LOGO

– A Project History –

Anit Chakraborty
Randy Graebner
Tom Stocky
6.933J
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Table of Contents

I. Introduction

In 1966, three men – Seymour Papert, Wallace Feurzeig, and Daniel Bobrow – met to discuss new techniques for teaching children using computers. The result was Logo, an aspiration to revolutionize fundamental methods in education. In essence, it was to serve as an entirely new method to support learning formal thinking, or the ability to effectively approach and solve a problem by breaking it into manageable parts. As Harold Abelson described, "Logo is the name for a philosophy of education and a continually evolving family of programming languages that aid in its realization."[1] Logo's original goals were not modest, nor were they understated. Designed primarily as a learning tool with a "low threshold and no ceiling,"[2] Logo's creators also required that it support "complex explorations and sophisticated projects by experienced users,"[3] while remaining accessible to novices, especially young children.

The early 1980s brought the widespread introduction of affordable personal computers. Quick to react, AppleLogo was introduced to make use of the Apple II's easily accessible new platform, with considerable support from its mainstream computer manufacturer. Other popular computer and software manufacturers were quick to follow suit with their own Logo implementations, and many found significant commercial success. As conditions changed, so too did the focus of Logo's efforts for some. The project's goals transformed and shifted over time, with new individuals entering the scene to redirect its trajectory.

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[1] Abelson, Harold. *Apple Logo*. McGraw-Hill, 1982.
[2] "About Logo." *The Logo Foundation*. http://lcs.www.media.mit.edu/groups/logo-foundation/
[3] "About Logo." *The Logo Foundation*. http://lcs.www.media.mit.edu/groups/logo-foundation/

These shifts in goals were primarily due to the dynamics between the two groups involved with Logo's development: Revolutionists and Reformists. Revolutionists such as Papert have remained true to the original goals, seeking a complete revolution in educational systems and their methods. Reformists like Feurzeig, on the other hand, have been less concerned with research and theory, and more concerned with producing what they consider a successful product – one that sells. These two inherently conflicting groups have defined Logo's technological trajectory over the past thirty-three years.

Examining Logo's history, immediately evident is its correlation with theories produced by Kuhn and MacKenzie. Kuhn develops and dispels the myth of "moments of invention," which applies to Logo, especially regarding its original conception, explored in more depth in Section II. Likewise, MacKenzie disproves the concept of "natural trajectories" regarding new technologies, which also applies to Logo's history. Logo's technological trajectory, though it may appear natural when observing it from the outside in retrospect, is anything but.

II. Kuhn's "Moment of Invention"

Kuhn's *The Structure of Scientific Revolutions* addresses the issue of "moments of invention." Through examples such as the discovery of oxygen, Kuhn successfully demonstrates that typical science textbooks have oversimplified progress in science and engineering, essentially providing timelines of dates to define the history of Science. More concerned with the who, what, and when for any specific invention, Science is structured as development-by-accumulation, against which Kuhn argues thoroughly. Through the oxygen example, Kuhn effectively dispels the possibility of the existence of a "moment of invention," reiterating his point with analyses of numerous scientific discoveries, including Aristotelian dynamics and caloric thermodynamics. His point is that in most cases of invention, there is no precise *when*, for discoveries happen over a period of time, not all at once in a flash of inspiration. And because the invention develops over time, there is no specific *what* either. Likewise, the *who* becomes less clear because oftentimes different individuals are responsible for different stages of development.

To bring Kuhn's theory into context, one can examine a reliable source on Logo, Papert's book *Mindstorms*. In *Mindstorms*, he writes "in 1967, … I began thinking about designing a computer language that would be suitable for children."[4] At first glance, Papert seems to directly contradict what actually happened, since Bobrow actually implemented the first version of the Logo programming language in 1966. But such may not be the case. Similar to Kuhn's oxygen's example, the Logo to which Papert is referring is different from that which Bobrow implemented. Bobrow designed and developed the actual structure and architecture of Logo as a programming language, but at that point it was not yet ingrained with Papert's theories on education. Logo is more than a programming language, and Papert is referring to his personal vision for Logo, stemming greatly from his work with Piaget in Geneva. He is describing his motivations behind the project and its direction.

Papert himself summarizes Kuhn's concept well. He writes that

> a 1980 Logo teacher looking at a version from thirteen years earlier and one from thirteen years later might recognize

[4] Papert, Seymour. *Mindstorms: children, computers and powerful ideas*. Harvester, 1980. Page 210.

> neither as “Logo.” The former because it had no turtle … The latter … because it has the very features that have come to be seen in debates about educational computing as “the opposite of Logo.”[5]

And this is certainly the case, for over the years Logo and its supporters have change dramatically.

III. MacKenzie’s “Technological Trajectory”

“Technological trajectory” refers to the process by which a specific technology continuously improves. It is easy to prematurely consider this process “simply natural, not created by social interests but corresponding to the inherent possibilities of the technology,”[6] a concept which MacKenzie tries to dispel throughout his book. “What is wrong [with this notion] is the fundamental idea that technological change can be self-sustaining, that its direction and form can be explained in isolation from the social circumstances in which it takes place.”[7] In the case of missile guidance systems and Draper’s direction, MacKenzie clearly demonstrates that such is not the case, though it appears so because “there is a sense in which the trajectory is a self-fulfilling prophecy.”[8] Instead, technological trajectory is a construct of myriad social and political influences. “Among the factors sustaining it were Draper’s technological vision and the practice of his

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[5] Papert. “Where’s the Elephant,” *LogoUpdate*, Vol. 1, No. 1, Spring 1993.
[6] MacKenzie, Donald. *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*. The MIT Press: Cambridge, MA, 1990. Page 167.
[7] MacKenzie. Page 167.
[8] MacKenzie. Page 168.

Laboratory, the Air Force's interest in counterforce, and the acceptance, in circles with the resources to help make them a reality."[9]

MacKenzie's theories can be applied to Logo's history. Without devoted individuals like Papert, Bobrow, and Feurzeig, Logo would not have survived for over 30 years. Take away just the effort necessary to obtain funding for the project, and Logo would never have gotten as far as it has. The Logo Foundation's web page itself references such influences:

> After almost three decades of growth, Logo has undergone dramatic changes in step with the rapid pace of development in computer technology. The family of Logo environments is more diverse than ever before. And Logo remains a worldwide movement of people drawn together by a shared commitment to a constructivist educational philosophy.[10]

Logo is not described as a programming language, but a "worldwide movement" maintained by a "shared commitment." The idea that Logo's trajectory was natural completely trivializes the efforts of Papert, Feurzeig, Bobrow, Resnick, and the many others who have contributed to its continued evolution.

Papert himself describes his own influence on Logo's trajectory, maintaining the responsibility for the project's continuance:

> I am sometimes introduced as "the father of Logo." The aspect of parenthood of which I am really proud is not conceiving the idea in the first place, but staying with Logo and participating supportively in its development – as a father should.[11]

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[9] MacKenzie. Page 237.

[10] "About Logo." *The Logo Foundation*. http://lcs.www.media.mit.edu/groups/logo-foundation/

[11] Papert, Seymour. "Where's the Elephant?" *Logo Update*, Volume 1, Number 1. Logo Foundation, Spring 1993.

In his own words, Papert reiterates MacKenzie's concept of "technological trajectory." Without the fatherly influence and support of Papert, Logo would have followed an entirely different trajectory, for no technology can sustain itself. And to add to specific individuals' influence, the dynamics of the Revolutionists and Reformists as groups of people played a large role in determining Logo's trajectory, the details of which will be explained more thoroughly in Sections V and VI.

IV. Pre-Logo

i. Educational Preconditions

The U.S. education system of the late 1960's was ready for drastic changes in the way children were taught. So-called "progressive education" was stressed in looking forward to a better learning system. For one, science and mathematics was given a newly discovered importance:

> The post-Sputnik crisis in the 1960s spawned the development of large-scale curriculum innovations and the advocacy of inquiry-oriented and student-centered instruction. It was a period of new math, radical revisions in chemistry and physics, open education, individualized instruction, and so forth … Innovations, the more the better, became the mark of progress.[12]

This new emphasis provided a conducive background for technological innovations that promised to make such teaching more efficient. Essentially, leaders in education were looking to completely change the accepted system of learning. And Logo proposed change with this in mind.

[12] Fullan, M. *The New Meaning of Educational Change*. London, Cassell: 1991, 2nd ed. Page 5.

ii. Technological Preconditions

In 1962, J.C.R. Licklider became the director of the Information Processing Techniques Office at the Advanced Research Projects Agency (ARPA). Licklider had a vision of interactive computing at a time when batch processing was the only mode of computing, envisioning a world where many individuals could use the same computer. In this world, multiple people could interact through their computers that were connected via networks. At the time, this concept of interactive computing was considered revolutionary, if not impossible. Regardless, Licklider wholeheartedly promoted these ideas, and by the early 1960s timesharing was successfully demonstrated for the first time at BBN. Another successful demonstration came soon after at MIT. With the ability to divide a computer's processing power among multiple users, it was possible to set up remote terminals. This worked out well for Logo, for which such terminals were implemented in schools. Over phone lines, students at school could access a computer stationed in a lab across town.

V. Logo's Beginnings

i. Background of the Inventors

Logo's primary inventors were Daniel Bobrow, Wallace Feurzeig, and Seymour Papert. Bobrow graduated from MIT in 1964 with a Ph.D. in mathematics under Marvin Minksy. While at MIT, he worked on Project MAC as a graduate student and continued on as an associate professor for close to one year. After a short stay as a professor, he left in 1965 for BBN, which had an excellent reputation as a research lab known for its explorations in various new technologies. This is not surprising since BBN was originally founded by two MIT professors, with its roots entrenched in research. Upon arrival, Bobrow began working on the MENTOR and TELCOMP systems, alongside Wallace Feurzeig. Bobrow's primary interest was working on programming languages,[13] and he was one of the original creators of Lisp. His deep interest and understanding of Lisp led to his work on Logo.

Feurzeig first became involved with computers while in college, at Argonne National Laboratories outside of Chicago. With the increased development of computational timesharing abilities, Feurzeig became more and more interested the numerous opportunities made possible with interactive computing.[14] When he came to BBN in 1962, he sought to explore and develop some such possibilities. At that time, CAI (Computer Aided Instruction) was an ongoing Air Force research project exploring ways in which computers could aid in educating Air Force personnel. At the time, the education model provided computers as knowledge sources, where students were passive responders to its instructions and questions.[15] Feurzeig realized the other possibilities for education and began exploring models where students were active in engaging the computer rather than the computer attempting to engage the student. In this manner, his group developed this Socratic System. The first major application this system was MENTOR, aimed at 3rd year students in clinical medicine. MENTOR was driven by the student, who would interact by pro-actively eliciting responses from the system, such as charts and tests, in order to diagnose the presented medical case.

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[13] Interview with Daniel Bobrow on November 8, 1999 via phone.
[14] Interview with Wallace Feurzeig on November 19, 1999 via phone.

From 1962 to 1963, Cliff Shaw at RAND Corporation designed and developed JOSS, the first conversational language.[16] Derived from FORTRAN, it was similar to BASIC, and used primarily for numerical applications. BBN created a more advanced version named TELCOMP shortly afterwards. Feurzeig conceived the possibility of teaching mathematics to very young children using this new language, and so in 1965 he created the Educational Technologies group within BBN to explore the use of computers in learning. The US Department of Education supported his work from 1965 to 1966 in 8 elementary schools.[17] Feurzeig, Bobrow, Papert (serving as a consultant), and several other BBN staff members went into these schools, using TELCOMP as an aid to solving standard problems in arithmetic, algebra, and trigonometry. The results were positive, demonstrating that this interpretive language motivated children to learn mathematics more effectively.

Papert began as a mathematician and researcher at Cambridge University from 1954-1958. When Jean Piaget, a psychologist well known for his work in cognitive development, invited him to the University of Geneva, Papert left and stayed there from 1958 to 1963. Piaget focused on understanding how the primitive mind of a child develops into an adult mind, specifically interested in the mind's ability to reason objectively. His studies involved questioning children, and then trying to understand and interpret their reasoning in answering. Piaget divided a person's cognitive development into four stages: Sensorimotor, Preoperational, Concrete-Operational, and Formal-

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[15] Interview with Wallace Feurzeig on November 19, 1999 via phone.
[16] Feurzeig, Wallace, *Digital Deli*. Workman Publishers: New York, 1984. Page 159
[17] Feurzeig. Page 159.

Operational,[18] and Papert's primary interest lay in the Formal-Operational stage, the stage during which a child learned to think formally. It was during this time that he began considering mathematics as a tool to understand how children think:

> I left Geneva enormously inspired by Piaget's image of the child, particularly by the idea that children learn so much without being taught. But I was also enormously frustrated by how little he could tell us about how to create conditions for more knowledge to be acquired by children through this marvellous process of "Piagetian learning". I saw the popular idea of designing a "Piagetian Curriculum" as standing Piaget on his head: Piaget is *par excellence* the theorist of learning without curriculum.[19]

As evident, one of Papert's biggest frustrations was the lack of methodology to actually create conditions for improved formal thinking.

Beginning in the 1950's, Marvin Minsky worked on modeling human thought processes using computational models.[20] In 1961, he published *Steps Towards Artificial Intelligence*, discussing his improved direction for the AI community. Papert became interested in Minsky's proposed computational models to understand more precisely how children think. He came to MIT to explore these ideas in more depth.[21] He was interested in using computer science not only to understanding how people learn and think, but to *improve* their process of learning. At MIT, Bobrow (at the time a recent MIT alumni) introduced Papert to Feurzeig, and together the three worked on TELCOMP.

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[18] Gray, Peter. *Psychology*. Worth Publishers: New York, 1991 (2nd Edition 1994). Page 432-437

[19] Papert, *Mindstorms*. Page 215

[20] "Brief Academic Biography of Marvin Minsky." http://www.media.mit.edu/~minsky/minskybiog.html

[21] Papert, *Mindstorms*. Page 209

ii. Conception

After the TELCOMP project in 1966, Bobrow, Feurzeig, and Papert met at Feurzeig's house one night to discuss current technologies and their impact on child learning. Their intention was to create a new language for that purpose. They set down three primary goals for this new language:

1) Lisp-like Manipulation
2) Syntactic Simplicity
3) Dynamic Creation and Easy Debugging

They wanted Lisp-like manipulation because most languages at this time were created for computation rather than symbolic manipulation. They needed a language that could manipulate and visualize symbols to ease children's interaction with the language. Most languages at the time were too syntactically complex and difficult to use for programming by children. As well, the current languages did not provide effective means for dynamic creation and execution, and lacked advanced debugging environments aimed at beginners.[22] The focus was to get away from programming complexities like extensive type declarations to provide an appropriate programming environment for children. A child should not be concerned with memory dumps or complex debugging techniques. The focus should be to help the child learn the necessary set of mental tools for problem solving. Considering BASIC and other current languages as ineffective for teaching kids, they looked to Lisp for a better answer.[23] With strong support from Feurzeig they

[22] Interview with Daniel Bobrow on November 8, 1999 via phone.
[23] Interview with Daniel Bobrow on November 8, 1999 via phone.

decided to implement the new language over Lisp.[24] Feurzeig was responsible named this new language: "I named it 'Logo' from the Greek 'λογος' which means a word, a thought, the idea, but word is very prominent."[25]

iii. Initial Implementation and Field Trials

Bobrow was responsible for the initial implementation since he had the most programming experience. Papert joined BBN as a consultant, and Feurzeig was responsible for the group's management. The first implementation was completed and ready for testing in the summer of 1967. Since BBN had already done a considerable amount of work with the military (CAI), Feurzeig was able to convince the Office of Naval Research to let them test Logo on children, provided those children were sons and daughters of military personnel.[26] The three went to Hanscom AFB that summer and worked with 5th and 6th graders. Papert and Cynthia Solomon, another member of the Logo group, served as teachers. The goal was to test if children were capable of programming in Logo, and observe them learning basic programming concepts along the way. The result was positive and the project was considered a success, for the students were able to comprehend language and use it to solve problems.

The Logo group wanted to do more testing in schools, and therefore need additional funding. After extensive arguing, the Logo project received NSF funding, but the NSF had considerable reservations. It was concerned with giving research funding to

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[24] Feurzeig, W., "New Instructional Potentials of Information Technology", *IEEE Transactions on Human Factors in Electronics*, HFE-8 (2), June 1967, Pages 84-88.
[25] Agalianos, A. S., *A Cultural Studies Analysis of Logo in Education*, Ph.D. Thesis at the University of London. August 1997. Chapter 5, Page 11.

a private institution such as BBN. A non-profit research oriented institute or university such as MIT seemed like a better choice.

> The tradition was funding universities. BBN was a suspect as being a money-grabbing kind of place rather than pure as a drift of snow like universities! So he [the Head of OCA Dr. Milton Rose] said: "Why should I fund you? You are not a university." [27]

The strength of Feurzeig's funding request lay in the fact that they were the only group doing this type of research at the time, and as a result the NSF obliged.

From September 1968 to November 1969, Papert and Solomon worked with 7th graders at Muzzey Jr. High School in Lexington, MA, and Feurzeig worked with 2nd and 3rd graders at Emerson Elementary School in Newton, MA. The project was limited in scope due to timesharing limitations, for they could support only a small number of users at a time. In each school, they connected two to three terminals to a DEC PDP-1 at BBN in Cambridge over the phone line. Feurzeig was primarily responsible for research and design, while Papert developed the philosophy governing the teaching style.[28] Once again, the classes were a success. Children were able to learn the elements of Logo, grasp basic programming concepts such as functions and variables, and even showed improvements in non-mathematical subjects such as reading.[29] This was especially noteworthy in its contradiction to Piaget's theories that such learning could take place only during a child's

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[26] Interview with Wallace Feurzeig on November 19, 1999 via phone.
[27] Interview with Wallace Feurzeig on February 21, 1995 at BBN in Cambridge (conducted by A. Agalianos).
[28] Agalianos, A. S., *A Cultural Studies Analysis of Logo in Education*, Ph.D. Thesis at the University of London. August 1997. Chapter 5, Page 13.
[29] Feurzeig, W., Papert, S., Bloom, M., Grant, R., and Solomon, C., *Programming Languages as a Conceptual Framework for Teaching Mathematic*: final report on the first fifteen months of the Logo Project, submitted to the U.S. National Science Foundation, Bolt, Beranek & Newman Inc. Report # 1889, November 30, 1969

Formal-Operational stage (around age 12), whereas many of these children were between the ages of 7 and 9 and showed development in formal thinking and mathematical reasoning abilities.

<u>iv. The Move from BBN to MIT</u>

Around 1970, the Logo group more or less moved to the MIT AI Lab where a new Logo group was formed. It may not be immediately obvious why this move took place. Most relevant were the project's financial necessities. Acquiring funding for a private institution like BBN proved much more difficult than for a university such as MIT. In addition, a dollar spent at BBN didn't go as far as a dollar spent at MIT because typical MIT research students represent a lower cost than BBN employees.

However, the political reasons behind the move are perhaps less obvious. During the late 1960s, as the Logo group was developing at BBN, a schism developed over time. In general terms, these groups can be thought of as Revolutionists and Reformists.[30] The Reformists were interested in Logo's acceptance from schools, to be used as a supplement to existing education systems. They were interested in providing curricula, materials and teacher training to expose school systems to Logo. The Revolutionists were interested not in enhancing the current system, but in creating a whole new educational system to replace it. When the Revolutionist Papert left BBN to start the Logo group at MIT, many of the key researchers, Revolutionist as well, left BBN as well to join him.

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[30] Agalianos, A. S., *A Cultural Studies Analysis of Logo in Education*, Ph.D. Thesis at the University of London. August 1997. Chapter 5, Page 17

With Papert at the helm of this Revolutionist group at MIT, and with the vast resources MIT offered, the MIT Logo group dwarfed the efforts of those who continued work at BBN:

> [Papert] was a very charismatic person and very well connected, he had of course obtained very large amounts of funding for MIT and the Logo Lab was in fact quite large... Having LEGO and other sponsors he obtained a very large amount of funding, he gathered around a number of very strong graduate students in the AI Lab and had his own project which dwarfed the BBN project from about 1970 on.[31]

BBN continued work on the project for only a few more years. During this time, they focused on distributing and testing Logo in schools. One of their final contributions was the creation of the turtle. Paul Wexelblat implemented the first turtle named Irving.[32]

Children working at BBN with one of the first wireless turtle-robots (named "Irving") in the early 1970s (photo courtesy of Wallace Feurzeig, BBN).

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[31] Interview with George Lukas in Boston on February 20, 1995 (conducted by Agalianos).
[32] Interview with Paul Wexelblat. November 3, 1999 via e-mail

It was a relatively large robot that looked a bit like a moving dome on the ground, created to help children visualize what they were programming. By interacting with their environment (which contained the turtle) they could better understand the result of the programs they were creating in Logo. A small child could even ride around on it and, needless to say, they loved using it.[33] Controlled by radio, it would respond to the commands given to the Logo interpreter running on the terminal. With this robot, kids could draw on the floor and watch it move around, creating an interactive learning environment.

AI was becoming a popular research area, and many people were interested in Logo and what it could do. MIT's AI Lab was especially interested in using computer as tools that could think. A side effect of this interest was using computers as tools to learn *how* to think.[34] Understanding human thought processes and cognition was necessary to create a thinking computer.

Papert was able to get more than sufficient funding for the Logo group. The NSF and many other corporate sponsors were very interested in the results of the project. During this time, Papert maintained that education should be a process of self-learning, with computers as aids in this process. As well, he believed children shouldn't be given a structured curriculum. He saw Logo as the means for an environment where a child could learn without being taught, a direct extension of the theories he developed through his work with Piaget in Geneva.

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[33] Interview with Hal Abelson. November 16, 1999 in his office at MIT LCS

Initially, they worked on a number of small, short-term projects. There was tremendous diversity among the various projects that reflected the diversity of the individuals who were working on it. At times, it seemed they did not have any specific objectives in mind, but were simply experimenting and playing around in order to figure out how children could learn better. For example, at one point Papert realized that kids were not very interested in working with lists in Logo, and needed something better at engaging them. So Hal Abelson worked on reinventing the turtle as graphics on the screen. He created a vector graphics display that could be used to display the turtle, the version of Logo that most people have experienced.[35] The turtle was very successful. Children would spend hours learning how to make figures. And they could create procedures to draw special figures, defining recursive processes to draw shapes such as circles.

However, one problem that arose from the turtle was that teachers and their students began considering the turtle simply a medium for drawing, which was not the Logo group's intent:

> Logo is best known as the language that introduced the *turtle* as a tool for computer graphics. In fact, to many people, Logo and turtle graphics are synonymous. Some computer companies get away with selling products they call "Logo" that provide nothing *but* turtle graphics... Historically, this idea that Logo is mainly turtle graphics is a mistake...Logo's name comes from the Greek word for *word*, because Logo was first designed as a language in which to manipulate language: words and sentences.[36]

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[34] Agalianos, A. S., *A Cultural Studies Analysis of Logo in Education*, Ph.D. Thesis at the University of London. August 1997. Chapter 5, Page 23

[35] Interview with Hal Abelson. November 16, 1999 in his office at MIT LCS

[36] Harvey, B., *Computer Science Logo Style*, Vol. 1, MIT Press 1985.

This issue continued to plague Logo's development, which will be discussed in more detail later in the paper.

Similar to experiences within the Logo group at BBN, the Revolutionists vs. Reformists split formed at MIT as well:

> Within the Logo group the people who were kind of MIT hackers – 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.[37]

Papert and the Revolutionists continued to dissociate with the current school system in their attempt to revolutionize it. They continued research and development, assuming that once the right technology was created it would gain success on its own merit. The Reformists, such as Dan Watt and Sylvia Weir at this time, were interested in designing projects to accent the existing school system. They were more interested in distributing their existing work into the current system. Given MIT's research-oriented culture and the fact that Papert led the Logo group, the Revolutionist's viewpoint prevailed.

However, the NSF was funding most of their research and wanted tangible results within the context of the current mathematics educational system. An ideal experimental success for the NSF was something like improved standardized test scores after using Logo. For without proven improvement in learning, the NSF saw no value in Logo.

[37] Interview John Berlow on February 22, 1995 (conducted by Agalianos)

However, the Revolutionists did not value standardized tests as an accurate determination of a child's developmental improvement. But what the researchers were overlooking was overall issue at hand. If Logo was to revolutionise learning, they were going about it the wrong way. A small group of researchers sitting in a building in Cambridge could not accurately determine what was right for systems of education. They needed to more thoroughly understand Logo's context within the current system and adapt Logo's development to fit they system's needs. Logo could not be only what the researchers wanted. The mathematics educational community has to want it too.[38]

Given that the original Logo developers were out to change mathematics by helping children improve problem solving abilities, they had failed since they could not fit their ides within the existing system. As a result of these differing viewpoints between the "funder" and the "fundee", the NSF cut its funding in 1977. These cuts succeeded in allowing the NSF to better control Logo's development as an educational tool rather than a revolution.[39]

VI. Shifts in Focus

<u>i. Logo 1975 to 1985</u>

Originally, Logo's primary goal had been to create a software tool to support learning how to think formally. Throughout its 33 years, Logo researchers have believed

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[38] Noss, R. & Hoyles, C. *Windows on Mathematical Meanings: learning cultures and computers,* Kluwer, London, 1996. Pages 180-181

[39] Agalianos, A. S., *A Cultural Studies Analysis of Logo in Education*, Ph.D. Thesis at the University of London. August 1997. Chapter 5, Page 30

that “what the kids learn and how they learn it needs to be changed.”[40] But during the 1970s, the computer infrastructure necessary for such a change was not in place. With few available computers, there were limitations on a child’s potential time for learning. Timesharing made it possible for more children to use fewer resources, but without a large number of computers, schools could not adequately provide children with enough computer time. Most Logo researchers realized this problem and therefore spent most of their time and effort spreading the philosophy of Logo in preparation for the day when computers would be available. Several approaches were taken in an effort to spread the ideas and influence of Logo.

First, during the early 1970's MIT and BBN distributed Logo to a number of universities and research centers throughout the world. This propagation spread Logo and its philosophies to other academic areas, fueling Logo’s popularity. By distributing Logo, researchers hoped to obtain feedback and new ideas that could be used to improve Logo.

Second, researchers began developing curricula that could be used when teaching with Logo. The first type of curricula focused primarily on the use of Logo as a medium for increasing children’s comfort with computer use. And while familiarizing themselves with computers, children would also learn formal thinking. It helped them realize that it was alright to make mistakes (create bugs), for Logo made it easy to fix these mistakes, a beneficial process in itself. In addition, Logo allowed children to easily learn about recursion and abstraction. The second type of curricula had a more tangible goal. Its

[40] Resnick, Interview

focus was to develop a set of lessons using Logo that, once computers were readily available, would replace the current methods of teaching math and science.

The third approach for spreading Logo was a concentrated effort to create affordable computers that could be used by schools. This caused several researchers, including Marvin Minsky, to leave MIT in an attempt to build their own low priced computers. Minsky secured funding from Guy Montepetit and formed General Turtle, a company that built a vector-graphics display known as the 2500 and a PDP-11 processor known as the 3500.[41]

While General Turtle was trying to establish their place in the microcomputer market, other companies were also trying to develop low cost computers for common users. In 1977, Apple Company released their Apple II microcomputer, Radio Shack released the TRS-80, and Commodore released the PET computer. 4 years later, Texas Instruments released their TI/99 and IBM released the first series of personal computers. All of these microcomputers sold well throughout the United States. This distribution of personal computers, couple with a strong push by the government to increase computer literacy, set the stage for a Logo revolution.

When these microcomputers starting arriving on the market, Logo's developers saw this as a perfect opportunity for universal use of Logo. With this in mind, Abelson and others wrote a version of Logo to run on the TI 99/4 Home Computer.[42] In 1979, he began working on a version to run on an Apple II. These two computers were due to

[41] Abelson Interview, Resnick Interview, Leigh Klotz (comp.lang.logo posting, 1995), American Society for Information Science (http://www.asis.org/Features/Pioneers/minsky.htm), MIT News Office (http://web.mit.edu/newsoffice/tt/1990/feb14/22855.html)

their individual strengths.. The Logo language itself was similar in both versions, but the video game hardware of the TI 99/4 lent itself to action-oriented projects, while the Apple version was best suited for turtle graphics and language projects.

In the early 1980s, with the help of Apple, TI, and IBM, the personal computer had a noticeably significant impact on society. Logo's original goals were now within reach. The revolution they sought required accomplishing only two tasks. First, the researchers needed to find an efficient method to distribute Logo. And second, educators needed to be convinced of Logo's educational value.

Originally, the developers of Logo wanted to distribute it for free. However, both MIT and Apple wanted to be able to sell the software. This conflict resulted in a lengthy legal battle, and in an effort to push Logo onto the market before the battle was over, companies started forming with the sole purpose of selling and distributing the Logo software. In 1981, Seymour Papert founded Logo Computer Systems, Inc. (LCSI) with the primary objective to create software that helps "develop a child's problem-solving and critical thinking skills."[43] LCSI was founded to create a different version of Logo that was not covered by the MIT patents. This was so LCSI could allow Apple to sell and distribute the software without having to wait for the legal battles with MIT to conclude. In addition, competing companies such as Terrapin, which was also populated with MIT researchers, were working on developing their own versions of the software. Terrapin, founded in 1977, actually licensed the Apple II version of MITLogo, but Apple chose to

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[42] Leigh Klotz (comp.lang.logo posting, 1995), Brian Harvey, UC Berkley Professor (http://www.cs.berkeley.edu/~bh/elogo.html), Abelson Interview

[43] LCSI website, http://www.microworlds.com/company/profile.html

package the LCSI version with its computers because LCSI was founded by Papert, the "father of Logo."[44]

During the affordable personal computer's first few years of existence, there was little software on the market, and only a very small percentage of that software was for educational purposes. For this reason, computer companies supported Logo because it gave them increased marketability with schools. IBM pushed Logo by selling LCSI's IBMLogo and Logo Learner. Apple Computer promoted Logo by bundling LCSI's AppleLogo with the computers it sold to schools in California. Even Atari, a video games manufacturer, embraced Logo by not only distributing AtariLogo but also founding the Atari Cambridge Research Center to encourage further research into Logo's philosophy.[45]

Over the next several years, computer companies continued to release new computers and software companies continued creating new versions of Logo. For example, in 1984 Apple released the Macintosh and both Terrapin and LCSI immediately developed a C version of Logo.

Terrapin and LCSI competed vigorously for some time, and this competition fostered innovation and rapid software development. The competition was fierce, but it was also amiable as both companies felt they were doing their part to "save the world."[46] These companies, through their multiple versions of Logo, played instrumental roles in spreading the Logo software and philosophy throughout the world.

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[44] In "Where's the Elephant," LogoUpdate, Vol. 1, No. 1, Sprint 1993, Papert wrote "I am sometimes introduced as 'the father of Logo.' The aspect of parenthood of which I am really proud is not conceiving the idea in the first place, but staying with Logo and participating supportively in its development – as a father should."
[45] The Logo Foundation (http://el.www.media.mit.edu/groups/logo-foundation/Logo/Logo.html), LCSI web page

With both the hardware and software in place, classroom use of Logo became a realistic option for many school systems. By 1980, Logo had been used in tens of thousands of elementary classrooms throughout the United States. The only thing left to do was teach educators the proper way to use Logo. Papert did his part to this end by publishing *Mindstorms*. Thousands of teachers throughout the world read his book and followed its ideas, allowing children to freely explore computers and with Logo and learn on their own about complicated ideas such as feedback, recursion, and abstraction.

> Papert's book *Mindstorms* (1980) was a breath of fresh air for those teachers who wanted to realise for their pupils all the promised benefits of the computer, but who rebelled at the simplistic "drill and practice" programs through which nirvana was supposed to be attained. The child-centred Piagetian pedagogy which seemed to be at the root of Papert's arguments chimed well with the way in which they had been educated as teachers, and with a still prevalent liberal-humanitarian concern for the personal development of the individual child. There was no expectation that here was a device for "jacking up" children's scores on conventional attainment criteria. At its peak, Logo combined a support environment not dissimilar to a charismatic religious movement, with a rationale which offered teachers a chance of actually putting child-centred approaches to learning into action.[47]

However, not all teachers shared in universal praise of Papert's ideas. Some teachers saw Logo as a computer game to introduce computers to young children with immediate feedback. Largely responsible for this use of Logo was its portrayal by the general press. There was also a small group of teachers that completely rejected Logo because they themselves were not comfortable with computers.

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[46] Leigh Klontz, Terrapin employee during the early 1980's, comp.lang.logo posting, 1995

[47] Cooley, *Human-Centred Education* 1992, page 59

The early 1980s witnessed incredible growth for Logo. Thousands of teachers across the country began teaching it to their students. With each passing year came additional versions of Logo and more and more schools using it. Hundreds of Logo books and papers were published and nearly every computing magazine had a section about Logo. By 1984, Logo was available to millions of students throughout the world. Beginning in 1984 and lasting for 3 years, Abelson held an annual conference at MIT with the purpose of bringing together the worldwide community of Logo users. By 1986, over 150,000 copies of Logo had been sold for the Apple II in the United States and Canada alone.

This Logo explosion took place mostly within elementary and middle schools as software companies marketed Logo as a way for young children to learn complex ideas. Since then, Logo has been seen as the programming language of choice for elementary school students whereas BASIC is viewed as the programming language of choice for middle and high school students.

ii. Effects of Commercialization

The rapid growth and commercialization of Logo had some major positive influences on Logo. First, commercialization made Logo available to a wider audience that increased interest in Logo even more. The increased number of Logo users significantly increased the amount of user feedback that was received. In addition, it helped spawn Logo user communities that allowed users to interact with one another. The commercialization of Logo has allowed its use by tens of millions of students throughout the world. As Mitchel Resnick, the current head of the Logo project at MIT's Media Lab, states,

> Obviously, commercialization was a good thing. It helped Logo get out to a lot more people and it allowed Logo to influence people who previously would have never though of some of the ides it presented. It allowed these new users to become contributors to the development of Logo either by influencing people in their own local circles or by influencing other people to think about the ideas presented Logo.[48]

However, the commercialization of Logo has negative implications as well. First, companies were making unrealistic claims about the value and potential uses of Logo. Companies were leading school administrators to believe that if you gave a child a computer with Logo on it then they would be able to teach themselves how to do algebra or geometry in a matter of days. Second, companies marketed Logo as a language for young children and placed strong emphasis on the turtle graphics. This was a departure from the original idea that Logo should be used to teach all ages about all sorts of mathematical and logical topics.

Logo was used primarily as a tool to supplement regular course materials. The problem with this approach is that teachers needed to be able to grade the students. Therefore, instead of letting the children experiment with Logo and design their own creations, teachers would instruct students to all draw the same thing and would then establish a grade based on how well they did so. This completely defeated the original purpose of Logo as the children were not being placed in control of the computers. While

[48] Resnick, M. Interview November 18th, 1999 at MIT Media Laboratory.

this was viewed as an acceptable path by the Reformists, it was not what was intended by the Papert and the Revolutionists.

Another major problem that arose from commercialization was that every different Logo vendor implemented a different version of Logo. Since there were no Logo standards, many different versions appeared on the market. Multiple versions created divisions in the Logo community. Instead of all users forming one large community, the multiple versions caused many different user communities to form. In addition, these multiple versions created confusion among teachers, for they had no basis for determining which version of Logo to use and, when they did decide, they had an equally difficult time locating the correct Logo support group.[49] A third problem caused by the multiple versions of Logo was that many of the versions sacrificed education in order to make their product sell. For instance, in the 1985 the company ExperTelligence marketed their version of Logo with the slogan "everybody else has turtles…bunnies are faster."[50] The speed was increased by sacrificing Logo's accuracy. Papert writes:

> What is beautiful for the designers of ExperLogo is the speed of their bunny. I, too, would like speed... and an ideal implementation of Logo... But in the real world there is no such thing as an "ideal" implementation of a computer language. 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. The bunny gains speed at the cost of a kind of intellectual power that may be of no consequence to a professional programmer working on expert systems, but could be highly consequential in shaping a child's computer culture... In ExperLogo, bunny speed was bought (in part)

49 Watt, D.L, "Logo in the Schools", *BYTE* magazine, August 1982.
[50] Angalianos page 165; Andy Cohen, "*ExperLisp, Common Lisp*", (http://www.mactech.com/articles/mactech/Vol.01/01.07/LispGraphics/),

> 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.[51]

This removal of mathematical accuracy directly hinders the ability for children to build mathematical intuition and therefore significantly decreases the learning potential of the students.

The final significant negative result of commercialization is that research slowed. Many of the main researchers, including Papert, joined companies in an effort to help sell Logo. However, since most of their time was devoted to these companies, Logo research was neglected.

<u>iii. Conflicting Goals</u>

From the very beginning, it was apparent that the Reformist Logo commercial community had goals that directly conflicted those of the Revolutionist research community. The commercial community targeted elementary school students and sold Logo as a supplemental tool for elementary schools. Companies portrayed Logo as an end in and of itself, and in doing so they stripped Logo of its ideas and simply sold the software.

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[51] Papert, S., "Computer Criticism Versus Technocentric Thinking", *Educational Researcher*, January-

The research community, on the other hand, designed Logo to be a means to an end. One of the original goals of Logo was to provide a mechanism such that people of all ages would be able to learn how to comprehend complex systems and ideas. Marketing Logo as a children's program goes directly against this goal. In order to accomplish this goal, Revolutionist researchers felt that the current system of teaching needed to be replaced, not supplemented. Most reformers sided with the companies and believed that any exposure to Logo was good exposure. Even to this day, the commercial community is driven by sales and profit while the research community is driven by the ideas set forth in *Mindstorms***.** The ideas "that children can learn to use computers in a masterful way, and that learning to use computers can change they way they learn everything else"[52] have driven Logo developers since the 1960s.

iv. Was Logo a Success?

Determining Logo's success depends on who you ask. Reformers will cite the tens of millions of users around the world equate that with success. Revolutionists will point out that Logo is used to supplement the regular curriculum, sacrificing many of its core ideas. Both sides will agree, however, that Logo has helped children become comfortable dealing with computers and it has, to a lesser extent, given children the opportunity to learn how to think formally. The question to examine, then, is why have the Revolutionists not yet been able to succeed in replacing the way children are taught?

February 1987, page 64.

[52] Papert, *Mindstorms*. Page 8.

Beginning in the early 1980's, the computer infrastructure was in place, there was Logo software written that would run on this hardware and there was widespread excitement about the promise of Logo. Why was Logo not able to live up to its potential? Why were the inventors of Logo not able to achieve their original goal of revolutionizing the way that children are taught?

The simple answer to these questions is that society changed between the mid-1960s and the mid-1980s. Society no longer desired to completely overhaul the educational system. The assumptions made in the 1960s underestimated the society of the 1980s. Papert, Bobrow, and Feurzeig wanted every child to be able to play with the computer and learn on their own. They wanted to teach every child how to think formally and experience the debugging process. They wanted children to be able to learn these things by having the freedom to explore the Logo language. However, teachers wanted a way to determine grades. Logo did not change the way that children were taught because the people pushing the software were not able to change the mindset of those actually responsible for teaching children. Papert recognized this fact in 1980 and made note of it in *Mindstorms*:

> The bottom line for such changes is political. What is happening now is an empirical question. What can happen is a technical question. **But what will happen is a political question, depending on social choices.**[53]

Teachers have always thought that they need to grade people in order for the person to learn. Logo has not yet been able to overcome these political and social factors that are

[53] Papert, *Mindstorms*. Page 28, emphasis added.

pushing Logo toward being an end in and of itself.[54] When Logo made its way in to schools, its core ideas were often sacrificed. The software was intended as a mechanism to teach children how to think formally. But instead, teachers taught children how to use Logo itself. The ideas behind Logo did not spread to the schools in a deep way.[55] The software companies often sacrificed features within the language in order to make it more fun or easier to understand. Software vendors wanted to push the software into schools. They wanted to sell copies of Logo and seemingly did not care how it was used. Thus, when teachers started using Logo, most of the fundamental ideas behind the software had been lost.[56]

However, even though the Revolutionists have not yet succeeded, that does not mean they have given up. In fact, Papert, himself a Revolutionist, wrote in 1993 that

> Approaching Logo as an idea in development rather than a fixed thing to be judged has placed me in a third position in relation to debates between people who think Logo is great and those who think it has 'failed.' Just as Logo encourages children to see bugs as positive things to think about, so I have taken weaknesses in the nature and the uses of Logo as rich sources of ideas about where to go next.[57]

It is clear that the Logo Revolutionist movement is alive and well.

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[54] Resnick, M. Interview November 18th, 1999 at MIT Media Laboratory; Abelson, H. Interveiw November 16th, 1999 at MIT LCS.
[55] Resnick, M. Interview November 18th, 1999 at MIT Media Laboratory; Abelson, H. Interveiw November 16th, 1999 at MIT LCS.
[56] Papert, S., "Computer Criticism Versus Technocentric Thinking", *Educational Researcher,* January-February 1987, Page 64.
[57] Papert, S. "Where's the Elephant," *LogoUpdate*, Vol. 1, No. 1, Spring 1993.

v. Present Day Logo

As computers became more and more commonplace, the excitement over the original Logo began to die out. The original ideas were still alive, but the novelty of Logo was no longer there. Realizing this, Mitchel Resnick and Steve Ocko, working at the MIT Media Lab, started to look for some real world applications for Logo. They developed a system that interfaced Logo with motors, lights, and sensors that were in turn incorporated into machines built out of LEGO bricks and other elements. This idea impressed the LEGO Company so much that they provided funding for Resnick to continue his work. In 1988, LEGO released a developed version of Resnick's invention and called it LEGO TC Logo. This application was built specifically for teaching purposes and was sold only to schools.

Another LEGO Logo innovation is the Programmable Brick, a research project at MIT led by Fred Martin. Unlike conventional LEGOLogo products where the computer receives instructions through wires connected to a desktop computer, the Programmable Brick has a computer inside.

Began in 1988, Resnick has also led the team that has created STARLogo, a massively parallel version of Logo. This allows thousands of turtles to interact with each other and patches on the ground while carrying out independent processes. These patches are placed on the ground and provide feedback for the turtle by letting the turtle know exactly where it is. STARLogo was designed with the intention of enabling older individuals to explore complexity theory as opposed to simple geometry or math offered by the original versions of Logo. In fact, Resnick refers to STARLogo as a "PG-13 version of Logo" because it is designed to be used by people over the age of thirteen. STARLogo is also powerful because it allows people to model decentralized systems and emerging phenomena. It tries to teach, in a simple way, things that were previously through too difficult for the high school level. For instance, most people believe that feedback and control mechanisms are too difficult to teach to high school students. STARLogo tries to provide the tools to learn these complex ideas. This parallels with some of the original goals of Logo.[58] And, just as the ideas driving the project parallel the original versions of Logo, so too do the problems that are faced when trying to get people to use STARLogo. STARLogo is making its way into schools, but has the same problems of losing its original ideas upon gaining acceptance.

After over thirty years of Logo development, the fundamental goals remain the same, as have the fundamental obstacles to spreading Logo's philosophy. Researchers continue to focus on developing the child's learning experience. They are still trying to create ways to teach children how to think formally, and they are still trying to provide children with the tools to help comprehend complex ideas. But as mentioned, they face the same problems the Logo originally had. Initial ideas of the Logo Movement are still very fresh and relevant today despite all the technological advances that have occurred. Researchers are still trying to convince educators to "rethink their approach to learning" by allowing children to "learn through the design experience." Logo was designed as a "tool to enable kids to deeply explore things" through "putting the kid in charge of the

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[58] Resnick, M. Interview November 18th, 1999 at MIT Media Laboratory; STAR Logo homepage < http://www.media.mit.edu/starlogo/>

computer." However, even though the fundamental goals have remained the same, many researchers have given up trying to revolutionize the way that children are taught. They are now trying to accomplish all of their main goals within the framework of the schools. Rather than trying to eliminate formal mathematical education, they are trying to convince educators to use Logo as a supplement to teaching children. There is currently less focus on computation and more focus on communication. And, although the project is still concerned with spreading the ideas of Logo, this is no longer the primary goal of the project.[59]

There are several reasons that researchers have abandoned the idea of revolutionizing the way children are taught. The main reason is that the introduction of computers into every day life has drastically changed the way people view programming. By the early 1990's some educators in the United States began to see Logo as old and out of date. In addition, the 1980s was a period where educators saw computers as being new and exotic and programming was considered to be an essential skill. Now that computers are commonplace, programming is no longer viewed as a necessary skill. This means that educators do not see a reason to use Logo since they simply view it as a way to teach children how to program. Thus, now that it is fully possible for Logo to infiltrate the schools systems, the schools no longer view Logo as an especially useful tool and thus the original goal of revolutionizing the way children are taught has been abandoned.[60]

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[59] Resnick, M. Interview November 18th, 1999 at MIT Media Laboratory; Kenway, J., Bigum, C., Fitzclarence, L. & Collier, J., "Pulp Fictions?: education, markets and the information superhighway, in Carlson, D. & Apple, M.W., *Critical Educational Theory in Unsettling Times*, University of Minnesota Press, 1996.

VII. Conclusion

As demonstrated, Logo's history was characterized primarily by the dynamics between the Revolutionists and Reformists and their interpretation of Logo's goals, as well as each group's concept of success. This issue of success brought about a shift toward commercialization, since the Reformists valued commercial success as a priority.

But looking at Logo's original goals, one might say that the project was not a success for the educational revolution never took place. Logo has served as more of an educational supplement. And in many cases, Logo was not used to support the learning of formal thinking, but instead served as a medium to give children exposure to computers. However, one should not be too harsh in criticizing Logo's efforts, for its history continues even today. Currently, Papert is starting alternative Logo schools in other countries, such as Thailand and Japan, fighting for the possibility that an educational revolution is still to come.

[60] Abelson, H. Interveiw November 16th, 1999 at MIT LCS.

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