. For a long time Papert tried to maintain Logo

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syntax as not having any exceptions, with the same set of rules applying across the board rather than many special cases. He remembers:

> But most languages had just compromised and didn't try to have anything systematic about the syntax. You would have a lot of special case expressions. We didn't want to have special case expressions and I fought quite consistently against that. And we had a lot of fighting about that, but usually I won on that. (interview)

Compromises over sensitive design decisions were frequent. Another example is given by Papert:

> I thought the right way to deal with variables in Logo was always through the metaphor of 'it's a name'. So I wanted the language of Logo to represent it so that we can say, for example, NAME 3 X. ... Other people wanted to have something that sounded more like the mathematical notation like 'LET X BE 3'. And since LET had been used for something else the idea of 'MAKE x BE 3' became a standard kind of syntax. I think that was under the influence of wanting to make it look more like mathematics. And I tried to struggle against it. And the compromise there is that most implementations of Logo allow both of those ways of doing it. But most of the books about Logo take the MAKE one, the one that's more influenced by mathematical usage rather than by what I think is a clearer, a more logical way of doing it. (Papert, interview)

MARKETING AND ECONOMICS IN THE EVOLUTION OF LOGO IN THE US CONTEXT

The commercialisation of Logo, which followed the increasing availability of microcomputers and the introduction of Logo in mainstream US and UK schools in the early 1980s brought in new players, including hardware and software companies which attempted to exploit the school market that appeared for Logo. The various attempts to commercialize aspects of Logo had both positive and negative implications. On the positive side, commercial activity made Logo available to a wide audience internationally, increasing the interest in it and the pressure to introduce Logo into schools. Mitchel Resnick,[15] a key figure in the evolution of Logo, remembers:

> Obviously the good thing is that it gets out to a lot more people, has a lot more influence on people who previously never would have thought of some of these ideas, get awakened, become meaningful contributors on their own right, either in their own local circles or getting connected to this larger community and starting influencing other people to think about these things. This was clearly a positive side of [getting commercial], reaching more people. (interview)

Dan Watt,[16] another key figure in the evolution of Logo, says:

> My feeling is that nobody would have ever heard of it still if it hadn't gone commercial. It would be in pockets around the world as experiments (interview).

On the negative side, research evidence suggests that commercialisation gave rise to unrealistic claims about the value of Logo in the early days of its implementation in schools. Commercial companies advertised extensively, very often making unsubstantiated claims for Logo, which were also raised at Logo conferences as well as in part of the early Logo literature. Al Cuoco, a curriculum developer at EDC, remembers:

> ... in many cases it [Logo] was oversold ... there were just grandiose claims for this environment ... the opposite was true, teachers are central to such a thing, the way the language was used was central to the whole success of the operation. (Cuoco, interview)

Another early effect of the way Logo was advertised and marketed was that it quickly became regarded as a programming language appropriate only for young children. The fact that Logo was represented as a language for young children was a conscious marketing decision dictated by the reality of the new promising market: elementary schools. Given the predominance of languages like BASIC and PASCAL which were traditionally regarded as more suitable for more advanced applications, commercial companies consciously targeted Logo to the part of the new market of elementary schools and young children, which had not been colonized by other languages. Al Cuoco recalls:

> Logo was being looked at as a language for elementary school students. By-and-large this was a product of the way Logo was advertised and marketed. We were constantly battling with people in the community and parents against this impression that Logo was an environment for little kids. And that was the reputation it had built

up in this country anyway, that it was something for elementary school kids. And that high-school kids should not waste their time with this language that was basically for little kids. I think it had a lot to do with the way Logo was marketed as a product by the companies. Most of the workshops that you would see advertised at conferences and so forth were how to use Logo in elementary schools. In the early days of using Logo there was a very clear emphasis to get kids interested in mathematics at a very early age and lots of people that I talked to were really surprised to find out that Logo could do things other than produce pictures. The fact that it was a dialect of LISP and all this other stuff came as a big surprise to most people that I talked to (interview).

The view that Logo became a 'language for babies' mainly due to commercial interests is also supported by Uri Leron,[17] who was an important figure in the evolution of Logo in the early 1980s:

... mainly because of business consideration Logo was never developed very much for ... high school students, let alone university students. And people like me and like Brian Harvey who worked a lot with [university] students were frustrated by the fact that LCSI didn't produce versions of Logo for this audience. And the reason for this was simply because this audience is very small. There are very few people in the world who teach Logo to older children. Most of the market is in the elementary school so they directed the product to the elementary school and we remained with very old and outdated versions. (interview)

At the same time, the fact that the standards developed for the US Advanced Placement Exams (APE) scheme for college credit were based on PASCAL (which was the dominant programming language at the time), reinforced the dominant 'reading' of Logo as a 'language for babies' and its deeper institutionalisation as part of the lower grades curriculum. The decision to have PASCAL as the standard language for APE constructed a sense of superiority around it and it made it appear a more advanced language than Logo, which was correspondingly viewed as not appropriate for higher grades. As PASCAL remained the standard currency for getting college credit for high school work, Logo did not have the same exchange value for high-school students. Uri Wilensky[18] recalls:

As a result, people believed that Logo should be for kids in the lower grades and then you grow up to do C, PASCAL, FORTRAN or even BASIC, whatever it is that they think it is the next computer language. So I guess school assimilated it to be just like other computer languages, but in this case as a language for young kids. (interview)

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PRESENTATION

The decision to hold elementary schools as the primary target for Logo had yet another effect: commercial companies tried to increase sales by adding attractive effects to the language. Given the limitations of the technology at the time, however, this 'flashiness' was added on at the expense of other features of the language. *ExperLogo*,[19] for example, was advertised as being incredibly fast, and *speed* was promoted as an aesthetic worth pursuing. However, the price paid for the speed was that the computer did graphics only in whole numbers. For example, if you typed the command, 'FORWARD 7.4', the 'turtle' moved forward only 7. Or if you typed 'REPEAT 10 [FORWARD 0.1]' the 'turtle' would not move at all. This meant that the producers of *ExperLogo* were prepared to sacrifice the aesthetic of mathematics and consistency for the aesthetic of speed. This process of compromising some of the original design principles of Logo by the commercial drive for 'flashiness' is characterised this way by Papert:

> … At the core of the process of design is the art of trade-off. If you want more speed, you have to take less of something else. ... Observing what a design team finds worth giving up is a window into its aesthetics and its intellectual values. … In *ExperLogo*, bunny speed was bought (in part) at the cost of making FD treat its input as an integer. So, 0.1 is simply treated as 0. REPEAT 100 [FD 0.1] is the same as FD 0. Thus the relationship between Logo and mathematical intuition is impaired, and the passage into mathematics through the turtle circle is impeded. ... What kind of decision did the *ExperLogo* team make in choosing speed over mathematical transparency? The point is not whether the choice is right or wrong but what it tells us about the decider. ... The designers of *ExperLogo* have the right to give higher priority to speed. But this *is* a choice. And each choice is a reflection of cultural affiliation. (Papert, 1987:64, original emphasis)

More recently, the commercially driven legacy of 'flashiness' was evident in one of the latest versions of Logo, *Microworlds Logo,* which has sacrificed some of the original aesthetics of Logo for the aesthetics of 'flashiness', although most of the technical limitations of the past (e.g. limited memory capacity) have been overcome. It seems, however, that the appearance

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of other kinds of commercial software in the 1980s, which had attractive features like colour and sound effects, put pressure on commercial companies to create more 'flashy' versions of Logo that would otherwise be very hard to sell. This was basically the reason that led to the development of *LogoWriter* by Logo Computer Systems Inc. (LCSI) in 1986. *LogoWriter* is a version of Logo that combined graphic design capabilities with a word-processor and other attractive features. The combination of drawing with word-processing capabilities and a number of other features allowed many more possibilities, and it was a conscious decision on the part of the producers to broaden the appeal and show that Logo could be used for many more things and in many more ways than turtle graphics[20] (see, for example, Harvey, 1997). However, the commercial decision to add new attractive features like animation had -- in this case as well -- its cost, as it implied that the resolution of turtle graphics had to be sacrificed for 'flashiness', something which was bad news for those who were trying to develop the use of Logo for mathematical and geometrical work. Molly Watt,[21] another key figure in the evolution of Logo, remembers:

> When LCSI came out with *LogoWriter* it broadened the appeal and harmed the mathematical side of Logo. ... It essentially de-emphasised a lot of the mathematics of turtle geometry for example. Because one of the things they did in the first implementations of *LogoWriter* was they gained features in the Logo program by reducing the resolution of the turtle graphics. The lines were thicker, so you couldn't draw such interesting graphic designs anymore. That's just a very small point of how a decision to add attractive features -- these little animations and things -- to Logo interfered with some of the .... They brought out something very new and very flashy. ... There became so many different possibilities that it was trying to be everything. And so it maybe spread itself too far. They brought out something very new and very flashy and very exciting and very marvellous. But I wish they had waited five years to bring it out. Because we were just beginning to develop what could be done with turtle geometry as a broader culture. And a lot of people just threw that stuff out. (interview)

THE TENSION BETWEEN THE MIT LOGO GROUP AND THE APPLE COMPANY

Another commercial decision that influenced the shaping of Logo is represented in the subsequent tension between the *Apple* company and the MIT Logo group. In 1981 the MIT

Logo group developed an implementation of Logo for the *Apple* computer and *Apple* wanted to have exclusive rights for the distribution of this new product. However, after consulting with lawyers for a long time, MIT decided that *Apple* should not have the exclusive rights on that version, because initially Logo had been developed with public funding. MIT decided instead that this version for the *Apple* microcomputer should be freely licensed to anyone who would distribute it, as it was with any other Logo version. The tension was resolved with the establishment of LCSI as a separate company by a group of investors and the creation -- by the LCSI -- of a new (second) version of Logo for the *Apple* computer, which was finally bought by *Apple*. Seymour Papert became the director of LCSI and many of the same people from the Logo Lab were hired. The two Logo versions for the *Apple* microcomputer were almost identical, with only a few minor differences which provided the legal ground for considering them 'different' for copyright purposes. *Apple* bought the exclusive rights of the 'new' version, which thereafter became *Apple Logo*. That was an acceptable settlement for both sides: on the one hand, LCSI continued to develop the original version; on the other, *Apple* were gratified to see that by summer 1986 approximately 150,000 copies of Logo had been sold for the *Apple II* family of computers in the US and Canada, which meant significant profits. Evidence suggests that this decision to produce the second version (for *Apple*) was not based upon educational reasons having to do with progression in the development of the language; rather, it was essentially a commercial decision. Dan and Molly Watt, curriculum developers and teacher trainers in Logo, recall:

> If you talk to some of the other people like Brian Silverman they may tell you that the MIT version of Logo had some mistakes in it and things they didn't like, which is true. It wasn't debugged enough and they wanted to make a few choices on it, a few commands. They did have some more powerful commands in the *Apple I*. But it was essentially a marketing decision this whole issue of different versions of Logo and different implementations. (joint interview)

COMMERCIALISATION/IMPLEMENTATION   ***VERSUS***   ***TECHNICAL***

DEVELOPMENT

An additional consequence of the involvement of commercial companies was the creation of

tension within the MIT Logo Group itself because -- as we discussed earlier -- a number of

people in the group were in favour of more research and technical development of Logo

instead of commercialisation and school implementation which was what the commercial

companies wanted.[22] The fact that people from the Logo research group became affiliated

with both the research team and the commercial companies seemed to slow down research in

favour of commercialisation and implementation, a direction that members of the Lab who

were in favour of research and technical development did not prefer. Lieberman remembers:

> The attempt to commercialise created some tension as the companies took people away from doing research so the research group felt like some of the resources were being taken away to commercial companies. There were also individuals who had conflict of interest as they were affiliated both with the [MIT] research group and commercial companies. This surely happened with the first company 'General Turtle' ...there was some uneasiness about who was involved in this company and who was not; also about to what extent the company was using resources of the Lab. … We thought that if the company was successful that would be a good thing for Logo. But there was always what the priorities were for the research versus the company. ... When you get that kind of situation it always influences the development in that it sort of puts more emphasis on short-term objectives rather than long-term objectives. (interview)

The view that commercial companies caused tension among the members of the research

community who were involved is also supported by Brian Harvey:[23]

> ... There was a kind of fragmentation of people's efforts. ... There was *Terrapin*, and *LCSI* ... and those companies came out of the same group of people, the MIT Logo Lab people. And there were other smaller companies. ... It's hard to support all those different companies and people ... and sometimes there are rivalries. So in the case of Apple, there were two different competing versions of Logo for the Apple. ... There was the LCSI Logo and there was Terrapin Logo which was the one developed at MIT by Hal Abelson's group. And that was too bad because sometimes people didn't like each other; it was also too bad because the two versions were incompatible.(interview)

The existence of commercially antagonistic versions also created tensions within the context of 'consumption', as the commercial companies forced those responsible for dissemination and implementation to take sides. These pressures were a divisive element within the wider 'Logo community' as well as being a source of confusion for teachers who were using Logo at schools. Dan and Molly Watt remember:

> There were these different versions ... and most people had their feet planted in one or the other ... we refused to take a position on which one, we would always try to do things that were common. [This] made us not so popular sometimes as Seymour and people who had a financial and a personal interest in this version or that version. We were always trying to show the universal thing that could be done. ... But we never, ever took a position of which one! And that made us incredibly unusual. And people would get quite angry at us about not being either for *Terrapin*, or *LCSI* or ... we didn't ally ourselves with any of the companies, so none of them would have loved us entirely although they all were very generous to us (Dan and Molly Watt, joint interview).

The antagonism between versions was also causing practical problems for teachers who were either learning to use or already using Logo at schools:

> And if you had a group of teachers and you got them trained in using the *Terrapin* Logo, you couldn't go and the next year take the other one or whatever. And the same applied to computers. If you used the TI computer, for example, it was very difficult to switch over and use something else. So that was a very divisive element. (Dan and Molly Watt, joint interview)

POLITICS AND ECONOMICS IN THE EVOLUTION OF LOGO IN THE UK

Beyond the commercialisation and marketing of Logo in the US, the study of the re-contextualisation of Logo in Britain in the early 1980s provides a window into the social processes involved in Logo's production and marketing, as well as into the important ways in which 'consumption' was partially determined by the decisions involved at earlier stages in the cultural circuit.

Logo appeared on the British scene in the early 1980s, at a time when Ronald Reagan's demand for educational quality in the US was paralleled in Britain by Margaret Thatcher's

call for a return to 'basics', and also by the Education Secretary's paper on 'teaching quality' (Cuban, 1993; Avis, 1991). Within this context, a similar attitude in the educational policies of both the US and the UK demanded a rapid introduction of computers in education by funding national initiatives to place computers in schools. In the UK, the Department of Industry (DoI) subsidised the introduction of 'home-made' computers to both primary and secondary schools while a massive training campaign was launched to teach teachers the basic skills thought necessary for operating the micro in the classroom.

British initiatives began in 1980 with the Department of Industry's *Micros in Schools* scheme, followed shortly by the Department of Education and Science's *Microelectronics Education Programme* (MEP).[24] Under the MEP scheme, secondary schools were offered half the cost of one of two British micros, one of which did not actually exist at the time the scheme was announced. The scheme was later extended, in a slightly modified form but still with the patriotic clause, to primary schools, special education schools and teacher training colleges. These various schemes had cost the government about £30 million by the end of 1983.

However, interests other than straightforward educational ones determined the kind of hardware and software as well as the overall character of the attempted innovation. Evidence suggests that the impetus for putting micros in schools came from industrialists rather than educationalists. Janet Ainley,[25] a mathematics teacher in the UK at that time, remembers:

> It was time when computers were first starting to come into schools and schools wanted to get hold of this new thing and ... 'there is this very good …offer'. But what was on offer was only British-made computers. ... The motivation was nothing to do with education; it was actually about supporting the British computer industry. (interview)

This view is also supported in the literature; for example, Self (1987), Doyle (1993) and Noss & Hoyles (1996):

The DoI schemes have played a notable part in sustaining the indigenous microcomputer industry. The apparent benevolence to the educational system cloaks a multi-million pound subsidy to manufacturers which would have been politically unpalatable if given directly. In 1981, American micros, with their greater software support, were beginning to predominate in British schools. Now they and Japanese micros together, of course, with non-recommended British micros are virtually excluded from British schools -- so much for the free market economy. (Self, 1987: 230)

Guided by the policy imperatives of centralising curriculum control and the rhetoric of high-technology business interests, the British government was poised for a major intervention which was clearly intended to convey a number of symbolic messages: that the government was well-informed, that it was in control and that it was 'out in front' of this important development. The initiative was also surrounded by justificatory rhetoric couched in terms of international competitiveness, business needs and, only lastly, the possibility of enriching students' lives. The process of mandating a standardised form of educational computer had to be carefully managed, in order to avoid the appearance that Local Education Authorities were actually being ordered to do something. The approach that was taken, in the end, was not openly to impose a particular computer configuration, but to 'recommend' one, and to make the selected system so economically attractive as to rule out any other alternatives on a cost basis alone. This point is registered clearly across a number of interviews. Janet Ainley remembers:

There was a Government initiative in the 1980s to put a computer in every school. And schools were able to buy at quite reduced prices and obviously a lot of schools did that. And lots of Local Authorities did the same on behalf of the schools. ... And what was on offer were BBCs and *Sinclair Spectrum* and the *480Z Nimbus* machines ... and so that was what schools bought. (interview)

Mike Doyle (a teacher at that time) and John Wood, also active players in the take-up of Logo in the UK in the 1980s, recall:

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> ... a government decision to support UK industry by way of controlling the market. Schools were not allowed to buy other than a specified range of computers initially, and the rules weren't relaxed until the later 1980s. A school could buy anything they liked but they got a subsidy from the government if they bought either *Acorn* or RM [*Research Machines*]. And when government initiatives came out initially they would only support... they said: 'you can buy from the following range of computers'. (Doyle, interview)

> Because there was a politically inspired government initiative to supply computers into the schools, which effectively defined the computers that were going to be in the schools. We had a choice between a CPM [operating system] machine (a British machine made by *Research Machines*), and the BBC computer. (Wood, interview)

On the hardware front, this politically inspired and economically motivated prescription effectively defined the computers that schools were allowed to buy. The possibilities and limitations of the hardware chosen in turn defined the sort of software that would become available to schools: the versions of Logo that would become available to British schools had to be compatible with the 'recommended' hardware. However, while schools (especially primary schools) 'chose' the BBC computer, there was no Logo implementation available for this computer at that time. The BBC microcomputer had BASIC as the standard language built into it:

> So that when you started up the BBC computer both the operating system and the BASIC language were there available for you … along with this silly little machine [BBC] there was also a version of BASIC, a 'new improved' wonderful [ironic] version of BASIC called 'BBC BASIC'. (Doyle, interview)

As *Acorn* had invested heavily in its own 'improved' variety of BASIC for the BBC computer, the company had a big vested interest in not having a version of Logo, because they wanted to sell BASIC as the best product. BASIC was already established as a programming language, so it was much easier to sell a new version of BASIC than a completely new language:

> ... as a result, there was little incentive for the company who manufactured it to develop a viable Logo. (Noss & Hoyles, 1996:162)

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The BBC BASIC was a structured BASIC, which allowed the user to do recursion at least in part: recursion is a powerful programming structure that was shared by Lisp and Logo but not – up to this point – by BASIC. This meant that users could write turtle graphics programs (that did the 'turtle' part of Logo but not the list-processing part) for use on the BBC computer and also on the *Research Machines* computer, for which there also was no Logo in the very early days. This meant that in order to do any Logo at all one had to write an emulation of Logo in BASIC. Mike Doyle, remembers:

> And I didn't use Logo because I had a BBC computer; I used the emulation of Logo called *DART*. ... And when I got my BBC computer I taught myself BASIC, because that was the language that came with it. (interview)

When Logo implementations for the BBC did become available later, technical constraints were a serious factor discouraging schools from buying some version of Logo for the BBC machine. For example, Doyle recalls that the BBC machine had a very low memory capacity and it could not run Logo properly:

> And I wouldn't be able to write Logo properly because the BBC computer wasn't powerful enough at that time for me to write a Logo program of any complexity. ... The difficulty was that Logo was too big a language for the computer with which I was working. (Doyle, interview)

To be able to do so an additional new kit had to be installed on the computer, a technical constraint which - as Doyle recalls - discouraged teachers even more:

> ... it had to have a new kit installed. So it was very tricky, you had to be really committed. If you wanted to buy that version of Logo for ten machines you had to buy ten new chips and install them without bending the pins. That was a nightmare. (interview)

In 1984 four implementations of Logo for the BBC computer became available. Out of these four, two Logo versions were competing effectively at the time: one written by *Acorn* themselves and one imported from France, *Logotron Logo*. The *Acorn* one required two

holes (two chip sockets), the *Logotron* one required one socket at the back of the computer. *Logotron Logo* was eventually adopted, as it required only one chip. Once again, the Logo version that came out on top did so not due to its educational merits, but for reasons having to do with the technological nature and limitations of the BBC computer:

> And in the BBC computer at that time there were two spare holes, you put a word-processing chip in one and you put Logo in the other. And if you needed to use two holes for your Logo you couldn't have a word-processing chip in. And so it's won out for that very simple reason that it only took one hole. It wasn't the best implementation. ... In effect this in a way determined the kind of Logo that came to be used in [British] classrooms. You had a spare hole, which one fitted in the spare hole? Which one was fairly standard? Why don't we go buy that one? (Doyle, interview)

In the meantime, however, the delay in producing these versions of Logo for the BBC machines already bought by schools (the gap between 1982 and 1984) had some surprising effects, the legacy of which still exists today. Several individuals, amateurs, saw a wonderful opportunity to make money and produced little graphics-drawing packages usually written in BASIC (one of them was *Logo-Challenge*, another called *DART*) which were called 'Logo'. As John Wood recalls, these packages were offered at attractive prices and caused confusion among teachers:

> But these other ones were called 'Logo' and how do you know? If you are sitting in an infant school and somebody says 'would you like a copy of *Logo-Challenge*?' and it's only £3.50 and you also get a book on what to do with it. ... And even now there are people who don't understand. … A lot of things like *DART*, of qualities lesser or greater than *DART*, were called 'Logo'. I guess that teachers ended up quite confused. There was no message that could be coming through from this. (interview)

In 1983 the British Logo Users Group (BLUG) referred a number of these products to Trading Standards. Mike Doyle (former chair of the BLUG) recalls:

> And we received a letter back from them that said: 'There seems to be a general acceptance within the trade that the use of turtle graphics is equivalent to Logo'. (interview)

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This meant that by 1993 -- legally in the UK -- Logo and turtle graphics were effectively regarded as the same thing. From being a computer language of interest to education, Logo in the UK had become equated with a language for turtle graphics. In 1985 *DART* was being used quite a lot for this purpose. At the same time, while the chip required for the installation of Logo cost £75, *DART* was a freely copyable package available from local school computer centres free of charge:

> And the only bits that mathematics teachers were talking about teaching were turtle graphics. ... And therefore people tended to buy ... -- they didn't have to buy *DART*-- they got hold of it and tried it-- and then said 'this does what I want, why do I have to go and buy the real thing for £75?' Because when they bought the real thing they didn't use any of the characteristics that make Logo a particular computer language, they simply used it for turtle graphics. (Doyle, interview)

It is instructive to note that -- as the following quotation from an interview with Bill Tagg (then Director of the Hatfield Advisory Unit which had developed *DART*) indicates -- in the manual accompanying *DART* its developers had written that, when Logo became available, teachers …

> ... should bury this software [*DART*] gratefully and buy the full version of Logo. But they didn't. At least a lot of them did not, a lot of them continued to use *DART*. And in fact when Logo became available on the micro we stopped selling *DART*. And after a couple of years we actually started selling it again because there was a huge demand for it, people were very angry. (interview)

As a result, DART, not Logo, was the formative experience for teachers in the UK -- the philosophy without the language through which it was expressed. Consequently, the notion of computer language degenerated to 'precise sequences of instructions'. Logo became little more than 'Turtle Talk' (Doyle, 1993:22).

Commissioned by the MEP, Beverly Anderson's evaluation report *Learning with LOGO* (1986) on classroom experiences showed that 'programmable toys such as Milton Bradley's *Big Trak* were seen as 'Turtles'; turtle graphics programs written in BASIC, such as *DART*,

were not distinguished from Logo; and Logo itself was viewed as difficult, expensive, and (possibly) not necessary for doing Logo' (Doyle, 1993: 24). Anderson's report confirmed that, in one form or another, 'Logo' had been rapidly taken up in the UK in a manner that had become acceptable to teachers and to the system. Noss & Hoyles (1996) provide a double explanation of this mode of 'consumption', arguing that two contradictory processes were at work. On the one hand, they argue, the introduction of cut-down 'Logo' resonated with the child-centred approach which had come to characterise many English primary schools in the 1970s:

> ... teachers, parents and head teachers could view 'Turtling' as happily fitting into the wide variety of 'child-centred' activities which could be found in many primary classrooms. (Noss & Hoyles, 1996:162)

At the same time, the very success of Logo's assimilation led to its being viewed as an 'activity' in its own right, not a way of introducing radical change but as a way of operationalising existing priorities by an 'added on' school topic rather than one integrated into the educational setting. By being equated with turtle graphics and incorporated as a minor activity among many others, Logo was fitted comfortably into existing school structures:

> So Logo became a way of ordering turtles around the screen. Turtle drivers such as *DART* shaped the attitudes of a generation of primary and secondary teachers, and at the same time, such programs were conjured into existence to express these attitudes and priorities. Drawing pictures with a turtle became a new curricular compartment. Logo became *marginalised* by its very incorporation -- everything had changed but nothing had changed. (Noss & Hoyles, 1996:163)

CONCLUSIONS

This paper provided a window into the social processes involved in the development and evolution of Logo. It has demonstrated that – far from being consensual – these processes were heavily contested. Logo was the product of complex social, technical, political and

economic decisions, and the product of negotiation shaped by the concerns of the social players involved. The various individuals, social groups and institutions involved lobbied for the system they wanted, all making claims to support what were inconclusive data about the educational value of Logo.

The lack of agreement on standards, the tensions within as well as between the research groups, the range of approaches and objectives within, between and beyond the research teams, the involvement of the NSF, all support the view that the evolution of Logo was not linear or even primarily technical. Rather, it was a seamless web in which the technical was interwoven with the social, economic and political, in ways that illustrate the dialectical interaction between historical contingency and the intentions and aspirations of individuals and communities.

Logo was not simply presented from the beginning as a device for turtle graphics – it *became* such a device through a process in which 'production' and 'consumption' were articulated. The technology was not just produced as a finished artefact which was then marketed and exerted an impact on 'consumption'. The activities of mediators like government departments and (in the UK) the domestic microcomputer industrial lobby were crucial to the modification and redevelopment of Logo.

The discussion of the re-construction of Logo as turtle graphics, especially in the UK, has illustrated how the decision to introduce the 'turtle' as an easy entry-route to the language resulted in a tension between intentions and effects. This was actually made easier by Papert's own emphasis on the 'turtle' in *Mindstorms*, but then commercial considerations led to the foregrounding of that aspect and to the marginalisation of other messages in the 'Logo text'. The tension over the introduction of the 'turtle' was not resolved at the level of initial

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production; rather, it is an issue which cuts across 'moments' in the life-cycle of Logo. Once again at this point, we realise that the struggle over the meaning of Logo was not confined just to the original producers of Logo in its early days. Rather, it echoes all the way through the different 'moments' of Logo's cultural circuit. The dominant construction of Logo as turtle graphics at the stage of 'marketing/economics' fed back powerfully to the 'production' stage, forming the background for new production.

The paper shows that the meanings attributed to the term 'Logo' were contested in the course of its development. For some of its creators, Logo was developed as an interactive tool for constructivist learning. As the material embodiment of a radical educational philosophy, it was seen as a potential vehicle for the radical transformation of education. For others, however, Logo was whatever it came to be defined as its meaning became increasingly restricted in its context of use, and in practice. When reflecting on what actually happened to Logo, its originators thus came to differ about whether these various contexts merely shaped the technology in particular directions or somehow detracted from an essentialist definition of what Logo ought to have been.

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language Logo (often mistakenly described as a 'language for kids') to a group of investment bank employees. At the other end of the age scale, the recently-completed Playground project has involved very young kids in designing and building video-games.

Richard is chief editor of the International Journal of Computers for Mathematical Learning, which aims to realise the vision of its chair, Seymour Papert, to 'foster a new, creative and more learnable mathematics with digital technologies'. He is also the co-author, with Celia Hoyles, of *Windows on Mathematical Meanings: Learning Cultures and Computers,* published by Kluwer, 1996.

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List of abbreviations

APE	Advanced Placement Exams
BBN	Bolt, Beranek & Newman
BLUG	British Logo Users Group
CAI	Computer Assisted Instruction
DoI	Department of Industry
DTI	Department of Trade and Industry
EDC	Education Development Centre (Newton, Mass)
LCSI	Logo Computer Systems Incorporated
MEP	Microelectronics Education Programme
MIT	Massachusetts Institute of Technology
MIT AI LAB	The MIT Artificial Intelligence Laboratory
NSF	The US National Science Foundation

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[1] The main body of the empirical data informing this study was gathered on a study trip to the USA through semi-structured interviews with the original developers of Logo. In addition, a number of key-players in the evolution of Logo in the US context (and internationally at a later stage) were interviewed. The sample was an opportunistic one and, in retrospect, it could usefully have included more people involved in some of the spin-out operations. Data were also collected by classroom observation, discussion with teachers and pupils, analysis of videotaped classroom activity with Logo and analysis of classroom talk about work with Logo in UK classrooms. In addition, semi-structured interviews were conducted with a number of people who were significantly involved in the evolution of Logo in the UK and internationally (some of them active or former teachers in UK schools at the time of the interviews).

[2] A wide range of perspectives and concepts have been advanced within the social sciences in recent years to help understand the relationship between technology and society. Drawing on different disciplinary roots, a number of analytical frameworks have emerged under the umbrella term 'social shaping of technology', a heterogeneous field which is constantly evolving. Social shaping of technology accounts demonstrate that technological change is not governed simply by its own 'internal logic', and that technologies do not follow some predetermined and inevitable course of development. Without offering as yet a single unified explanatory schema, the 'social shaping of technology' demonstrates (through an array of empirical enquiry) that the relationship between technology and society is genuinely an interaction -- a recursive process (Edge, 1995:15) -- and that a range of social, economic, political and cultural factors influences the development, implementation and use of technology. For a review of the field see Williams & Edge (1996). Reviews of European approaches to the 'social shaping of technology' can be found in Cronberg & Sørensen (1995), Sørensen (1999).

[3] Johnson provided a seminal account of cultural studies and maintained that all social practices can be looked at from a cultural point of view. He defended the departure of cultural studies from the individualistic

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barriers of isolated academic disciplines in favour of 'a collective project different from the usual academic purposes' which will grasp more adequately the complexity of cultural processes (Johnson, 1983:11).

Based on the hypothesis that existing theories and the modes of research associated with them express incompletely different sides of the same process, Johnson seeks 'to explain the theoretical and disciplinary fragmentations of cultural studies as a whole' (Johnson, 1986:283). For this purpose he suggested an analytic 'provisional description of the different aspects or moments of cultural processes to which we could then relate the different theoretical problematics'; he suggested (1983:15) that we can view the various forms of analysis within cultural studies as addressing different stages (or 'moments') in the *circuit of cultural production*:

- moment 1: the conditions or means of material production;

- moment 2: the product itself as a 'text' encoded with meanings;

- moment 3: the different socially-located 'readings' or uses of a product;

- moment 4: the intersections of these 'readings' with the lived experience of users.

Johnson's model has influenced a number of researchers. Past examples of cultural products which have been analyzed along the lines of Johnson's model include TV soap operas (e.g. Buckingham, 1993), the Italian scooter subculture, the BBC microcomputer (Haddon, 1989), the 'consumption' of satellite TV (Moores, 1993), the presence of *Channel One* in US classrooms (Apple, 1993), the SONY Walkman (Du Gay *et al.*, 1997).

[4] In the summer of 1965 Papert had written the basic syntax for Logo which was first implemented by Daniel Bobrow on a SDS 940 computer. Daniel Bobrow, then a consultant with *System Development Corporation* (SDC), had been one of the first graduate students in the MIT Artificial Intelligence group. He had been involved with project MAC at MIT and was the manager of BBN's Artificial Intelligence department since 1967. After Bobrow's first implementation, Richard Grant assisted by Cynthia Solomon, Frank Frazier and Paul Wexelblat made substantial modifications to the design and implementation. Bobrow and Solomon (the latter had worked with Papert at MIT previously) had initially suggested that Papert be brought in as a consultant to assist the design of an education-oriented conversational programming language. Paul Wexelblat was the young engineer who in 1971 would make the first RF (wireless) floor 'turtle'.

Technically, the first version of Logo was very different from present-day versions. It had only one variable: it did not have the flexible number of variables and variable naming that it acquired very soon thereafter. Also, it did not have any graphics; there would be another four years before that. So some of the features usually associated with Logo had not yet been developed.

5 It was perhaps the Lamplighter project (1979-1982) more than other which showed that an application of Logo close to what its developers envisaged was possible within conducive local environments which value alternative approaches to teaching and learning. The project was an interesting case study illustrating clearly the important role of the local institutional context of use in shaping the outcome. It provided a concrete example of how radical ideas can be successfully utilised within specific locations providing a fertile context.

6 The 'turtle' is a computer-controlled robot that responds to Logo commands such as 'Forward' and 'Right', providing what Papert calls 'an object-to-think-with'.

7 Although Papert is often accused of taking a 'revolutionary' rather than 'evolutionary' view, this is an oversimplification. Throughout the period in question, he worked consistently with teachers, and in his later work, he has recognised explicitly the crucial role that teachers can play.

8 Feurzeig's initial interest in Logo as a tool to help children to acquire a constructivist approach to learning about the structure and use of language was realized several years later through his cooperation with Paul Goldenberg (Goldenberg & Feurzeig, 1987).

9 At the time of the interview, George Lukas was professor of Computer Science at the University of Massachusetts Boston.

10 In the meantime Seymour Papert had taken the Cecil & Ida Green Mathematics Chair at MIT and was co-director with Marvin Minsky of the AI Department.

11 BBN was an R&D organisation dedicated to advanced technical innovation with an educational technologies department.

12 Founded in 1958, the Education Development Center, Inc. (EDC) is a publicly supported non-profit organization dedicated to promoting human development through education. Through a wide range of projects, EDC works to address educational, health and social problems and improve the quality of life for people of all ages and from all racial, ethnic, and cultural backgrounds. EDC's staff of more than 300 work

on over 150 projects throughout the United States and in 20 developing countries (source: EDC promotional material).

[13] We should state that this refers to the original meaning of the word, not as someone who breaks into computers, but a term of approbation about technical expertise, competence and focus.

[14] At the time of the interview, Henry Lieberman was a computer scientist in the MIT Logo Lab.

[15] Mitchel Resnick directs the *Lifelong Kindergarten* research group at the Media Laboratory of the Massachusetts Institute of Technology.

[16] Dan Watt holds a PhD in engineering from Cornell University and is a former elementary school teacher. He was involved in the Brookline Logo project at MIT and for a number of years he has been an editor with BYTE Books. He works at the Education Development Centre (EDC), Newton, Mass., where he is involved in curriculum development.

[17] At the time of the interview, Uri Leron was professor of Mathematics Education at the Technion University of Haifa, Israel.

[18] At the time of the interview, Uri Wilensky was professor of Mathematics Education at Tuffts University, Mass., and member of the MIT Logo Lab team.

[19] A Logo version for the Macintosh developed in 1985.

[20] The vision was that by 'teaching' the turtle – a computerized robot attached to the computer – the learner would come to appreciate deep ideas of mathematics and computer science.

[21] Molly Watt is a former teacher and Logo teacher trainer. In the 1970s she had a position in the faculty of the Educational Foundations Masters Program for experienced, practicing teachers at Antioch New England Graduate School of Education in Keene, New Hampshire. At the time of the interview, she was a curriculum developer at the Education Development Center (EDC) in Newton, Massachusetts.

[22] There was a steady stream of memos, papers and reports emanating from the group at this time, both technical and in terms of student interaction. An early example of the latter is Feurzeig (1969).

[23] Brian Harvey is professor of computer science at the University of California at Berkeley.

[24] The MEP ran only in England, Wales and Northern Ireland: Scotland had its own programme, the Scottish Microelectronics Development Programme (SMDP).

[25] Janet Ainley is Deputy Director of the University of Warwick Institute of Education, UK.