VISUAL LITERACY IN COMPUTER CULTURE:
READING, WRITING, AND DRAWING
LOGO TURTLE GRAPHICS

DISSERTATION

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Visual literacy is defined as a cultural understanding of the visual symbolic mode. This study explores visual literacy competencies pertinent to computer culture. The problem under investigation has two parts: (a) to review published literature about visual perception, visual literacy, and the visual information technology of computer graphics, specifically Logo turtle graphics, to identify traditional visual literacy competencies possibly relevant to computer culture; and (b) to visually analyze and interpret Logo turtle graphics assignments to determine the presence or absence of real world correspondence in computer culture to the published literature about traditional visual literacy skills.

Logo is an educational computing philosophy that strives to build creative intelligence through self-knowledge about moving in space (up, down, left, right, forward, backward, and centered). Turtle graphics is a dialect of the computer language Logo which uses these body-syntonic concepts in programming and problem solving. In this research, Logo turtle graphics functions as

a representational model through which to analyze the visual literacy skills of graphics end-users.

The findings of this research illustrate that Logo turtle graphics is a self-contained model to teach visual literacy skills pertinent to computer culture. This model is drawn from synthesizing published literature and the classroom experience of Logo learners, which is demonstrated through their visual solutions to Logo assignments. A visual analysis and interpretation of the subjects' work concludes that the principles and competencies associated with traditional visual literacy skills manifest during the Logo turtle graphics experience. The subjects of this study demonstrate that visual literacy pertinent to computer culture includes reading, writing, and drawing alphanumerics and pictographic information with linguistic equivalence. The logic for this symbolic metaphor is body-syntonic spatial experience explained in geometric terms. The Logo learner employs computational models for visual ideas and visual-verbal symbols for spatial ideas in the course of doing turtle graphics.

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CHAPTER I

Introduction: The Literacy Continuum

Although the meaning of literacy changes among different cultures through time, the contemporary notion that literacy is a technology for information transmittal is receiving widespread acceptance (Levine, 1986, p. 10). The diffusion of literacy within a society, however, is dependent upon people -- individuals -- understanding and using the tools, sights, sounds, concepts, and techniques of language, "our highest cognitive function" (Mayeaux & Kandel, 1985, p. 699). Traditional investigations into systems of language argue the differences between people reading and writing alphanumeric symbols versus seeing and understanding pictographic materials. As a result, mutually exclusive logistics between verbal literacy and visual literacy have developed over the years. For purposes of this study, language is broadly defined as any system for communicating intended meaning and literacy is defined as a relative cultural event which varies with the information needs of society.

Conventional literacy refers to verbal competencies in the language arts: reading, spelling, and writing language as well as to spoken culture. Visual literacy is relatively defined as a cultural understanding of the visual symbolic mode -- gestures, marks, signs, and symbols used to convey ideas. Visual literacy is primarily concerned with competencies essential to culturally agreed upon interpretations of pictographic events. Visual literacy is not equivalent to visual acuity, but is learned through visual experiences with linguistic conventions. Visual literacy training involves learning to know through the sense of sight. Being visually literate, one is able to make sense out of what one sees -- to comprehend the meaning behind visual experiences. Traditionally,

> Visual literacy refers to a group of visual competencies a human being can develop by seeing at the same time he has and integrates other sensory experiences. The development of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person to discriminate and interpret the visible actions, objects, and/or symbols, natural or man-made, that he encounters in his environment. Through the creative use of these competencies, he is able to communicate with others. Through the appreciative use of these competencies, he is able to comprehend and enjoy the masterworks of visual communication. (Debes, 1970, p. 14)

The visual environment in today's culture is saturated with computer graphics which simultaneously present alphanumeric and pictographic information. The inability to read, write, or draw these electronic messages is becoming a functional disability. International acceptance of computer graphics has made visual literacy a critical educational issue in computer culture. "Educators have begun to realize that, first, this visual age requires visual as well as verbal skill of everyone, and, second, the verbal and visual skills are interconnected and both must be developed" (Fransecky & Debes, 1972, p. 9).

In today's electronic society, computerized visual information is a highly valued international commodity; traditional literacy is a global initiative; and computer literacy is being mandated by educational organizations around the world (Horn & Poirot, 1985). Visual-verbal images are playing a key role in harnessing data and communicating information, computer generated graphic messages are viewed as a natural outgrowth of the information age, and vernacular literacy is rapidly embracing icon-based computer literacy. Innovative advancements in imaging science have necessitated that the traditional concepts of visual literacy be updated to reflect technical change in the visual realm of computer culture.

Historical Overview

Leroi-Gourhan (1967) contends that primitive man had acquired the conventions of pictographic language long before the Upper Paleolithic period [ca. 60,000 - 10,000 B.C.]. He further asserts that the development of graphic skills most likely co-evolved with the capacities for increased abstract thinking and verbal tools (p. 43). Archaeological evidence shows that ancient humans started engraving or drawing lines as early as the close of the Lower Paleolithic period [ca. 500,000 - 250,000 B.C.]. People of the Upper Paleolithic culture could depict realistic animals and what appear to be abstract, geometric shapes. The invention of writing joined such pictographic representations with language codes about 5,500 years ago in southern Iraq and in a few other places during the ensuing three millennia (Hewes, 1978, pp. 11-12). Throughout the major portion of the past five thousand years, however, written communications, along with the ability to read and write visual information, have been the monopoly of religious and secular authorities. Barriers surrounding access to the written word were destined to fall, however, because the ability to draw letters and to understand their intended meanings lay within the intellectual reaches of most (Resnick, 1983, p. 1).

In general, literacy spread throughout the Western culture because people benefitted from the ability to recognize, analyze, and synthesize changing linguistic conventions. Historically, important privileges have been reserved for the litterati. Baker's study (cited in Clanchy, 1983) reports that in medieval England "a person found guilty of a serious crime was exempted from the death penalty if he could prove that he was litteratus" (p. 16). There were, and still are, however, many different kinds and levels of literacy -- a fact that Resnick and Resnick (1977) claim may be overlooked when the term literate applies to different populations in different settings (pp. 370-385).

Surviving sources from the twelfth to the fifteenth centuries indicate that growing public reliance on written records, rather than oral testimony, assured the spread of literacy within the Western world. Documents for taxation, justice, commerce, and the religious authority changed to reflect the preferred written record (Resnick, 1983, pp. 1-2). Books were given prestige; literates were the privileged elite; documents and their writers were bureaucratic representatives; and popular literacy was evolving (Clanchy, 1983, p. 18).

Reading and writing were already important in Europe before Gutenberg of Mainz invented movable type. Resnick (1983) contends that this cultural condition "was a necessary precursor to the adoption of the technology of the printing press, for it provided what we would call a growing market" (p. 2). Medieval scribal culture was vigorous enough to sustain the mass production of printing, while the Gutenberg Bibles made monastic manuscript books available to buyers. The pioneers of printing, however, "were not the academics and authors who were to benefit from it, but technologists and businessmen for whom it was an industrial venture" (Clanchy, 1983, pp. 8, 14).

> Printing thus emerged not from a vacuum, but from a rich and complex culture which gave extraordinary prestige to the written word. In the earliest printed works, Gutenberg and his associates, out of commercial necessity, identified the chief features of medieval literate culture and aimed to reproduce them as exactly as possible. In doing so, they acknowledged the achievements of a millennium of writing. (p. 20)

Cressy (1983) reports that a succession of authors from the sixteenth century onward make high claims for spreading literacy. For example, clergy and businessmen in seventeenth century England and New England supported the belief that reading and writing were essential skills which led to a broad range of civic and moral benefits -- "as if it were the indispensable correlate of civilization." Some authors even drew attention to the "worldly advantages associated with being able to write" (p. 23).

The privileges and importance of literacy were circumstantial, however, depending upon the complexity of one's dealings with others. For example, Cressy (1983) explains that four out of five husbandmen in seventeenth century England could not sign their own names. These farmers could live competent lives without literacy skills. As their business affairs and life stations improved, however, being able to decipher writing and to record things on paper became more appreciably important. "Applied literacy gave a documentary firmness to transactions which could be disputed if they simply turned on a handshake or verbal agreement. Literacy offered proof" (pp. 27-29, 31).

Throughout preindustrial England, literacy was typically present where it was needed and absent where it was not. The social distribution of literacy was more closely associated with economic activities than with anything else (Cressy, 1983, pp. 35, 37). Printed words were essentially a consumer good before the mid-nineteenth century after which the mass production and distribution of print materials was made possible by paper manufacturing and printing technologies. Thereafter, the popular culture, education, and economic priorities impacted the meaning of literacy, its growth, and social distribution (Laqueur, 1983, pp. 44-45; Suhor, 1984, p. 21).

Being literate in the twentieth century has come to mean being able to read and write well enough to cope with the simplest communications of everyday life (Lennon, Cook, & Jennings, 1986, p. 1). This functional definition of literacy has political roots in Western culture, because a call-to-arms during World Wars I and II identified hundreds of thousands of able-bodied allies who could not read basic military instructions written in their native tongue. In 1942, President Roosevelt reported to the United States Congress that 433,000 men had been deferred because they could not meet the Army's literacy requirement (Levine, 1986, p. 26).

Shortly after peace was declared, the United Nations Educational Scientific and Cultural Organization (UNESCO) initiated international efforts toward universal literacy. In 1961, the United Nations General Assembly passed a resolution giving UNESCO the task of researching the scale of world illiteracy and recommending solutions. The resulting plan entitled "The World Campaign for Universal Literacy" was proposed in 1962, revised and presented in 1963, and subsequently abandoned as politically and economically unrealistic (Levine, 1986, pp. 27-30).

The concept of functional literacy was proposed in 1964 as a new approach to literacy in the five-year "Experimental World Literacy Programme" (EWLP) by the Thirteenth Session of the General Conference of UNESCO. As with subsequent massive literacy campaigns, the plan strongly emphasized the economic, civic, and social potentials of reading and writing (Levine, 1986, pp. 29-32). Today's attitude is that functional illiteracy jeopardizes a nation's economy as well as its national security; lack of literacy threatens a country's competitive position in the world; and in the United States, illiteracy is also felt to jeopardize the country's democratic ideals. Living in an era of information technologies, the demands for literacy have increased (Lennon, Cook, & Jennings, 1986, pp. 2-3).

Since the invention of written language, the concept of literacy has been most closely aligned with the alphanumeric marks that people make on surfaces. Such a traditional focus upon the printed word often overlooks the simultaneous importance of other printed visuals like maps, pictures, charts, diagrams, and calendars -- all of which contribute toward the mass distribution of information. Citing Ferguson's research, Hewes (1978) points out that:

> The [medieval] illustrated herbals, textbooks of anatomy, astronomical charts and tables, and all sorts of works containing, for example, technical diagrams or plans on architecture, shipbuilding, and fortifications were an essential ingredient of the scientific and technological revolution of the past few centuries. (p. 12)

Today one also sees that:

> A very large part of modern science has been made possible by methods for reducing data and relationships from almost all domains of the natural world to visible patterns -- to graphics of one sort or another. To an overwhelming extent, science has advanced by finding means to visualize relationships and events. (p. 13)

Conventional pictures and graphic symbols, like those seen on a chalkboard, in textbooks, films, and other visual materials, have traditionally had an intimate relationship with education and the spread of literacy. Computers in the classroom are giving additional meaning to the basic concept of literacy which must now include reading and writing computer generated visual information. The inability to read and write computerized images constitutes a type of illiteracy in today's world, because the ablity to understand and apply computer graphics has become synonomous with accessing and sharing information.

Communicating using cultural conventions, like computers and their electronic messages, is central to the process of becoming literate and to the definition of literacy. People have created natural and computer languages in response to the universal need to express ideas. The manner in which a language is transmitted, however, is a uniquely cultural process primarily dependent upon the evolution of communication technology and each individual's need to possess and/or share information. Therefore, there are levels of literacy and relative states of being literate which can change when new methods for language acquisition, development, and implementation are introduced into a society. Historically, literacy flourishes when and where a group of people value the social benefits associated with reading and writing current cultural messages.

One of the effects of global computer implementation is the public demand for computer literacy -- experiences that teach toward improving the ability to communicate using computers.

> Since the business and professional worlds now depend on computer and information-based systems in meeting daily work requirements, progress towards these goals depends upon the achievement of "computer literacy" throughout our society. Our educational institutions and special training programs will make a significant contribution toward fullfilling these goals by playing a lead role in providing both conceptual and practical knowledge of information processing and transmission systems to all student groups. (Brown & Simon, 1980, p. 11)

To meet this goal, there is a fundamental need for a shared experiential foundation in learning about, using, and communicating through high technology. The visual-verbal experience inherent in the computer language of Logo turtle graphics appears to have evolved into such a shared foundation. Logo turtle graphics is an educational computing philosophy that strives to build creative intelligence through self-knowledge, specifically, knowledge about the way one's body moves in space (up, down, left, right, forward, backward, and centered). Turtle graphics, or geometry as it is also called, is a dialect of the computer language Logo which uses body-syntonic concepts in programming and problem solving.

Logo, with its concept of a learning and programming environment, was invented at the close of the 1960s in the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology (M.I.T.). Papert (1971), a researcher on the Logo team with Feurzeig, Bloom, Grant, and Solomon, states that their research objective was to develop new methods and materials for teaching in computerized environments. The goal was to develop a vision of children-mathematicians using technology with self-confidence and intellectual power (p. 1).

> I [Papert] believe with Dewey, Montessori and Piaget that children learn by doing and by thinking about what they do. And so the fundamental ingredients of educational innovation must be better things to do and better ways to think about oneself doing these things. (1971, pp. 1-1 & 4-1)

Logo's design logic is to facillitate human-machine communications using the mathematics of dimensions -- measurements of width, length, and thickness in a particular direction, along an axis or a diameter. The language of Logo contains a set of powerful graphics elements called primitives, a text editor, and capabilities to process full lists (Weir, Russell & Valente, 1982, p. 342.) Turtle graphics is a diagrammatic dialect of Logo; it is also a technique in software for problem solving. The first turtle was a small computer controlled vehicle that could be programmed to draw or to move without leaving a visible trace (Papert, 1971, p. 6-1). Although, there are robotic turtles, the most common turtle seen today is a graphics cursor on a computer display surface.

> In Turtle geometry we create an environment in which the child's task is not to learn a set of formal rules but to develop sufficient insight into the way he moves in space to allow the transportation of this self-knowledge into programs that will cause a Turtle to move. (Papert, 1980, p. 205)

The realms of spatial phenomena and experiential facts meet upon the turtle graphics working space, because Logo logic provides a systematic concept of causality based upon natural experience. Papert (1980) refers to the resulting cybernetic environment as a microworld. One aspect of a microworld is that it provides opportunities for the development of body-syntonic mathematics through turtle geometry. Another microworld characteristic is the aesthetic dimension of turtle graphics which is, according to Papert, continually placed in the forefront of the Logo experience (p. 205).

Two symbol systems for human-machine communications are used when Logo turtle graphics software is being run: (a) the alphanumeric language used to express human ideas to and from the computer, and (b) the visual-spatial language used by the designer to create screen displays for others to see. Each of these symbolic languages builds upon the logistics of an oral conversation and can be broken down into its traditional parts of: (a) the vocabulary, (b) grammatical rules for using the language, and (c) the meaning of the words or other symbols. Citing Arnheim and Macdonald-Ross, Bernard and Marcel (1978) explain:

> Visual representation in symbolic or pictographic form can obviously serve many functions. It may, for example, be considered both as a tool for thought and as a form of communication.... As a form of communication, it must convey information as clearly as possible. In this respect symbolic and pictographic representations must fulfill at least some of the communicative properties of natural language. (p. 38)

Lexicons are the minimal units of meaning in a particular language -- the vocabulary; lexicons are called primitives in Logo. The lexical design of the visual interface employed in Logo determines the interaction technique for each input and output word -- the blending of machine capabilities and the hardware-independent units of information manipulated during the human-computer conversation (Foley & Van Dam, 1983, p. 221).

The syntax of a language determines the rules for the formation of sentences. Logo procedures, being equivalent to constructed sentences, demonstrate the linguistic concept of syntax -- the conventional order for language elements. The syntactic design of the visual interface defines the sequence of input and output information -- the grammatical rules for using verbal or graphic words that cannot be further decomposed without losing their meaning. Spatial and temporal factors are also syntactic considerations (Foley & Van Dam, 1983, p. 220).

Semantics refers to linguistic meaning. Logo's semantic design is extensible, thereby, enabling users to assign meaning to vocabulary words of their own creation as they are needed to express an idea. Margenau (1973) has shown that data, being synonomous with facts, have little meaning or value in and of themselves (p. 167). The semantic design of the visual interface, therefore, defines meanings attached to units of information according to their function in the human-machine dialogue (Foley & Van Dam, 1983, p. 220).

The linguistic rapport experienced by the person using an interactive graphics language, like Logo, is determined by the conversation protocol. Conversation protocol refers to the ways in which temporal relations occur throughout the course of a human-machine conversation (Foley & Van Dam, pp. 220 & 222). Conversational protocol in Logo may involve various user-defined temporal relations beginning with an immediate mode.

The visual-verbal linguistics of Apple Logo turtle graphics are listed in Table 1.

Table 1

Apple Logo Turtle Graphics Conventions

- Visual Lexicons: Point, line, shape, color
- Verbal Lexicons: ST (SHOWTURTLE), HT (HIDETURTLE), FD (FORWARD), BK (BACKWARD), LT (LEFT), RT (RIGHT), HOME and their resulting procedures which include numbers and mathematical symbols

- Visual Syntax: Geometry
- Verbal Syntax: Procedural logic with list processing capabilities

- Visual Semantics: Composition
- Verbal Semantics: User-defined within geometric model

Papert (1984) claims that, "Anything that can be drawn can also be described in this turtle talk, the turtle's coordinate system" (p. 2). Inside Logo's coordinated microworld, a student can explore ideas by manipulating shapes using a type of diagrammic communication system. The information-bearing qualities of turtle graphics, however, vary with the experiences of the Logo user. The communicative function of these conveying qualities illustrates how ideas are translated into meaningful visual events, which are described in terms of their figure-ground relationships. Such a visual interface is designed around the intended application of technology to a particular problem -- the concept of a user model. The conceptual model of a successful Logo user is a significant dimension of the Logo culture.

Logo environments provide opportunities to simulate the visual-spatial activities of life. Logo images are, therefore, conveyors of information about observed realities -- about natural conditions and their meaning. Herein, one sees why turtle graphics can provide a vehicle for genuine intellectual achievement. Logo's instructional logic emphasizes the process of thinking; its primary teaching purpose is to develop the idea of splitting a task into logical subgoals. The Logo experience provides students with opportunities to "tackle problems which require them to initiate solutions, try them out, respond to feedback, and decide whether to change track or to persist" (Weir, Russell, & Valente, 1982, p. 347).

Discussing the Logo language learner as a model builder, Weir et al (1982) point out that the child can use the screen turtle to explore a naturally defined spatial world in which to learn about shape, length, angle, size, position, and number -- to use lines that become models of objects (p. 355). The Logo language experience helps to create an intellectual connection between what is known about space and its contents and what is a new perception about the way things are.

Logo has been called "a language for learning how to perceive things, how to think" (Polin, 1982, p. 2). It is widely used throughout the world's educational computing community and Logo turtle graphics is considered a powerful way to introduce beginning students to computers. Logo techniques for establishing user-machine communications involve visual perceptual-cognitive events. Thousands of children and adults have had opportunities to experience turtle graphics and, thereby, to translate computerized messages from the verbal to the visual and vice versa.

The idea of being able to translate from visual language to verbal language and vice versa is central to the concept of visual literacy proposed by Debes in 1969 at the First National Conference on Visual Literacy in Rochester, New York. Specifically, he presented participants with "A

Hierarchy of Visual Literacy Skills" representing visual literacy competencies which would enable a person to read, write, and express visual ideas by knowing the grammar and syntaxes of visual language as well as how to use the cultural tools of visual literacy, thereby, appreciating, understanding, and contributing to the visual realm (1970, pp. 13-14). The competencies are:

Distinguish light from dark

Recognize differences in brightness

Recognize differences and similarities in shape

Recognize differences and similarities in size

Distinguish hues from greys

Recognize differences and similarities in hue

Recognize differences and similarities in saturation

Perceive distance, height, and depth

Recognize differences and similarities in distance, height and depth

Perceive movement

Recognize differences and similarities in rates of movement

Recognize a whole shape even when partially occluded

"Read" simple body language and make simple body language utterances

Recognize groups of objects commonly seen together

"Read" a spatial arrangement of objects commonly seen together

Group objects related by process commonly seen together

Group objects related by process though not necessarily seen together

"Read" a sequence of objects and/or body language arranged in chronological order and related by process

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in an idealized order to represent elements of a process or a genotype, etc.

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in cogent order

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in "original" yet "significant" order

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in order so as to communicate an intended idea about a process

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged to communicate intended nonphysical concepts

Compose an utterance as above

"Read" a sequence of objects and/or body language
arranged to transmit a fictional narrative

Compose an utterance as above

"Read" a sequence of objects and/or body language
arranged to create a desired emotional reaction

Compose an utterance as above

"Read" a sequence of objects and/or body language
arranged to express, so that others may understand
it, a personal emotion

Compose an utterance as above (pp. 11-13)

Although competencies essential to human-machine dialogues change with technical innovations, the premise of knowledge acquisition through the user's visual perception remains a tradition within the computer industry. Logo turtle graphics not only builds upon this principle of visual literacy and such visual constants as points, lines, and shapes, but does so using the descriptive logic of geometry. Figure-ground relationships within a Logo viewing surface are defined, using visual-spatial words like forward, backward, left, and right. Logo's visual-verbal information is so understandable across native language barriers that Papert (1971) has referred to Logo as "a full-fledged universal language" (pp. 4-2). The concept has to do with the universality of body-syntonic logic [self knowledge about moving in space] and the iconic elements of language which have evolved through the widespread use of a visual interface in computing.

Statement of the Problem

The visual literacy movement is traditionally associated with visual language, logic, learning, and communication -- with understanding visual organization and its intended meaning. Visual literacy is relatively defined as a cultural understanding of the visual symbolic mode. This exploratory study concerns visual literacy competencies pertinent to computer culture. Specifically, the study will seek to explore relationships between Logo turtle graphics and visual literacy by addressing two related questions: (a) can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? and (b) do the literature and "hands-on" experience with turtle graphics indicate that Debes' (1970) visual competencies are pertinent to graphics-based electronic communications in computer culture? There are two strategies to research the problem under investigation. The first is to review the published literature about visual perception, visual literacy, and the visual information technology of computer graphics, specifically Logo turtle graphics, and to identify traditional visual literacy competencies possibly relevant to computer culture. The second task is to visually analyze and interpret Logo turtle graphics assignments to determine the presence or absence of real world correspondence in computer culture to the published literature about traditional visual literacy skills.

Significance of the Problem

The popular view of literacy in crisis expressed by Lennon, Cook, and Jennings (1986), reflects the cultural consequences of the new mix of electronic technology and print media in computerized society. There has been a shift in media dominance away from printed visual materials during the twentieth century and electronic techniques are now used to provide increasing amounts of information and entertainment. Suhor (1984) argues that this complex relationship has created a multiliterate society.

> Radio, films, the telephone, television, computers, lasers, and other electronic forms have had, and continue to have, profound effects on social organization and on the way people experience the world. The linear, eye-oriented bias of print culture has been challenged by electronic media that call for wider, more richly interrelated sensory responses. (pp. 16-22)

Today, as in the past, there is growing public reliance on written records which, when computerized, command prestige; privileges of position and financial opportunities are largely reserved for the <u>litterati,</u> many of whom are also computer literate; electronic information is considered an indespensable correlate of the world's computer culture; and the ability to accurately decipher computer graphics is increasingly important. Logo logic and turtle graphics appear to be an exemplary model for developing visual-verbal literacy skills appropriate to culturally agreed upon interpretations of computer graphics -- opportunities to become <u>litteratus</u> in a contemporary sense. Logo enables the beginning user to experience the communicative function of computer graphics by generating numbers, letters, and corresponding geometric shapes. Turtle graphics also engages the user in active interpretation and evaluation of the visual-verbal information seen on the display surface.

Logo user groups have been established in many countries including the United Kingdom, Canada, France, the Netherlands, West Germany, Japan, and the United States (Martin, 1985, pp. 239-241). These nations are large producers and consumers of visual information technologies (computer graphics hardware, software, amd images) -- the tools of literacy in the world's computer culture. This exploratory study, therefore, focuses traditional ideas about visual literacy upon the Logo turtle graphics experience of reading and writing alphanumerics while drawing corresponding computer graphics.

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CHAPTER II

Review of the Literature

In exploring visual literacy in computer culture, it was determined that the review of related literature would examine the literature and research about (a) visual perception, (b) visual literacy, (c) computer graphics, and (d) the language of Logo turtle graphics. Literature about general literacy in Western culture would also be reviewed for historical trends toward popular literacy. The majority of the published and unpublished literature selected was produced between 1960 and 1988.

The review of literature about visual perception describes a natural basis for consistency in visual education. Visual perception is the process whereby vision and cognition provide the viewer with personally meaningful interpretations of the visual realm. It was determined that the review of related literature about visual perception would: (a) describe the visual system and its elements in perceptual terms, (b) define the phenomenal relationship between a viewer and his or her field of vision, and (c) identify the information-bearing qualities of visual information. The ideas in review progress from general perceptual events, to visual percepts and neural coding of visual information. The resulting perspective is a topological theory of perception which considers the biophysics of sensory coding and the process of visual perception.

> According to the topological theory of perception, each individual is surrounded by a "phenomenal field." This field consists of the individual's experience about the world in general, the objects and his own self. The forces of this psychological field exert their pressure on the individual. He experiences himself as moving ("locomoting") under their influence towards positive goals or away from negative goals. The region of the psychological field in which the individual experiences himself as acting is called "life space." (Taylor, 1960, p. 77)

The visual literacy movement is concerned with visual language, logic, learning, and communication -- with understanding visual organization and its intended meaning. It was determined that the review of related literature about visual literacy would: (a) describe traditional visual literacy concepts and associated competencies, focusing upon Debes' (1970) "Hierarchy of Visual Literacy Skills," (b) emphasize mainstream thinking about visual literacy in the United States, (c) identify international efforts toward visual literacy, and (d) describe visual literacy as a cultural event necessitated by the mass presence of visual technologies, specifically computer graphics. The selected literature describes competencies associated with reading, writing, and drawing visual information and their development.

Computer graphics refers to electronic computations resulting in alphanumeric and/or pictographic images. It was determined that the reveiw of related literature about computer graphics would: (a) identify the newest and best innovations in the development of computer graphics technology (hardware, software, and images), (b) describe the cultural impact of computer graphics in today's society, (c) describe the role of computer graphics in computer education, and (d) describe interactive computer graphics imaging techniques. Computer graphics technology is discussed as a tool for literacy in computer culture.

Logo turtle graphics is an educational philosophy, a computer language, and a technique in software for generating alphanumerics and corresponding geometric shapes. Logo is functioning as a representational model of the computer graphics experience in this study. It was determined that the review of related literature about Logo language research would: (a) describe the turtle graphics experience, (b) describe educational research issues associated with who? what? where? and when? about Logo, and (c) identify introductory course content, methods, and activities implicit in the research.

It was determined that the review of related literature about literacy in general would: (a) describe the evolving needs for universal literacy in Western culture, (b) identify the current state of literacy in the United States, and (c) describe the impact of information techologies on literacy needs in computer culture. The majority of information about popular literacy is presented in the Introduction.

Visual Perception

> (Perception) refers to any differentiation a person is capable of making in his perceptual field whether or not an objectively observable stimulus is present. Differentiation in the perceptual field resulting in perceptions of seeing, hearing, smelling, or feeling are in our theoretical perspective fundamentally the same as those made in conceiving, knowing, or understanding. Although the subject matter varies, the process is the same. The differentiation of an idea or a concept is not basically different from the differentiation of a scent, a sound, or the printed words on a page. Each involves some measure of personal meaning on the part of the person/perceiver. (Combs, Richards, & Richards, 1976, pp. 16-17)

This broad definition of perception as personal meaning has received much acceptance from critical thinkers, many of whom also support the idea of a perceptual field as the domain of accumulated experience. What one understands, however, will depend upon the way in which perceptions are organized and the point of view from which they were made. A fundamental thesis of such a perceptual psychology is that all behavior is a consequence of a person's perceptual field at the instant of behaving. Every behavior, therefore, is a product of the perceptual field and may be used to infer the nature of the perceptions which produced the behavior. This perceptual view of human nature has, according to Combs et al (1976), been explored by numerous authors including, Boulding (1956) in The Image, Gibson (1966) in The Senses Considered as Perceptual Systems, Arnheim (1969) in Visual Thinking, Gregory (1970) in The Intelligent Eye, and Keen (1975) in A Primer in Phenomenological Psychology (pp. 9, 17, 22 & 393).

Perceptions in daily life are seldom simple and are more likely to involve vast areas of the perceptual field, because events within a field are interacting and interdependent. Any new awareness in the perceptual field derives its properties from its relationship to the field as a whole. Citing Murphy and Spohn (1968), we do not live in a world of objects without meaning; our perceptions are never masses of meaningless and unrelated stimuli (Combs et al, 1976, pp. 23 & 35).

The early Gestalt psychologists, who studied the characteristics of human perception, observed that perceptions are always organized into a configuration which they termed a Gestalt. They also learned that what is perceived is always a totality and never an isolated event. The perceptual facts learned by Gestaltian researchers explain that what one perceives is not an isolated occurance but the result of the relationship of an event to the observed whole. They call this relationship of the part to a whole the figure-ground relationship (Combs et al, 1976, pp. 23-28 & 35).

The figure-ground concept involves a continual change in the perceptual field caused by the constant rise of a new awareness into figure and the consequent lapse of other elements into ground. The process, the emergence of figure from ground, is one of increased awareness of details and is, therefore, called differentiation (Combs et al, 1976, p. 28).

Visual perception involves a search for meaning in the spatial relationship seen among figures and their ground. Visual perception is an experienced event that fosters the sensing and understanding of spatial realities. It is also a system of descriptive logic that renders visible events meaningful to the observer. Many of the logical distinctions pertaining to the actual state of the world need no object evidence other than justification through the senses (Piëtila, 1975, p. 12).

> We observe, study, perceive, watch, inspect, recognize, detect, identify, and discern the elements in our environment. We distinguish and discriminate between them; we glimpse, spot, notice, spy, and catch sight of them. Moreover, we see, or at least say we see, not only teapots and tigers, but what these things are, how they look, who they belong to, where they are located, what they are doing, that they have moved, whether they are nearby, when they arrived, and why they are late. We see under them, over them, the differences between them, the condition they are in, if they are in trouble, what caused it, and how to remedy it. (Dretske, 1969, p. 1)

Although objects and events can been seen without being recognized or identified, the sense of sight is generally credited with being one of the chief resources for discovering the content and character of our surroundings (Dretske, 1969, p. 78). The visual arrangement of images conveys ideas about space, its natural and synthetic contents, and their relative relationships. The process of "seeing and saying" visible things is a continuously evolving cultural phenomenon. Typical observations tend to reflect individual and egocentric frames of reference, which in turn mirror societal or cultural norms and/or prejudices (Boehm & Weinburg, 1977, p. 3). The meaningful elements of a visual arrangement change when innovative ideas are expressed as new events to be seen and described.

All of the senses are involved in perceiving, although it is usually the visual and auditory senses that are the dominant organs delivering messages to the brain for interpretation. Regardless of modality, the process of interpreting sensory input is related to past experiences with the same or at least similar situations. A knowledge or recognition of the effects of the perceptual process, if applied to a communication system, can greatly aid in understanding and avoiding communication breakdowns (Cakir, Hart, & Stewart, 1980, p. 67). As Combs et al (1976) point out, communication is possible through that part of the phenomenal field that is common to two persons (p. 361).

Visual communication involves the basic principles of perception and is concerned with the ways visual information is distributed throughout the perceptual field over time -- its spatiotemporal organization. The structural characteristics of visual perception begin with the visual field -- all of that which is perceived by the eyes at a given moment. Major features of the field of vision are its edge [perimeter], the space within the perimeter, and the visual events within that space. The components in the visual field, like points, lines, and colors, are called elements or sensations (Taylor, 1960, p. 52).

> We translate an inner experience, inside our nervous system, into pulsed electrochemical codes that instruct our muscles to contract or expand in specific ways....
>
> Our muscles translate these codes into activities that move objects outside-our-skin into patterns that have a prescribed left-to-right or up-to-down order in space.... These patterns reflect wavelengths of light in the visible range. The wavelengths are transmitted to and received by other nervous systems in exactly the same way as any other event in space/time.... Received by another nervous system, these patterns of light waves form the basis for a new experience, which, in turn, may result in a new set of symbol responses. (Fabun, 1960, p. 19)

Haber (1968) defines perception as the study of the interaction of the perceiver with his or her environment, noting that "this definition implies clearly that perception is a process and not a thing, and it also implies that perception is inferred and cannot be directly observed" (p. 1). An important aspect of the scientific study of perception is the realization that the researcher is dealing with the private experience of individuals. Percepts are not seen as overt events, but as a covert process (Dember & Warm, 1979, pp. 14-15).

Citing Murphy's research, Taylor (1960) reports that there are three basic phases in the visual perceptual process: (a) the diffusion phase, (b) the differentiation phase, and (c) the integration phase. The initial phase of diffusion is first developmentally and in the perception of a complex configuration for the first time. Taylor explains that, "The visual field is inarticulate and undifferentiated at this stage appearing flat and unextended, because the perception of depth in space requires a great deal of articulation" (p. 56). The second phase is analytic and inductive as the viewer relates the visible parts to a coherent organization. Elements begin to segregate and become identifiable to the perceiver during the differentiation phase; their relationship, however, remains unclear. Integration, the final phase of perceptual development or in observation, occurs when elements are composed into a pattern. Structuring visual events occurs when sensations are grouped by "proximity, similarity, common movement, common destiny, and closure, and separated by means of contrast, figure-ground, and depth cues." Finally, the entire visual configuration is integrated into a single coherent whole, according to the principles of good figure and constancy (pp. 56-57, 70).

> Integration has several important identifiable characteristics which make for its high degree of communication. It is efficient in the sense that there is the proper amount of material to produce understanding. It is simple in that there is a minimum of or no adornment. Finally, it is reliable in that it evokes similar responses among many people in the same culture. (Taylor, 1960, p. 57)

The study of perception is the oldest area in psychology. With its century-long research history, much of the basic empirical information, for example, about visual perception, has been demonstrated and even replicated (Haber, 1968, p. v). Information theory represents a relatively recent innovation in thinking about and describing phases in the perceptual process.

> It is generally agreed by psychologists of diverse theoretical orientations that perceiving, as it occurs in people, is a process whereby stimulus information is elaborated and interpreted so as to yield organization and meaning. (Dember & Warm, 1979, p. 5)

One characteristic of living things is their multidimensional sensitivity to physical energy impinging on them. In this sense, energy is a carrier of signals or messages -- a carrier of information. Explaining further, Dember and Warm (1979) remark, "Evidently our awareness of the world is somehow developed by a process which seeks and extracts information from the ambient flow of energy surrounding us and imposes complex transformations and synthesis upon this incoming information." They insist, "Information is something we gain when an event tells us something that we did not already know" (pp. 5, 10 & 108).

This information model is a recently developed conceptual tool that is being used by experimental psychologists to analyze the flow of information within an individual perceiver.

> The information-processing approach has its origins in the need to understand the complex perceptual skills involved in operating complex man-machine systems and in the development of communication engineering and the general-purpose computer. (Dember & Warm, 1979, p. 18)

Within this model of information flow, consisting of an information source or message, an encoder, a channel, a decoder, and a destination plus a noise source:

> ....the selected message refers to a stimulus, the sensory receptors of the organism are the encoding devices, and the central nervous system is the communication channel. The message is decoded by cortical centers in the brain and the organism's response is the destination. The message is also subject to the degrading effects of "noise," stemming from events both within and outside the observer. (Dember & Warm, 1979, p. 107)

> One of the most exciting and important developments in our understanding of the perception of form has been the discovery of neural elements which are specialized for the detection of contours and for the coding of information regarding the features of patterns. (Dember & Warm, 1979, p. 218)

Modern neural science is concerned with the idea that all behavior is a reflection of brain function. From this perspective, "the mind represents a range of functions carried out by the brain" (Kandel & Schwartz, 1985, p. 3).

> Information coming from peripheral receptors, which sense the environment, is analyzed by the brain into components that give rise to perceptions; some of these perceptions are stored in memory. The brain also issues motor commands for the coordinated movements of the muscles of the body. The brain does all this with nerve cells and the connections between them. (Kandel, 1985, p. 13)

Uttal (1973) contends that the external world of objects and events is represented within an organism by essentially equivalent neural patterns of organization -- an isomorphism of neural activity and the percept. Uttal's research is concerned with "the physiological processes of the highly specialized nervous tissue responsible for the transduction, transmission, and integration of incoming information patterns" (pp. 1 & 3).

Uttal, says:

> Sensory processes in biological systems are defined, in large part, by an intrinsic directionality of the flow of information. The sensory system is designed .... to pick up patterns of information from the external world, transduce this information from any number of physical forms of energy to the electrochemical forces of neural activity, and transmit that pattern toward the complex central portions of the nervous system. (1973, p. 4)

Uttal (1973) asserts that there are general principles of sensory organization that apply regardless of modality and that should be emphasized independent of a specific modality. The coding of sensory quantity, space and time, or even quality have organizational elements with common attributes, because all receptors perform the process of transduction -- converting one form of energy to another as a result of the primary sensory action. Each sense organ, however, is designed to be maximally sensitive to a certain type of physical energy. These sensed patterns of information, which are defined by external forces, are subsequently represented at each level of neural processing. "Neural events are used as symbols in this representation" (pp. 6 & 11-13).

> In all of the sciences the following question is asked: how do signals or symbols from one universe of discourse represent patterns of information from another? The major theoretical notion that underlies coding theory is that there are invariants of organization, pattern, or meaning, which can be conveyed from sources to destinations even though represented by different symbols and in different kinds of physical energies in the communication process. (Uttal, 1973, p. 207)

An important aspect of the visually sensed perceptual world is that "it is built, in part, upon figures which are sculptured out of a kaleidoscopic array of ambiguous stimulus elements and organized two-dimensionally on a plane surface" (Dember & Warm, 1979, p. 216). The biophysical events of the visual perceptual process involve figure-ground relationships determined through (a) brightness, (b) hue, (c) saturation, (d) contour, and (e) pattern. "The only way in which we can see anything is by brightness contrast (effective light energy) and by spectral contrast (wavelength) formed by an object relative to its background" (Gouras, 1985, pp. 384-394). The functional organization of the visual system involves complex transformations of energy-coded information. As visual information is transformed it becomes increasingly abstract at each level of its neural processing. "Visual perception [per se] resides largely in the abstracting capabilities of the neurons of the brain" (Kandel, 1985, p. 382).

Allowing for individuality, differences in perceptual growth are reflected in the different ways that people handle information. McFee (1961) reports that "intelligence is found to be related to ability to handle detail and asymmetrical material (more complex organized detail)" (p. 308). The ability to observe and organize visual information can be developed by perceptual training (p. 309).

> Perceptual training can enrich a child's reservoirs of possible combinations and reorganizations. It can make him much more aware of the functions of form, line, texture, and color in the world around him and give him a much richer "language for expression"..... (p. 309)

In summary, the literature about visual perception says that specific neurological events enable the brain to see figure-ground contrasts in the visual realm through brightness, hue, saturation, contour, and pattern. These visual events are used by normally sighted people to interpret space and its contents. The spatial descriptors of up, down, left, right, forward, backward, and centered are, therefore, also associated with the process of visual perception. The elements within a visually perceived experience are frequently called points, lines, and colors. The major features of a field of vision are its perimeter, the space within that edge, and the visual events within that space. Herein, the conceptual foundation for the visual literacy movement finds biological correspondence and a natural basis for consistency in visual education.

Visual Literacy

> Since the majority of the world's peoples, in all cultures, possess normal vision and are exposed to the world of visible phenomena in which there are worldwide consistencies it might be argued that visual literacy is simply the general human condition. However, there is perhaps a sense in which we can think of visual literacy as at least a continuum from very restricted competence, even where vision is normal, to high competence. I [Hewes] think it reasonable to say that not all cultures offer their members equally rich visual information, and that not all segments of the cultures that do so may be equally informed. The range of man-made visual experience in the world's cultures is very great. (1978, pp. 9-10)

Culturally meaningful interaction with visual information is dependent upon a type of phenomenology, wherein, images are understandable alone or within the situational context. Visual literacy is demonstrated through the continuous efforts by people to order newly seen realities -- to systematize visual events into meaningful and non-meaningful images for later semantic reference.

> Whether visual literacy, media literacy, or visual communication is the best label, the concept needs to be considered an essential element of today's curriculum everywhere in the world. As educators consider a broader definition of literacy, it should include the study of symbols, message carriers, non-verbal language, communication channels and effects on human behavior. (Ely, 1984, p. 104)

The above statement summarizes prevailing attitudes toward visual literacy from several academic points of view. It also represents almost half a century of evolving thought about visual technology, visual knowledge, visual communication, and visual logic. During the 1940s, however, seed thoughts about visual literacy were just beginning to form around three basic concepts: (a) the sense of vision as language (Kepes, 1945), (b) educating toward reality (Kelley, 1947), and (c) systems for behavioral organization (Hebb, 1949). The word systems is key to the way that information processing theory was central to the thinking of the day and to ideas like the visual system of language, educational systems, and programmed learning.

A structural approach to language, similar to that of Charles Fries (1952), provided the framework for thinking about visual literacy as communication during the 1950s

(Gibson, 1954; Kees & Ruesch, 1956; Chomsky, 1957). At the close of the decade, some of the most critical variables involved in "visual discrimination learning" were identified to be states of enhanced visual stimulation and visual deprivation (Gibson, 1959, pp. 74-81).

Thinking about visual literacy during the early 1960s began to crystallize the relationship between systems of language and pictorial learning (Wendt, 1962; Williams, 1963). Fransecky and Debes (1972) report that during 1965 and 1966 a widespread concern for visual language and learning began to be recognized as the visual literacy movement. Professionals using visual means of instruction had begun to work together in small exploratory meetings (p. 32). The pressure for holding a conference about the visual language began late in 1967. The rationale for promoting visual literacy was twofold:

> First, because of TV and other factors, today's child is far more visual in his learning needs and preferences than the child of a few years ago. This necessitates different learning and teaching strategies. Second, success in dealing with today's world requires a degree of visual sophistication and literacy hitherto not so necessary. (Williams & Debes, 1970, p. i)

The early focus of these pioneer thinkers was upon the film experience; the camera was most often used to record a child's visual perceptions. It is, therefore, not surprising that the first publication for interdisciplinary discussions about the visual language, called Visuals Are a Language, was published by Eastman Kodak Company in 1967. John L. Debes, who has been called the father of visual literacy, directed the production of this significant work. A second influential publication, however, points to another research direction also being taken at the time: Visual Differentiation, Intersensory Integration, and Voluntary Motor Control (Birch, 1967), which examines "the perceptual basis for the development of the child's ability to reproduce two-dimensional figures" (p. 2).

By 1968, the systematic process of visual communication was receiving scholarly attention (Debes; La Polt). The phrase visual literacy first appeared in the Spring of that year among major presentations at The Association for Educational Communications and Technology's (AECT) annual conference in Houston, Texas. Interest among convention participants resulted in a committee being formed and a meeting scheduled for August, 1968 at the University of Rochester. The decision to call the First National Conference on Visual Literacy was made by these committee members (Fransecky & Debes, 1972, p. 32).

Debes also wrote his first article on visual semantics during 1968, later explaining:

That article was concerned basically with three points:

1. that in intentional communication about a semantic

> process one can communicate visually, verbally, or in other ways; 2. that there are many parallelisms between the visual communication and the verbal communication; and 3. that the process of making abstractions from reality is much the same whether you use verbal paths or visual ones. (Williams & Debes, 1970, p. 2)

Three-hundred and fifty linguists, art teachers, AV (audio-visual) supervisors, speech pathologists, psychologists, inner-city leaders, and other educators attended the First National Conference on Visual Literacy held March 23-26, 1969. Culture, education, and visual media were the focus of the newly formed visual literacy movement (Gross, 1969; Hall, 1969; McLuhan, 1969). Debes insisted, however, that "visual literacy didn't really become possible until visual communication was made easy by visual technology and possible on a mass scale" (Fransecky & Debes, 1972, p. 9).

The following tentative verbal definition of visual literacy was proposed in 1969 by Debes (1970), as he addressed the Conference participants at Rochester:

> Visual literacy refers to a group of visual competencies a human being can develop by seeing at the same time he has and integrates other sensory experiences. The development of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person

> to discriminate and interpret the visible actions, objects, and/or symbols, natural or man-made, that he encounters in his environment. Through the creative use of these competencies, he is able to communicate with others. Through the appreciative use of these compentencies, he is able to comprehend and enjoy the masterworks of visual communication. (p. 14)

Debes (1970) also presented the conference attendants with "A Hierarchy of Visual Literacy Skills" which he felt to be the developmental components of visual literacy and representative of competency goals. These competencies are not presented in their original order, but are arranged by related skills; they are:

- Distinguish light from dark and hues from greys
- Perceive distance, height, depth, and movement
- Group objects related by process commonly seen together as well as those related by process though not necessarily seen together
- Recognize differences in brightness
- Recognize differences and similarities in shape, size, hue, and saturation
- Recognize differences and similarities in distance, height, depth, and in rates of movement
- Recognize a whole shape even when partially occluded as well as groups of objects commonly

seen together

- "Read" simple body language and make simple body language utterances
- "Read" a spatial arrangement of objects commonly seen together
- "Read" a sequence of objects and/or body language arranged in chronological order and related by process; in an idealized order to represent elements of a process or genotype, etc.; in cogent order; in "original" yet "significant" order; in an order so as to communicate an intended idea about a process; to communicate intended non-physical concepts; to transmit a fictional narrative; to create a desired emotional reaction; to express a personal emotion so that others may understand it, and
- Be able to compose an utterance equivalent to each of the above visual events (pp. 11-13).

Debes (1970) continues to clarify his 1969 concept of visual literacy by enumerating the following desirable attributes and skills of the visually literate person, who should:

- Read visuals with skill
- Write with visuals, expressing oneself effectively
- Know the grammar and syntaxes of visual language and be able to apply them

- Be familiar with the tools of visual literacy and their use
- Appreciate the masterworks of visual literacy, and
- Be able to translate from visual language to verbal language and vice versa. (pp. 13-14)

The phrase "compose an utterance for each of the above" coupled with the idea of being able "to translate from visual language to verbal language and vice versa" is, perhaps, the essence of this interpretation of visual literacy -- it is a receptive and expressive mode of communication, a language, as it were.

Agreeing with Debes, Geraci (1969) adds that "the real key to the development of visual understanding, of visual fluency, is a sequence of disciplined tasks -- mental, visual, oral, written exercises" (p. 237).

The decade of the 1970s provided the basic concept of visual literacy with philosophical adjuncts. In particular, McLuhan and Fiore (1970) pointed to the ways that electronic visual technologies were dramatically reshaping popular thinking about essentially everything.

> All media work us over completely. They are so pervasive in their personal, political, economic, aesthetic, psychological, moral, ethical, and social consequences that they leave no part of us untouched, unaffected, unaltered. The medium is the message. Any understanding of social and cultural change is

impossible without a knowledge of the way media works on environments. (p. 26)

Visual literacy education also gained momentum during the early 1970s with visual literacy concepts being based upon "a confluence of knowledge, theory, and visual technology" (Debes, 1970, p. 9). In 1972, the Center for Visual Literacy was established in Rochester, New York where it published Visual Literacy and the Classroom (Heffernan-Cabrera, 1972). The Association for Educational Communications and Technology also published an influential text in 1972, called Visual Literacy: A Way to Teach -- A Way to Learn (Fransecky & Debes). An academic lobbying force had begun to represent the diversified interests of the movement. Typically, visual literacy was concerned with those issues of visual communication beyond the limits of recognizing and understanding the written and spoken word to include all of the connotations of the word visual (p. 15).

Fransecky and Debes (1972) also point out that every culture has basic visual symbols that are generally understood by members of the culture to stand for particular objects or events. They argue that the basic structure of visual language is a set of relationships between visual thinking, reading, and writing -- the structure of discourse itself. It was considered vital to make this distinction without fragmenting visual learning; rather connections between structure, knowledge base, and skills, acting upon that knowledge, must constantly be made clear (pp. 7 & 12).

In 1973, the International Film and Television Council (IFTC) officially defined media education, the internationally used phrase referring to visual literacy training, as:

> ...the study, teaching and learning of modern methods of communication and expression considered to be part of a specific and autonomous discipline in pedagogical theory and practice as opposed to their use as teaching and learning auxiliaries in other areas of knowledge, such as mathematics, science and geography. (Morsy, 1984, p. 8)

Consequently, 1973 brought a strong research lean toward identifying visual literacy competencies (Dondis, 1973; Feldman, 1973; Horn, 1973; McLuhan, 1973; Montebello Unified School District, 1973). In particular, Dondis (1973) argues that visual literacy must also be concerned with the structural forces existing in the functional relationship between visual stimuli and the human organism, the characteristics of visual elements, and the form-building power of visual techniques. The governoring principle of visual solutions was proposed to be intended meaning at the personal and cultural levels, whereas, visual media legislate the character and limitations of problem solving methods (p. 17).

> Indeed, the educational system is moving with monolithic slowness in this area [training in the visual mode], still persisting in an emphasis on the verbal mode to the exclusion of the rest of the human sensorium and with little sensitivity, if any, to the overwhelmingly visual character of the child's learning experience. (Dondis, 1973, p. 10)

Dondis (1973) also contends that the irreducible elements of the visual process are dot, line, shape, direction, tone [presence or absence of light], color, texture, scale or proportion, dimension, and motion (pp. 15-16).

> The visual mode is a whole body of data that can be used, like language, for composing and understanding messages at many levels of utility from the purely functional to the lofty precincts of artistic expression. Inevitably, the final concern of visual literacy is the whole form, the cumulative effect of selected elements, the manipulation of the basic units through techniques and their formal compositional relationship to intended meaning. (p. xi)

By the mid-1970s, the key concepts relating to visual literacy were established to be technology, philosophy, art, psychology, programmed learning, semantics, rhetoric, and linguistics.

> In our society we are bombarded with visual information daily -- movies, television, advertisements, catalogs, billboards, to name a few. Most of us, students and adults alike, are good at "reading" this language without understanding how the language works or being able to "write" it ourselves. The goal, therefore, of visual literacy programs is to develop in students the ability both to understand -- and to express themselves in terms of -- visual material, to enable them to relate visual images to meanings beyond the images themselves. (Platt, 1975, p. 5)

Visual literacy is primarily seen by researchers in the 1970s to encompass perceptions developed from visual experiences. In this context, perception refers to both the incoming material of the physical universe -- people, objects, series of events, scenes, gestures -- seen through the eyes, and to the ordering and giving meaning to that material (Platt, 1975, pp. 8-9). Van Geert (1983) later states that, "The process of perception is defined formally as a transformational relationship between a perceived, external world and the physical energies acting upon the senses" -- sensory integration, space perception, and the perception of form and pattern (p. vii).

Supporters generally agreed throughout the 1970s that visual literacy had acquired a broader meaning since the popularity of photography and television. Using the camera in the classroom was a typical method for teaching visual literacy concepts. The expressive possibilities inherent in photography supported the researched belief that "the angle of vision, the relationship of objects in space, the effects of distortion, the degree of detail, the depth of field -- all of these work for, and are used by, visually articulate students" (Platt, 1975, p. 16).

The process of seeing, understanding, selecting, and expressing visual information was being treated as a mode of communication during the 1970s. Visual literacy and the visual language were acquiring universal dimensions, because it was felt that "the expansion of perception that takes place as soon as serious observation begins is relevant to everybody in every place." However, "the objectives of different programs involving literacy vary. Each teacher must assess the needs of her/his students and present visual materials and techniques accordingly" (Platt, 1975, pp. 20 & 24).

Research also shows that the ability to develop visual perceptual-cognitive skills is dependent on the development of skills in the following other areas of vision: (a) accuracy of perception, (b) rate of perception, (c) directionality, (d) figure-ground relationships [contrast], and (e) visual memory [sequence] (Efron and DuBoff, 1976, pp. 26-27). Whereas, capabilities in visual organization involve a conceptual understanding of the principles of spatial relationships which were clarified by the early Gestaltists. Nearness, similarity, intensity, common fate, contrast, and movement or directionality are essential to visual organization. They are also principles of Gestalt perception common to all sense modalities (Combs et al, 1976, pp. 34-35).

An expert meeting convening in Paris at UNESCO during September, 1979, took the position that media literacy was to be studied, taught, and learned at all levels of education and in all circumstances. Curricular content for media education was determined to cover:

> . . . the history, creativity, use and evaluation of media as practical and technical arts, as well as the place occupied by media in society, their social impact, the implication of media communication, participation, modification of the mode of perception they bring about, the role of creative work and access to media. (Morsy, 1984, p. 8)

Wileman (1980) defines visual literacy for the 1980s as "the ability to read and understand that which is seen and the ability to generate materials that have to be seen to be understood. Visualization, like verbalization," he continues, "creates a language out of its elements, structure, and uses and, like any language, can serve infinite communication needs" (pp. 13 & 17). The importance of the contribution that modern methods of communication and expression could make to education was further emphasized in the 1980, MacBride Report, Many Voices, One World, sponsored by UNESCO's Commission for the Study of Communication Problems (Morsy, 1984, pp. 11-12).

In his keynote address to the Australian National Media Education Conference in 1982, Masterman (1984) said:

> Let us be quite clear: media education should aim to increase students' understanding of how the media work, how they produce meaning, how they are organized, how they go about the business of constructing reality, and of how that 'reality' is understood by those who receive it. (p. 151)

Hitchens (1984) points out that within the international context of media education, the ability to transmit electronic visual information around the world is a phenomenon attracting concern in many nations. Practical considerations relating to global communications using visual signs include: "teaching about visuals, relationships between visual learning/literacy and verbal learning/literacy, visuals in classroom teaching, and influence of media" (pp. 319-321).

Dieuzeide (1984) argues, however, that "research shows that the influences of technology are in fact differentiated in accordance with the psychological, intellectual, social and cultural conditions of the individuals exposed to them" (p. 76).

> Culture, in its widest sense, means the entire artificial environment which man creates by acting on the external world: it includes tools, machinery and works of so-called art, but it also includes the tools of thought -- words, concepts, mental techniques, algorithms and know-how. (Moles, 1984, p. 23)

Literacy traditionally means that a cultural group shares the assigned symbolic meaning of a common body of verbal knowledge; visual literacy is historically concerned with a pictographic rendition of the same concept which includes body language. Their purposes, however, are essentially the same: "to construct a basic system for learning, recognizing, making, and understanding visual messages that are negotiable by all people" (Dondis, 1973, p. x).

Paivio (1978) stresses the logic of approaching visual learning, language, and communication as a dual process, which assumes that the structural and functional properties of verbal and nonverbal systems are interconnected. Visual knowledge refers to "long-term memory information concerning the appearance and function of things" (p. 113).

> ... the higher order of visual processes implied by such terms as visual literacy, visual scholarship, or visual knowledge cannot be understood or even studied

> in isolation. This restriction stems from the fact that language constantly imposes itself on the activity of nonverbal information-processing systems, both developmentally and in specific situations. (p. 115)

For an example, Paivio (1978) describes the way young children "eagerly" look through a catalog or book of pictures demanding the name of unfamiliar objects and how the situation of processing visual imagery is often prompted by verbal cues (p. 115).

> Developmently, much of our knowledge about objects and events is acquired in a linguistic context of descriptions and comments by parents and other members of the linguistic community. The result is an association between words and things that gives language a compelling and pervasive psychological prominence" (p. 115).

Paivio (1978) insists that a dual coding approach to verbal and nonverbal information processing be taken, stressing that the two systems are functionally independent but interconnected. "Each system presumably is specialized for different functions and either can initiate activity in the other, given appropriate contextual stimuli, so that cooperative action is possible" (p. 115).

Recently, Harste, Woodward, and Burke (1984) reported that although they had not discovered scribbling, they had learned that "the process of scribbling bears sociolinguistic and psycholinguistic similarity to the highly prized process called reading and writing" (p. x). Their research goal was "to identify and explicate language and language learning principles that undergrid theoretically based reading and writing instruction" (p. xix). Their findings suggest a new theory of literacy learning based upon the multimodal nature of literacy, allowing "language users to shift perspectives and to alter their sociological and psychological stances during the course of their involvement in the literacy event" (p. xi). Harste et al argue that shifting linguistic points of view enables the language user to "triangulate their knowing" (p. xi).

> All of a sudden scribbling isn't just "cute"; we see it as an unfrozen form of the very process characterizing our involvement and growth in literacy. Children, we argue, attend to the cue complexes we attend to. They do not outgrow strategies. There are, in that sense, no developmental stages to literacy but rather, only experience, and with it fine-tuning and continued orchestration. (p. x)

Observations of children in the experimental situations which we set up show that children gesture, act out, draw, and speak during the fulfillment of a request to write. Speech and the use of alternative communication systems arise spontaneously and seem to assist the child in planning. These activities do not

> lie outside the writing process, but are an intimate and integral part of the process. To call them "intrusions" is to fail to understand theoretically the literacy process. (p. 37)

In summary, visual literacy skills are relative to the visual technologies of any given culture at a specific time in history. Culturally agreed upon interpretations of the visual symbolic mode are learned through visual experiences with linguistic conventions. There are, however, basic visual competencies which apply generally to the process of reading, writing, and/or drawing visual information. The visual language requires that the user distinguish, group, recognize, read, and/or compose the presence or absence of light, dot, line, shape, color, texture, and such concepts as direction, scale or proportion, dimension, and motion. The goal of a visual literacy program, then, is to develop in learners the ability to understand and express themselves using the visual symbolic mode of their culture.

Within computer culture, practical concerns relating to global communications using visual signs include teaching about visual language, logic, learning, and communication as well as the relationship between visual and verbal information. The most widely implemented visual technology in today's society is computer graphics which simultaneously presents alphanumerics and pictographic information.

Computer graphics technology uses a visual interface for human-machine communications.

Computer Graphics

> Pictorial communication is a medium that is both natural and efficient to human beings and yet is sufficiently precise for computer manipulation. Interactive graphics can be used to understand complex phenomena, to design technological artifacts, and to amuse -- it is an extremely versatile, aesthetically pleasing and instructive medium. (Foley & Van Dam, 1983, p. xi)

The majority of computerized information is reported for human review in some readable form. Machines specialized for computer imagery have been used to report the results of programmed digital computations since the early 1950s when interactive computer graphics was a research subject. Devices called electronic displays, computer controlled displays, information displays, and evaluated data displays were invented at that time. The SAGE air defense command and control system, which converted radar signals into computer generated pictures, was also operational (Machover, 1979, pp. 21, 23).

The beginning of modern computer graphics technology, however, is most often associated with the work of Ivan

Sutherland who developed an interactive drawing system in 1963 at the Massachusetts Institute of Technology (M.I.T.). Sutherland's Sketchpad program enabled the user to define (draw) points on a television-like, cathode ray tube (CRT) with a light pen (Zandi, 1985, p. 5). As Machover (1979) remarks, "one of the prime hardware issues [in the early 1960s] was how to generate characters and lines on a tube." Sketchpad provided some of the theoretical logic needed in software to display computer generated images (pp. 21 & 23).

Three other significant computer graphics programs were also developed in 1963. Johnson introduced a version of Sketchpad with multiview and perspective options, enabling the operator to make a design change in one view and the software to make corresponding changes in other views (Zandi, 1985, p. 5). Coons developed surface patch techniques with modeling applications, and General Motors Corporation initiated DAC/1 (Design Augmented by Computer) for car and truck design (Machover, 1979, p. 22).

Rapid developments in graphics hardware, software, and programming languages throughout the 1960s attracted major industrial corporations like Rolls Royce, Lockheed, North American Rockwell, Boeing, and McDonnell-Douglas to the idea of computer-aided design and manufacturing techniques. Digital Equipment Corporation developed the DEC 338, considered to be the first, commercially available intelligent graphics terminal. Tektronix introduced a

$4,000 storage-tube display, thereby, essentially opening the computer graphics marketplace to small business. In 1969, the Evans and Sutherland computer company was formed to produce graphics equipment; Los Alamos Scientific Laboratory (LASL) produced computer graphics on color film producing motion pictures; and the graphics turtle was introduced into the Logo computer language (Horn & Poirot, 1985, p. 346; LASL, 1980, p. 6; Machover, 1979, pp. 21-24).

The plummeting cost of computer graphics hardware and software throughout the decade of the 1970s gave the individual consumer access to the technology. By 1979, advances in visual display technologies and solid state memories produced personal microcomputer systems with drawing and design software for less than $1,500. The economics of television technology had made personal computer graphics affordable (Blinn, 1979, p. 150; Machover, 1979, pp. 24-25; Waite, 1979, p. 10).

When considering technology trends in 1979, Negroponte accurately remarked that the value of future computer systems would be measured through the subjective experience of a human interface.

> ...to appreciate the general intention of making sound, visual, and tactile interfaces to serve conjointly as the modes and media of interaction with a computing resource, at once transparent and ubiquitous. Such

> quality is no longer a luxury but a requirement.
> (p. 5)

Toward that end, Negroponte's Architecture Machine Group at M.I.T. developed the concept of spatial data management -- accessing data by going to where it is seen on the display surface rather than referencing it by name. Symbolic retrieval of items from familiar places like bookshelves or table tops is key to the concept. The Group was "experimenting with the creation of an information management system whose distinguishing characteristic is that it exploits the user's sense of spatiality for purposes of organizing and retrieving data" (Negroponte, 1979, pp. 6-9).

The decade of the 1980s represents the development phase during which researchers were working to seriously apply computer graphics to daily needs. As a result, image quality and methods for accessing graphical data have dramatically improved. Graphics workstations for new or highly computer literate users typically involve icon-based menu selections to create and enhance pictographic information. Descriptions of the features available for designing graphics are displayed and visual prompts solicit the user's selections. A "help menu," describing how to use the drawing tools [routines] of a software package, is standard. User selections and drawings are executed using a hand operated pointer or brush. Historically, computer graphics has developed in four basic applications areas: (a) user-computer interfaces, (b) animation, (c) simulation, and (d) modeling. Evolving from early military applications, many of today's innovations in computer graphics are produced by corporations and private individuals alike; they are often displayed in electronic theaters and galleries.

> We think of picture construction as the process of creating (or modifying) a model of an object whose image we are viewing. Common operations in this process are defining points and lines, moving, rotating, or scaling objects. We manipulate the object by indirectly manipulating its physical appearance on the screen. (Foley & Van Dam, 1983, p. 208)

Computer graphic images have been seen in the classroom since computer literacy became an instructional objective for the 1980s throughout the world's educational community (Horn & Poirot, 1985, p. 137). Goldman reports that computer graphics in education was the main theme at several sessions of the 1981 National Educational Computing Conference (NECC). Quoting presenter Bork, "Interactive graphics is continually being used as a visual interpretation in learning. Nobody works in non-graphics environments anymore" (p. 6).

Course goals for primary and secondary computer education, cooperatively produced by several Oregon school districts in 1979, include a section on computer graphics. Core concepts involve knowing: (a) that computers can generate and display drawings, graphics, and charts, (b) which conventional programming steps are involved in creating and transforming a picture into computer output, (c) examples of computer graphics applications, specifically including art, mathematical models, television, movies, and engineering design, (d) hardware and software characteristics and limitations associated with graphics systems, as well as (e) depth cues and techniques used to program three-dimensional graphics (Tri-County Goal Development Project, pp. 109-111).

Wohlwill and Wills (1987) report that elementary school age children using the BASIC language to design computer graphics, were above all else -- imaginative. In their descriptive investigation of the characteristics of children's programmed drawings, they found substantial individual differences among the participants' mental sets and task orientations. Unfortunately, "Explicit evidence as to how cognitive control operates is not available from the data" (pp. 9-11). Data were obtained, however, from the programs for each drawing: (a) the program length, (b) the number of color changes, (c) the number of BASIC drawing commands [HLIN, VLIN, PLOT, etc.], (d) the number of errors, and (e) the number of observed changes. Additional ratings were made by two judges experienced in evaluating children's artwork. The design rating scale evaluated: (a) mastery, (b) complexity, (c) imaginativeness, and (d) aesthetic pleasingness. The results indicate that programming strategies, process versus product orientations, varied greatly as did the programmed drawings (p. 4). The implications of this research lie in the researchers' observation that "Most of the children appeared to derive considerable satisfaction and enjoyment from their work on the computer and were highly motivated to complete the design they had set out to create" (p. 11).

Picture recognition and comprehension, however, are learned phenomena resulting from cultural conventions (Sigel, 1978; Arnheim, 1969; Gregory, 1970; Hudson, 1967; Segall, Campbell & Herskovits, 1966). The principle prerequisite for picture comprehension is the concept of equivalence. Sigel (1978) points out that "The awareness that items can be similar and different at the same time is a cognitive achievement that evolves gradually" (p. 103). Citing Paris and Mahoney, Sigel identifies the one rule common to comprehending pictures and the comprehension of written language as "the knowledge that objects and/or events can be represented by the picture or by a word" (pp. 95-96). A computer graphic represents some referent. The individual in computer culture must learn how a given graphic represents an object or event in such a way that he or she can tell which specific referent is referenced on a visual display.

> Pictorial representation, one of the oldest forms of human expression, can provide an effective alternative. Unlike words and numbers, pictures are a universal language, and perhaps the most natural way for people to communicate. They can convey information directly, by stimulating the brain's unique abilities to distinguish shapes, patterns, colors, and shadings. Converting information to pictures can therefore assist the human use of machine-processed data. (I.B.M., no date, p. 1)

> ...psychologists have recently discovered that the form used to present information is a key to whether the content can be understood. Research into the functions of the two halves of the brain has revealed that information can be absorbed more easily and profoundly if it is presented in both verbal and visual form -- especially if the hands are used to draw or color the images. (Aero & Rheingold, 1983, p. 5)

The computer graphics community in world culture depends upon high quality visual information. Applications of computer graphics technology are unlimited. Popular graphics-essential applications include: desktop animation, business graphics presentations [33mm slides, paper copy handouts, overhead transparencies], and desktop studio graphics for the artist. In the United States, the impact of computer graphics on computer culture is most strongly reflected in everyday business and manufacturing. Meilach (1988) reports that "of the estimated 30 million business presentations made daily, a third will include visuals, and about half of those will be composed on a computer. And those percentages are going up" (p. 203).

> The use of numbers to convey information pervades modern life. This mode of communication is well suited to machines, but is often found wanting by people. Few of us can easily extract and fully comprehend the information content of purely numerical data. The task becomes much more difficult when we try to deal with large masses of numbers, or seek meaningful realtionships among several sets of data. (I.B.M., no date, p. 1)

Citing Oppenheim's research, Meinel (1982) reports that meetings are significantly shorter when people giving presentations use graphic aids. "If you pit an executive armed with overhead transparencies against another who must rely on written backup materials, the one with the visuals typically wins over two-thirds of the audience" (pp. 74-75).

> Bulky lists of nearly incomprehensible data quickly become clear when converted into graphic form. Instead of pouring over dull listings of accounts receivable,

> executives can now, at the touch of a finger, control the hue, saturation, and brightness of pie charts and bar graphics that depict the same numbers. (p. 74)

In summary, computer graphics technology has dramatically changed the visual realm in the recent past. Today one sees that the majority of computerized information reported for human review is in some readable form. Rapid innovations and widespread applications of computer graphics by government and corporate interests have made the technology of electronic imaging cost-efficient for the individual consumer. The icon-based interface of modern computing enables users to create and modify pictographic information. Computer graphics applications have developed in the four basic areas of: user-computer interface, animation, simulation, and modeling -- all of which require a sense of equivalence for comprehension. Graphics technology has had numerous applications in educational computing, which depends heavily upon electronic imaging for the communication of representational information.

The Logo Culture

Logo turtle graphics is an educational computing philosophy that strives to build creative intelligence through self-knowledge, specifically, knowledge about the way one's body moves in space [up, down, left, right, forward, backward, and centered]. Turtle graphics, or geometry as it is also called, is a dialect of the computer language Logo which uses body-syntonic concepts in programming and problem solving. The majority of research about Logo is educational and concentrates upon the relationships between learners and Logo's mathematical logic. Logo turtle graphics, however, is also a prototypical example of the computer graphics experience in today's culture. In this study, turtle graphics functions as a representational model of computer graphics technology through which to analyze the visual literacy skills of graphics end-users, and thereby, to demonstrate the information-bearing qualities of computerized images.

Logo language research, which varies widely in scale and style, goes on in many parts of the world including most Western European countries, several South American nations, the United States, Japan, Canada, Australia, Israel, and Senegal in Africa. In the United Kingdom, for example, numerous Logo evaluations were underway throughout the country by 1985. There were government funded projects, college and university studies, local school authority programs, and individual case studies initiated by teachers (Martin, pp. 14-16, 239-241). Earlier Logo research environments, however, were computer laboratories in major institutions, like Edinburgh University, M.I.T., and Syracuse University, where small groups of children worked with researchers to develop and evaluate programming techniques for the language.

It was assumed during early developments in the Logo culture that users gained not only fundamental knowledge about programming and algorithmic logic, but also "a set of heuristics and a problem solving model useful in other situations" (Statz, 1974, p. 5418A). In a primary study seeking to validate these ideas, Statz reports that data from her research neither confirms nor rejects that children who have had a Logo experience perform significantly better on problem solving tasks than those in a non-Logo control group; that there is a tendency for the data to support the acquisition of conditional problem solving skills through the Logo experience; that children with a long-term Logo experience score significantly higher on a test of recursion in daily communication than non-Logo users; and that the use of recursion in daily communication relates directly to using recursive techniques in Logo. Children with the Logo experience did not, however, demonstrate a higher correlation between their problem solving test scores and Logo learning than with intelligence quotient (IQ) or achievement scores; nor were Logo users more positive toward problem solving than their control group counterparts (p. 5418A).

Martin (1985) reports that Logo was also being researched at Edinburgh University's Artificial Intelligence

Applications Institute in the early 1970s. The goal was to provide objective measures of Logo, anticipating that it would be valuable in standard primary and secondary school mathematics curricula. Learning outcomes were measured and the conclusion that Logo could be useful in learning mathematics concepts reported. It is interesting to note that female subjects improved their math skills more than their male counterparts during the study (pp. 13, 17-18).

Large-scale observations and interpretive evaluations of what has come to be called the first Logo culture of fifty children began in 1977 at Lincoln School in the Brookline, Massachusetts school district. The Brookline Project started in the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology and later moved into the public school classroom. A team of researchers implemented an open-ended approach to Logo learning, incorporating self-directed logic and discovery learning, which admittedly made objective measurement difficult. Observations, however, resulted in several conclusions: the subjects enjoyed Logo and the problem solving success achieved through it; the environment facilitated high levels of interaction among participants and their teacher; and the role of the teacher as participant observer involved the dynamics of individual- and/or group-based child-centered learning styles (Martin, 1985, p. 12; Papert, 1979; Watt, 1979; Weir, Russell, & Valente, 1978).

Shortly after the Logo Group at M.I.T. reported the results of the Brookline Project, a comprehensive experiment began at the private Lamplighter School in Dallas, Texas. Texas Instruments Corporation (T.I.) provided the school with a large number of personal computers and a newly written version of Logo software. Implementation of T.I. Logo was met with success from school teachers who supported such a "progressive" approach to education (Martin, 1985, p. 13).

Attempts to objectively measure Logo and its influence upon the acquisition of thinking skills were undertaken at the Bank Street College of Education in New York during the early 1980s. Primary researchers Pea and Kurland (cited in Martin, 1985) concentrated on problem solving or planning tasks, comparing the progress of Logo users and non-Logo users. Their conclusion that little evidence supported the idea of Logo enhancing general thinking skills attracted hostile attention from Logo supporters. Accusations criticizing the Bank Street researchers and their methods were made. Specifically, it was felt that their subjects had insufficient time to develop general Logo skills and that the uninvolved role of the teacher in their experiment was atypical (pp. 13-14).

As a result of the Bank Street study controversy, much of the Logo research throughout the 1980s focuses upon the relationship between Logo learning and cognition. Studies investigating the effects of Logo instruction contrast greatly and involve many user characteristics. The subjects studied range from kindergarteners to adults. The research effort can be grouped into two broad categories: (a) studies that indicate improvement in certain student abilities, and (b) studies that do not demonstrate improvement in certain student abilities.

Research in the first category indicates that students trained in Logo improve their abilities to solve problems (Evans, 1985, p. 3583A; Fickel, 1986, p. 2066A; Mann, 1986, p. 1702A) and to use the mathematics of geometry (Assaf, 1986, P. 2952A). The Logo learning and programming environment was also found to improve the attitude of students toward learning arithmetic and toward school in general (Assaf, 1986, p. 2952A; Bamberger, 1985, p. 918A; Evans, 1985, p. 3583A). Akdag (1986) points to Logo's positive effect on math readiness and upon understanding the concept of mathematics (p. 77A). Whereas, Fickel credits Logo with improving a learner's computational and cognitive ability (p. 2066A).

The second general category of research includes those studies indicating that no improvement in certain abilities resulted from Logo training. No improvement in math attitudes was reported by Bamberger (1985, p. 918A). The ability to solve problems was unimproved in Le Winter's (1986, p. 1640A) research, and Williamson (1986) asserts that cognitive skills showed no improvement after Logo instruction (p. 1261A).

Several researchers from both categories also looked at the effects of gender on students' abilities, reporting that sex had no effect on a student's Logo ability (Akdag, 1986, p. 77A; Fickel, 1986, p. 2066A; Luckow, 1985, p. 3625A; Mann, 1986, p. 1702A). Le Winter (1986) reports that male students' math attitudes became more positive, whereas female students' math attitudes became more negative as a result of Logo (p. 1640A).

There have been numerous studies about the various methods and materials appropriate for the Logo programming and learning environment. Blaustein (1986), for example, compared the attitude and performance of Logo users to those associated with students learning conventional computer curricula. Overall, performance and attitudes did not increase significantly, but sex differences were evident. Males, who had more average experience with computers than the females, had a more positive attitude and higher performance ratios than did their counterparts (p. 1296A).

Shore (1987), however, reports that the attitudes of students toward "task persistence" in math improved with both a direct and indirect instructional method. The subjects exhibited a strong desire to solve assigned problems and, reportedly, their skills in problem solving and higher order thinking also increased (p. 823A). These findings support Dalton's (1986) research about Logo instruction and improved attitudes, but do not concur with Dalton's conclusion that Logo does not improve a student's ability to solve problems (p. 511A).

Measurements for user's satisfaction, motivation, and learning performance were compared for one group taught Logo with a direct method against another group taught indirectly. Herman (1987) reports that there was no evidence of an increase in motivation or learning performance between the methods, but extrinsic students taught with the direct method showed more enjoyment in the class than extrinsic students taught with an indirect method (p. 4024A). In contrast, Rodefer (1986) found that Logo trained subjects did not exhibit significant, higher level thinking skills being taught with a direct or indirect approach. The results, however, did appear to indicate a shift toward supporting a direct teaching method. The only significant difference among the groups was that younger subjects had lower thinking skills than older subjects (3239A).

Looking at special populations, studies indicate that gifted subjects' ability to problem solve may improve with Logo training (Hlawati, 1986, pp. 402A-403A; Rood, 1984, p. 469A), while Logo training did improve computer competence and met individual needs of gifted subjects with handicaps (Meckley, 1985, P. 3573A). In contrast, Logo does not improve the ability of learning disabled students to solve problems (Horan, 1986, p. 512A; Horner, 1984, p. 1716A). Additionally, Horner (1984) states that Logo does not improve the learning disabled subject's attitude toward math or "locus of control" (p. 1716A).

Brous (1986) and Leonard (1983) present results conflicting with those of Horan (1986) and Horner (1984). The Brous study asks two questions: were learning disabled students capable of gaining the knowledge required to utilize Logo? and how did the observed learning behaviors develop? Brous reports that the subjects did acquire the necessary ability to use Logo, while developing a greater awareness of their own error causing disabilities (p. 2993A). Leonard's (1983) study concluded that learning disabled students improved their learning skills with the use of Logo's "whole task" programming as opposed to sequential programming (p. 1419A). These studies show that the subjects actively exchange information and exhibit socially appropriate interaction as a result of Logo training (Brous, p. 2993A; Leonard, p. 1419A).

Some adult learners were also found to grasp computer concepts, feel competent in a computer setting, and to plan continued computer learning as a result of Logo training (Abramson, 1986, p. 3566A). Whereas, other adults experienced learning difficiulities when faced with programming in Logo without instructor intervention (Murphy, 1985, p. 1977A). No age or gender differences were reported among adults learning BASIC or LOGO and critical thinking skills (Sattler, 1987, p. 1439A).

A difference in teacher attitudes toward computers has been observed among new and experienced instructors learning Logo. Young teachers with less than sixteen years experience, had a more positive attitude toward Logo than teachers with more than sixteen years of experience (Potter, 1985, p. 2390A). Furthermore, experienced teachers showed a greater unwillingness to pass their computer knowledge on to their students (Gilbreath, 1986, p. 1289A). Logo training in a flexible, supportive school environment has, however, made teachers more self-confident. They experienced greater confidence in learning mathematics and were able to comfortably introduce Logo materials into their curricula (Ferres, 1984, p. 3264A; Mitchell, 1984, p. 777A).

Competency studies have centered around observing the problem solving abilities of students. Looking at the ability and thinking processes of five year old subjects using Logo, Hines (1985) reports that two subjects were able to write programs independently, two were able to write procedures, but experienced difficulty in correcting errors, and one subject could not be classified as a programmer (p. 1983A). Reimer (1987) conducted a study to determine whether or not Logo trained kindergarten students were ready for first grade "creativity" and "self-confidence." Various tests for readiness and creativity were administered before and after Logo instruction. This study concludes that Logo use helped to prepare the subjects for first grade. The tests revealed that the subjects made significant gains in readiness and creativity (p. 830A).

Research about subject-oriented Logo instruction has been conducted in several areas and is used to describe the effectiveness of Logo in the classroom. Kline (1986) used student compositions to determine whether or not Logo revision practices enhance the revision practices of third graders. The study reports that students trained in word processing in Logo did increase their revision practices. They also showed an increase in rereading habits and in comfortably changing text. This study concludes that word processing in Logo can aid in improving a child's overall writing ability (p. 2602A).

Billings (1987) found that subjects do improve their mathematics problem solving skills through Logo instruction (p. 2433A), and Olson (1986) reports that students also improve their ability in geometry and spatial visualization with Logo training (p. 819A). Whereas, subjects taught Logo in order to indicate a relationship between developmental math knowledge and the ability to solve math problems did not demonstrate a significant relationship. Logo did not benefit these subjects significantly (Hamada, 1987, p. 2510A).

Sweetland (1987) reports that sixth grade students with previous Logo training demonstrated PASCAL programming techniques superior to college students without Logo experience. The findings suggest that different computer languages facilitate student learning and intellectual exploration. It is also suggested that PASCAL instruction follow Logo training (p. 2442A). Some students, however, have been found to have difficulty programming in Logo due to its structure and command logic (Lee, 1987, p. 3297A). Others are helped, in a supplementary way, to experience geometric shapes physically through the Logo programming experience. Pateman (1986) reports that when posed with geometric problems, subjects used Logo to direct their problem solving (p. 2607A).

Studies have also revealed sex differences in math skills as a result of Logo training. Blackwelder (1987) investigated Logo as an aid to attaining Piaget's "formal reasoning" level of cognitive growth. Results indicate that males scored higher than females on post-Logo tests for formal cognition, and that cognitive levels basic to abstract thinking were exceeded by male participants (p. 4043A). Olson (1986) indicates that the subjects' locus of control varied based upon gender, reporting that females felt success in a non-competitive Logo environment. This, in turn, kept the focus of their attention on geometry and suggests that Logo can alter a student's perception of a specific learning situation (p. 819A).

Various studies test and retest subjects to measure learning and to determine cognitive characteristics associated with Logo training. Logo instruction increased students' analysis and evaluation abilities, quantitative reasoning and spatial visualization skills (Mohamed, 1986, p. 406A; Odom, 1985, p. 2390A), as well as conditional reasoning (Seidman, 1980, pp. 2249B). Young (1983) and Forte (1985) report that although Logo training by itself does not lower impulsiveness in students, such students who were able to design their own Logo programs did move toward a greater degree of reflective thinking (p. 64A; p. 2803A). Young also points out that these subjects developed a pride and self-confidence in developing Logo programs.

Research about Logo training has also revealed that dependent students tend to be product-oriented, concentrating on a specific goal, but not on the procedures for achieving the goal. Whereas, independent students tend to be process-oriented and focus on procedural thinking which only suggests a goal (Rampy, 1984, p. 2971A). The Hopkins (1984) study showed that not only can Logo be used to show students degrees of procedural thinking in solving problems, but that subjects procedural thinking is consistent when solving dissimilar problems (p. 2790A). Van Dyke's (1985) study suggests that a direct correlation exists between Logo training and increased creativity, but points out that additional research is needed (p. 2815A). Taking a quasi-experimental approach to Logo, Hyink (1988) examines the development of formal operational thinking, higher level thinking skills, and creative thinking. Pretest and posttest measurements indicate that although the experimental group of seventh-graders increased their Logo programming ability, none of the analyses indicate a significant difference that could be attributed to Logo in the other areas (p. 2047A).

Recent research efforts continue to evaluate Logo's relationship to problem solving and thinking strategies. Banerji (1988) reports that many previous Logo studies are statistically inconclusive, especially about problem solving abilities associated with Logo. Using the graphics mode of Logo to teach mathematics and problem solving, Banerji looks at how the logical structure of the subject being studied may be self-taught through Logo interactions. The conclusion is that a significant improvement was observed in the application of problem solving strategies and in understanding problem solving through Logo training, but that individual components of the problem solving process, like pattern recognition, remain unclear due to small sample size (p. 33A). Whereas, the Bradley (1988) study looks at the strengths and weaknesses of Logo for American Indian children of low-income families. Analyzing mathematics learned with Logo, Bradley looks at planning, angles, and variables as well as changes in attitude toward computing, mathematics, and school-math competency. The findings show that the students who did gain in Logo competence increased their ability to develop top-down planning and increased appreciation of computing (p. 2266A).

The Glim (1988) study analyzes the effects of Logo on concrete operational students, anticipating that students taught Logo programming would be able to learn abstract science concepts more easily. No evidence was found, however, to support the idea that Logo instruction was better than traditional science instruction for learning abstract concepts about physics (p. 2319A). Also looking at Logo instructional strategies, Loncar (1988) investigates the relationship of semantic and syntactic language development in an unstructured environment and in teacher-directed activies. The findings indicate that for preschoolers to use Logo, they must understand personal left and right, the relativeness of left and right, and the idea of multiple points of view. The study showed that these concepts can be learned through teacher-directed activities, but not from unguided play (p. 2804A).

In summary, research about the Logo culture says that the experience of learning how to program a computer in Logo may result in several beneficial effects. Specifically, within the dynamics of child-centered learning styles, learners as young as preschoolers who understand personal left and right, the relativeness of left and right, and the idea of multiple points of view improve their learning skills in several ways. Researchers report that Logo learners increase their abilities to solve problems, to understand the concept of problem solving, to apply problem solving strategies, and to apply mathematics to problem solving. Improvements in higher order thinking skills, like those of analysis, evaluation, quantitative, and conditional reasoning, are also reported. The ability to develop top-down planning logic is also improved. The relationship between the philosophy of Logo and improvements in the use of geometry and increased understanding of the concepts of mathematics is strongly reflected in the literature. General computer competence is improved through Logo training in numerous studies. One study asserts that word processing in Logo can increase a child's overall writing ability. Spatial visualization skills also improve with Logo training. Recently, an increase in creativity was suggested as a result of learning Logo.

Summary of the Literature

The review of related literature examined for this study included the literature and research about (a) visual perception, (b) visual literacy, (c) computer graphics, and

(d) the language of Logo turtle graphics. Literature about general literacy in Western culture was also reviewed for historical trends toward popular literacy.

The review of literature about visual perception explained that the brain sees figure-ground contrasts through brightness, hue, saturation, contour, and pattern recognition. Spatial descriptors for directions are also associated with visual perception and the sensations within a field of vision. The major features of a visual field are its perimeter, the space within that edge, and the visual events within that space which are frequently called points, lines, and colors.

The review of related literature about visual literacy described basic competencies essential to reading, writing, and/or drawing visual information. The visual language requires its user to distinguish, group, recognize, read, and/or compose the presence or absence of light, dot, line, shape, color, and texture, incorporating such concepts as direction, scale or proportion, dimension, and motion. The goal of a visual literacy program is to develop the ability to understand and to express ideas in the visual symbolic mode.

The reveiw of related literature about computer graphics presented interactive visual technology as a tool for literacy in computer culture. Computer graphics has dramatically changed the visual realm in the recent past.

The icon-based interface of modern computing enables users to create and modify pictographic information. The world's computing community depends heavily upon electronic imaging for the communication of representational information.

The review of related literature about Logo language research described the Logo culture as an international group of individuals who are trained to understand and apply mathematical strategies to problem solving. Logo turtle graphics users must understand personal left and right, the relativeness of left and right, and the concept of multiple points of view to implement its logic.

The review of related literature about literacy in general, interjected throughout the study, presented trends toward universal literacy in world culture.

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CHAPTER III

Methodology

Restatement of the Problem

This research is concerned with visual literacy in computer culture, because computer graphics technology is a worldwide cultural event appearing to be of pedagogical importance. The relative nature of literacy is connected to innovations in communications technology for any given culture. In computer culture, computer graphics technology depends upon visual perception for a system of learning, recognizing, making, and understanding visual data. Pictographic communication and comprehension are primary linguistic considerations. The inability to read, write, and/or draw these image-based electronic messages is becoming a functional disability -- a new type of illiteracy in modern society.

While exploring visual literacy in computer culture, this study addresses the problem of updating traditional visual literacy concepts in terms of Logo turtle graphics. Herein, the graphics dialect of the computer language Logo functions as a representational model of the computer graphics experience. There are two parts to the problem under investigation. The first is to review published literature about visual perception, visual literacy, and computer graphics, specifically Logo turtle graphics, to identify traditional visual literacy competencies possibly relevant to computer culture. The second task is to visually analyze and interpret Logo turtle graphics assignments to determine the presence or absence of real world correspondence in computer culture to the published literature about traditional visual litracy skills. Specifically, two questions are posed: (a) can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? and (b) do the literature and "hands-on" experience with turtle graphics indicate that Debes' (1970) visual literacy competencies are pertinent to graphics-based electronic communications in computer culture?

Assumptions are the researched opinions that: (a) visual perception is fundamental to normal learning, (b) line is a visual tool used to describe ideas, and (c) it is important for people to understand the icon-based idiom of computerized visual information.

Research Question #1

The first of two questions being researched is: what are the conventional published competencies associated with visual literacy? In particular, can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics?

Sources of Information

Published and unpublished literature about visual perception, traditional visual literacy, computer graphics technology, and Logo research were the sources of information to address this question. Literature about literacy in general was also reviewed for historical trends. Specifically, the visual system is described through the literature about perception and its visual elements. Herein, materials focus upon the definition of a visual interface and its relationship to the information-bearing qualities of visual information. Three publications were of particular importance in identifying sources of information about visual perception. Research, Principles and Practices of Visual Communication, produced in 1960 by the Association for Educational Communications and Technology, provided a comprehensive survey of visual communications research. Perceptual Psychology: A Humanistic Approach to the Study of Persons by Combs, Richards, and Richards (1976) presented perceptual theory, informed opinions, and research information. Principles of Neural Science edited by Kandel and Schwartz (1985) explained the biological basis of mentation [perceiving, acting, learning, and remembering]. The resulting perspective is a topological theory of perception which also takes into account the biophysics of sensory coding.

Published literature on visual literacy was the source for the essential elements and competencies of traditional visual literacy. These resources emphasize mainstream thinking about visual literacy in the United States and internationally accepted ideas about media education [né: visual literacy]. Literature supporting visual literacy as a cultural event necessitated by mass presence of visual technologies, specifically computer graphics, was also reviewed.

Published and unpublished literature about computer graphics technology was reviewed for the newest and best developments relative to the time of their invention. These resources provided information about the cultural impact of graphics hardware, software, and images as well as the role of computer graphics in educational computing. Published and unpublished information about the interactive imaging techniques in computer graphics was also reviewed.

Research about Logo was the source of information about the turtle graphics experience. Specifically, the literature provides information on the following questions about Logo: who? what? where? and when? Research about the Logo culture that focused upon educational issues and the turtle graphics experience was also reviewed. Specifically, Papert's (1980) book Mindstorms: Children, Computers, and Powerful Ideas influenced the selection of the majority of readings in this area.

Literature about literacy in general that provided an overview of evolving needs for universal literacy in Western culture was also reviewed. Research about literacy was reviewed if it provided historical perspective and insights into literacy in the United States. As Suhor (1984) points out, "the data describing the current state of literacy are highly ambiguous, although there is general agreement that electronic media threaten print culture" (p. 19). Harste and Mikulecky (1984) contend, however, "that technology and the electronic media are not likely to wipe out print and literacy, but they do seem to have complicated our understanding of what literacy is. For better or for worst, literacy is being transformed" (p. 70). The transcribed script from the ABC News Closeup (1986) "At a Loss for Words: Illiterate in America" was used to establish recent literacy trends in the United States.

The majority of published and unpublished literature reviewed was produced between 1960 and 1988.

Methods of Collecting Information

Information about visual literacy in computer culture was collected over a ten year period, during which mass distribution of graphics-based electronic artifacts dramatically changed the visual realm. The search was for visual skills pertinent to culturally agreed upon interpretations of computer generated, pictographic messages. The logic for collecting data began with the posture papers published in the Proceedings, the First National Conference on Visual Literacy (Williams & Debes, 1970). Specifically, the criteria for visual literacy proposed by Debes in the article "The Loom of Visual Literacy -- An Overview" became the foundation against which to compare subsequent competencies. The visual skills which guided the literature selection for this portion of the research were:

Distinguish light from dark

Recognize differences in brightness

Recognize differences and similarities in shape

Recognize differences and similarities in size

Distinguish hues from greys

Recognize differences and similarities in hue

Recognize differences and similarities in saturation

Perceive distance, height, and depth

Recognize differences and similarities in distance, height and depth

Perceive movement

Recognize differences and similarities in rates of movement

Recognize a whole shape even when partially occluded

"Read" simple body language and make simple body language utterances

Recognize groups of objects commonly seen together

"Read" a spatial arrangement of objects commonly seen together

Group objects related by process commonly seen together

Group objects related by process though not necessarily seen together

"Read" a sequence of objects and/or body language arranged in chronological order and related by process

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in an idealized order to represent elements of a process or a genotype, etc.

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in cogent order

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in "original" yet "significant" order

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged in order so as to communicate an intended idea about a process

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged to communicate intended nonphysical concepts

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged to transmit a fictional narrative

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged to create a desired emotional reaction

Compose an utterance as above

"Read" a sequence of objects and/or body language arranged to express, so that others may understand it, a personal emotion

Compose an utterance as above (pp. 11-13)

The literature identified was synthesized by focusing upon reading, writing, and drawing visual information. The effort was guided by the Randahawa and Coffman (1978) compilation Visual Learning, Thinking, and Communication.

Survey texts about perception were collected to identify general theories of perception, the process of visual perception being central to the idea of visual literacy. During the collection of data, the phenomenal events of visual perception were identified and provided a natural logic upon which to build visual literacy skills, regardless of media. The biophysical events of the visual perceptual process were identified to be figure-ground relationships determined by (a) brightness, (b) hue, (c) saturation, (d) contour, and (e) pattern. The balance of data collected about visual perception supports various dimensions of body-syntonic learning, including the Logo turtle graphics experience of: (a) up, (b) down, (c) left, (d) right, (e) forward, (f) backward, and (g) centered. These spatiotemporal events, which are multimodal and multilingual, also emphasize biological criteria for seeing and understanding visual information.

In examining developments in the computer graphics industry since the 1960s, it became apparent that popular visual experience had changed as a result of the science of imaging. An electronic visual language was in place in computer culture. The questions were: which skills do viewers need to use the technology of computer graphics?; are they different or the same as the visual skills traditionally associated with visual literacy?; how do people make sense out of what they see on a computer display surface?; and what are the information-bearing characteristics of computer graphics? Information addressing such questions about computer graphics was chosen from published literature as well as unpublished vendors' brochures, new product announcements, operational manuals, and software guides. Popular reading material for the computer graphics user was selected to provide information about the quality and cultural impact of current images. Published literature about computer graphics in education was also collected in the form of course goals, educational computing research, and instructional materials.

The computer language of Logo turtle graphics was selected as a model of the computer graphics experience. Literature was reviewed to determine the extent of influence Logo was having upon computer culture. Herein, general publications from the first Logo Memo in 1971 through the popular literature of 1984 were selected. Afterwhich, the focus was upon Logo related research cited in Dissertation Abstracts International from 1973 to the present.

Literature about the relationship between changing technology and the spread of literacy was reviewed to examine the ways in which advancements in imaging science have necessitated that visual-verbal literacy be the synthetic goal of contemporary language training. Language is broadly defined as any system for communicating intended meaning. Holdaway's (1979) text The Foundations of Literacy provided an eclectic instructional logic against which other language training materials were viewed. The Library of Congress compilation Literacy in Historical Perspective

(Resnick, 1983) established popular literacy trends in Western culture.

Analysis of Information

All of the literature reviewed was analyzed to determine (a) the nature of the topic being examined, (b) its basic features, and (c) their relationships. The resulting information was synthesized into a unified concept by focusing upon reading, writing, and drawing visual information. Published literature about perception was analyzed to determine a natural basis of consistency in visual perception research. Literature concerning general visual field phenomena as well as the process of visual perception was analyzed to describe the visual interface in biophysical terms.

A content analysis of the published literature about traditional visual literacy concepts was made in search of competencies and desirable attributes of visually literate individuals. Essential elements and principles were listed and combined when similar. A semantic analysis of visual literacy literature was also made to clarify the meaning of important terms of high generality [assumed to represent competencies].

Information about innovative developments in computer graphics technology was compiled and sorted chronologically. Literature which described graphics in educational computing or visual events with implications for the Logo culture was noted. Unpublished vendors' information was analyzed for descriptions of the information-bearing qualities of visual data.

The published literature about the Logo computer language was analyzed to document the research base and theoretical ideas about the turtle graphics experience. These publications were read and semantically analyzed for key concepts, words or phrases, and skills associated with Logo programming and learning environments. Similar studies, some with different results, were combined.

Literature referring to general literacy in Western culture was chronologically compiled and analyzed for historical trends.

Research Question #2

The second research question investigated was: do the literature and "hands-on" experience with Logo turtle graphics indicate that Debes' (1970) visual literacy competencies are pertinent to graphics-based electronic communications in computer culture? Specifically, which traditional visual literacy competencies are demonstrated through the subjects' Logo related assignments?

<u>Sources of Information</u>

Literature as well as classroom assignments produced by eight and nine year old third-graders learning Logo turtle graphics were the combined sources of information for data collected in response to this question. Published and unpublished information about visual perception, visual literacy, computer graphics technology, and the language of Logo turtle graphics were the literary sources of information. Literature about literacy in general was an additional source of information, and perceptual research directed toward understanding visual organization and its intended meaning was reviewed. Publications which focused upon visual literacy and its development were also reviewed. The visual literacy competencies proposed by Debes (1970, pp. 11-13) which were used to address the first research question were also central to exploring the second. Published and unpublished literature about computer graphics was the source of information pertaining to current imaging techniques, implied competencies, and educational applications of graphics technology. The language of Logo turtle graphics and related published literature were the sources of information about introductory course content, methods, and activities. Published materials explaining trends toward popular literacy in Western culture were another source of information.

The majority of the reviewed published literature was written between 1960 and 1988. The unpublished information is primarily produced and distributed by technology manufacturing companies.

Data related to the "hands-on" experience were gathered from one class of twenty-seven, eight and nine year old public school third-graders at Woodrow Wilson Elementary School in the Denton, Texas, Independent School District. This convenience sample was selected for Logo research at the principal's suggestion because neither the students nor their veteran teacher had yet experienced turtle graphics in the classroom. These subjects participated in approximately four hours of Logo instruction once a week over a nine week period. The schedule for each session is presented in Table 2.

Table 2

Instructional Schedule

8:00 - 9:40	Language Arts Training
9:40 - 10:30	Physical Education then Library Time
10:30 - 11:30	Logo Class Activity
11:30 - 12:00	Lunch
12:00 - 1:15	Logo Class Activity
1:15 - 1:30	Break
1:30 - 3:00	Logo Class Activity

The hardware and software used by the subjects are commonplace in educational computing settings. The hardware consisted of an Apple IIe microcomputer with 64K memory equipped with a color monitor and two disk drive units. The Logo instruction used Apple Logo software produced by the Product Development Group at Logo Computer Systems, Inc. of Quebec, Canada. The text COM-LIT: Computer Literacy for Kids (Horn & Collins, 1984) was used as the instructional guide; Logo - Parts One, Two, and Three were implemented with modifications by the researcher.

During the instructional sessions, the subjects produced written and drawn records of Logo related assignments for visual analysis and interpretation (see Appendices A and B). Specifically, they provided visual indices of their turtle graphics experience in several written and drawn forms. The subjects' writing and drawing tools were pencils, crayons, colored map pencils, felt markers, chalk, and Apple Logo turtle graphics software. The subjects' work was presented for viewing on plain white, lined, or grid papers, on photocopied or mimeographed worksheets, on the chalkboard at the front of the classroom, and/or on the computer display screen.

Only the most obvious demographic data were collected about the subjects to avoid creating the perceptual bias of performance expectations on the part of the researcher/visual analyst. Of the fourteen male and thirteen female subjects, two subjects [one male and one female] were Afro-American, one subject [male] was Hispanic, and the remaining twenty-four subjects [twelve males and twelve females] were Caucasian. All of the participants were generally familiar with an Apple IIe microcomputer keyboard, color monitor, diskettes, and disk drive units. Some of the subjects had run educational software; a few had personal computers at home; and one subject had attended a summer computer camp session. None of the subjects enrolled in the class had previous Logo experience. The subjects' teacher had participated in several Logo in-service programs, but had not taught Logo. Neither of the two parent volunteers assigned to the class was familiar with Logo beyond name recognition and its association with children using computers.

Methods of Collecting Information

Data related to the second question were collected from published and unpublished literature as well as from a visual analysis and interpretation of Logo related assignments produced by the subjects. Although this study does not involve laboratory verification, Kanizsa's (1979) research method described in Organization in Vision: Essays on Gestalt Perception strongly influenced data collecting about visual literacy by focusing upon ordinary visual events: "theory -- observation of everyday experience -- discovery -- laboratory verification -- correction of theory" (Legrenzi & Bozzi, 1979, p. vii). In particular, information describing the development of visual skills and associated competencies, specifically those of Debes (1970), was reviewed from the published literature about visual literacy.

Published and unpublished literature about the information-bearing aspects of computer generated visuals was reviewed if the technology being described was widely implemented in popular computer culture. Logo related materials were reviewed on the basis of introductory instructional content, methods, and activities. The textbook COM-LIT: Computer Literacy for Kids (Horn & Collins, 1984) was chosen as the instructional guide because of its diverse content, methods, and activities. Apple Logo Turtle Graphics software was implemented because it was compatible with available classroom hardware. Literature about conventional literacy competencies which supports Ely's (1984) concept of literacy was reviewed.

> A literate person today is one who is able to understand, interpret and use myriad stimuli that are present in a given environment. Written and spoken language, music, sounds, still and moving pictures, natural objects and actions are some of the stimuli that affect people and hence need to be understood, interpreted and used. Schools often limit teaching to the traditional skills of reading and writing,

> with some time spent in observation. Such a limited approach is not sufficient for students who live in a much more sophisticated world that requires a type of literacy beyond basic primary-school knowledge and skills. Two new facets related to the concept of literacy are visual and computer literacy. (p. 104)

Information regarding "hands-on" turtle graphics was gathered by making assignments and collecting visual solutions composed by the subjects. All of the written and drawn solutions to Logo assignments were compiled weekly into a class notebook which was periodically passed around for all participants to see. These pictographic compositions and letters written to the investigator by the subjects were compiled alphabetically.

Analysis of Data

The publication of research directed toward understanding visual organization and its meaning has been on-going throughout the twentieth century. In Western culture, Gestaltian thoughts about perception have shaped the methods employed to analyze the visual realm, like those employed by Kanizsa (1979) to research the phenomenal regularity of visual organization. Of strongest influence in the analysis of the literature reviewed, however, was the research of Upton, Samson, and Farmer (1978) presented in *Creative Analysis,* which supports the metaphorical relationship between language and ordinary life experiences.

They think that an awareness of this relationship "necessarily provides the expanded vocabulary each person needs to act knowledgeably in the modern world" (p. v). It is through this approach to reading, writing, and drawing visual information that literature relating to the second research question was synthesized.

Publications about visual literacy were analyzed for descriptive lists of competencies applicable to everyday visual experience in computerized society. Published and unpublished literature about widely implemented computer graphics technology was analyzed to identify current imaging techniques and their implied competencies. The language of Logo turtle graphics and related published literature were analyzed for application in the classroom learning environment. Specifically, published Logo turtle graphics course content, methods, and activities were analyzed for introductory level information. Published literature about conventional literacy was analyzed for recent trends in teaching literacy skills.

Logo assignments produced by the subjects were viewed as cultural artifacts composed of visual-verbal events. This position is supported by Harste and Mikulecky (1984) and their social perspective of language.

> In the past ten years, linguistics has shifted from studying language as an object to studying language as an event. [Citing Gollasch (1982)] The position

> holds that language can be understood only in use: that a theory of language must evolve from watching real language users use real language in real language situations. Language is not an object, but an event, with both psychological and sociological components. (pp. 52-53)

The goal was to visually analyze and interpret subject-produced compositions to determine the presence or absence of real world correspondence in computer culture to the published literature about traditional visual literacy skills. The thought that behavior infers the nature of the perceptions which produced the behavior was central to the method of analysis used when viewing the subjects' assignments. Each visual-verbal solution was treated as a product of the perceptual field of the subject, thereby, inferring the nature of the perceptions which produced the behavior.

The system used to classify the information-bearing qualities observed in a subject's composition was designed around the ideas of Fransecky and Debes (1972). They emphasized the connections in visual learning between one's knowledge base, the visual skills used when acting upon that knowledge, and the logical structures employed in visual expression. Herein, when looking at a pictographic composition, its visual information reveals the designer's intended meaning, mode of expression, and logic.

The process of examining the visual literacy skills inherent in the Logo turtle graphics experience began by placing all of the solutions to an assignment on the floor for simultaneous, comparitive viewing. The first level of analysis was to look for similarities and differences in information-bearing visual events among all of the individual solutions. Similar solutions were piled on top of each other with the most communicative visual on top. The most different images were then grouped for more comparative viewing. The three examples selected for further analysis were chosen according to the quality of their image-talk -- image-talk refers to the visual semantics of the intended meaning behind the visual message. Which compositions in the group "said" more? The remaining compositions were returned to the notebook in alphabetical order.

Each of the three samples of an assignment was then examined for information-bearing features and processes by answering the following questions: (a) what are the main things that you see in the composition? (b) what kinds of marks were made on the drawing/writing surface? and, (c) what did the subject do to arrange the visual information that you see? The language of design extracted from the visual literacy literature as well as the language of Logo turtle graphics were used to describe the observations (see Figure captions throughout Appendix B).

The identified visual-verbal events in the subjects' assignments were then sorted into the three interconnected categories of visual learning proposed by Fransecky and Debes (1972, p. 7): (a) conceptual knowledge used by a subject when composing a visual solution, (b) linguistic tools used in writing and drawing solutions, and (c) the logic used in designing solutions. Lists of the observed visual events were generated, counts made for frequency of similarity, and tables arranged indicating semantic hierarchies of diminishing frequency.

Compositions about Logo written by the subjects were read and analyzed for their information-bearing qualities. The content was semantically analyzed for frequency of key concepts, words or phrases, and related competencies. Lists describing the observed information were made, information tallied, and tables arranged indicating frequencies of a semantic unit. No further hierarchies were determined.

All of the information extracted from the subjects' work was then synthesized into a list of words and phrases demonstrating a perceptual relationship between the Logo turtle graphics experience and visual literacy.

Of the approximately five hundred Logo related assignments composed by the subjects, about ten percent of the completed assignments were selected as examples for inclusion in the study.

Summary of Methods

What are traditional visual literacy skills and which visual literacy competencies are pertinent to computer culture? The procedural steps taken in response to these questions included: (a) an exhaustive review of published and unpublished literature about the visual dimensions of perception, visual literacy, computer graphics technology, the computer language Logo, and literacy in general; (b) Logo turtle graphics classroom instruction and subject-produced visual solutions to assignments; and, (c) the subsequent content and/or semantic and/or process analysis of the data. Assumptions are the researched opinions that: (a) visual perception is fundamental to normal learning, (b) line is a visual tool used to describe ideas, and (c) it is important for people to understand the icon-based idiom of computerized visual information.

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CHAPTER IV

Findings

Restatement of the Problem

The world's computing community is dependent upon computer graphics technology for the communication of representational information. The purpose of this research is to update traditional visual literacy concepts to reflect the changes that visual information technologies have brought to the modern visual realm. More specifically, the investigation focuses upon illustrating the visual perceptual-cognitive events of the computer graphics experience through the educational computing language of Logo turtle graphics. The relationships between Logo turtle graphics and visual literacy are demonstrated by addressing two related questions: (a) can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? and (b) do the literature and "hands-on" experience with turtle graphics indicate that Debes' (1970) visual competencies are pertinent to graphics-based electronic communications in computer culture?

Presentation of Findings

The findings of this research support the position that Logo turtle graphics is a self-contained model to teach visual literacy skills pertinent to computer culture. This model is drawn from integrating related published literature and the classroom experience of Logo learners, which is demonstrated through their visual solutions to Logo assignments.

Literature

The findings in the published and unpublished literature reviewed for this study are synthesized from a perspective which considers computer graphics technology a worldwide cultural event with pedagogical implications. Today one sees and reads that the visual realm in computer culture is saturated with image-based electronic communications. Icons are the idiom of the modern human-machine interface. Literature about visual perception, visual literacy, computer graphics, the language of Logo, and general literacy point to the urgent need for visual-verbal literacy in computer culture. Visual-verbal literacy means that a cultural group shares the assigned symbolic meaning of a common body of knowledge composed of alphanumeric and pictographic features. The literature also reveals some of the social ramifications of a shift in media dominance from print media to electronic imaging during the twentieth century. The cultural consequences of global communications using graphics-based electronic images are the possibility of visual messages that are negotiable by all people.

Research Question #1

The first of the two questions explored is: can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? Conventional ideas about visual literacy involve visual perception and the definition of the visual interface. The literature reviewed points to a multidimensional description of the relationship between a viewer and the visual realm which begins with the biology of visual perceptions. The readings indicate that there are specialized nerves to perceive specific visual qualities, like contours and patterns. From the natural view of neural science, the visual interface is a figure-ground relationship determined by the perception of brightness, hue, intensity, contour, and pattern. Whereas, from the perspective of visual communication in general, the visual interface is the shared relationship between the field of vision and its viewers. This communicative relationship, described in terms of figure-ground organization, considers line, shape, space, color, and texture in the visual environment. The perceptual psychologist also explains the visual interface as personally meaningful, visible field phenomena described in terms of figures emerging from the background. The resulting topological theory of visual perception presents sensory coding as patterns of organization equivalent to the external world of visible events, all of which are best explained in terms of figure-ground and field relationships. Descriptions of the visual interface in the general literature about perception include two recurrent ideas: (a) general field and systems theories of logic applied to visual perception, and (b) the concept of visual perception as a process (Combs, Richards & Richards, 1976; Dember & Warm, 1979; Fransecky & Debes, 1972; Haber, 1968; Kandel, 1985; Kandel & Schwartz, 1985; Piëtila, 1975; Taylor, 1960; Uttal, 1973).

The visual arrangement of perceived images conveys ideas about space, its natural and synthetic contents, and their relative relationships. Major features of the field of vision are its perimeter, the space within the perimeter, and the visual events, called elements or sensations, within that space [points, lines, colors, and such]. The visual interface involves a search for meaning in the spatial relationship among figures and their ground in the visual field. The sequence of events in visual perception progresses from the diffusion phase, to the phase of differentiation, and finally to integration.

Integration is essential to visual communication, because it evokes similar responses among many people in the same culture. Visual communication is possible when two or more people share a common visual field. Visual phenomena, however, are culturally time-bound to environmental realities. Visual events are structured when sensations are grouped according to proximity, common movement and destiny, similarity, and closure while also separated through contrast, depth cues, and figure-ground relationship. The resulting visual perceptual-cognitive configuration is an integrated whole. The common visual field being researched is that of the Logo turtle graphics experience (Boehm & Weinburg, 1977; Combs et al, 1976; Debes, 1970; Fabun, 1960; Taylor, 1960).

The role of the visual interface in mentation [perceiving, acting, learning, and remembering] is demonstrated through the expansion of perceptions associated with serious observation. The development of perceptions from visual experience involves sensory integration, space perception, and the perception of form and pattern. The ability to develop visual perceptual skills, however, depends upon other skills: (a) accuracy of perception, (b) rate of perception, (c) directionality, (d) figure-ground relationships, and (e) visual memory (Dember & Warm, 1979; Efron & DuBoff, 1976; Gouras, 1985; Kandel & Schwartz, 1985; McFee, 1961; Platt, 1975; Van Geert, 1983).

Visual literacy is concerned with visual technology, visual knowledge, visual communication, and visual logic as well as with the relationship between the visual symbolic mode and learning. Visual literacy per se is generally defined in terms of visual competencies associated with pictographic events and visual expressions, including body language and gestures. It has been suggested that visual literacy did not become possible until mass visual communication was made easy by visual technologies, like cameras and television. Traditional ideas about visual literacy training evolved from three conceptual points: (a) the sense of vision as a language, (b) educating toward reality, and (c) systems for behavioral organization. An early rationale for promoting visual literacy in the 1960s was that children were increasingly visual in their preferences and learning needs, thereby having different educational requirements than students in the recent past. It was agreed by early supporters of the visual literacy movement that the modern visual world requires verbal literacy and visual sophistication (Debes, 1970; Hebb, 1949; Kepes, 1945; Kelley, 1947; Morsy, 1984; Wileman, 1981; Williams & Debes, 1970).

Contemporary ideas about visual literacy have been increasingly inclusive as visual information technologies [computer graphics hardware, software, and images] dramatically change the visual realm in computer culture. Concern over meeting the intellectual needs of visual media consumers resulted in the international media education movement [né: visual literacy movement]. Although the verbal literacy skills of reading, writing, listening, and speaking oral language continue to be extremely important, the pictographic dimensions of electronic communications necessitate that visual literacy skills also be developed. Culture, education, and visual media are the core of traditional visual literacy (Debes, 1968; Dieuzeide, 1984; Fransecky & Debes, 1972; Gross, 1969; Hall, 1969; La Polt, 1968; McLuhan, 1969; Moles, 1984; Morsy, 1984).

Competencies associated with visual literacy involve the processes of distinguishing, perceiving, grouping, recognizing, reading, and composing visual elements. Regardless of the method for transmitting a visual message, the irreducible elements of visual process are thought to be presence or absence of light, dot, line, shape, color, texture, scale or proportion, dimension, direction, and motion. Whereas, the principles for organizing visual information involve nearness, similarity, intensity, common fate, contrast, and movement or directionality. Techniques used by the visually literate include (a) the angle of vision, (b) the relationship of objects in space, (c) the effects of distortion, (d) the degree of detail, and (e) the depth of field. In essence, visual literacy skills enable an individual to translate from the visual language to the verbal language and vice versa; body language and gestures are also components of the visual language. A structural approach to the visual language enables researchers to draw connections between systems of language and pictorial learning. The governoring principle of visual solutions is intended meaning at personal and cultural levels (Chomsky, 1957; Combs et al, 1976; Debes, 1968, 1970; Dondis, 1973; Feldman, 1973; Fries, 1952; Gibson, 1954, 1959; Harste, Woodward & Burke, 1984; Horn, 1973; Kees & Ruesch, 1956; La Polt, 1968; McLuhan, 1973; Montebello Unified School District, 1973; Paivio, 1978).

Visual solutions in computer culture involve icon-based electronic communications and the technology of computer graphics, which have dramatically changed how and what people see. Visual information technologies have developed rapidly since the early 1950s and now dominate computer culture. Innovations in hardware and software have resulted in computerized images evolving from simple lines and alphanumeric characters to complex multiview compositions in realistic colors with options for motion. Visual information technologies depend upon visual perception for a system of learning, recognizing, making and understanding visual data. Pictorial communication and comprehension are important linguistic considerations in computer graphics. The inability to read, write, or draw these electronic images is becoming a functional disability in computer culture -- a new type of illiteracy. Computer graphics technology has been present in the classroom since the global initiative toward computer literacy for the 1980s. Research has shown that when children design computer graphics, they are above all imaginative (Aero & Rheingold, 1983; Blinn, 1979; Foley & Van Dam, 1983; Goldman, 1981; Horn & Poirot, 1985; I.B.M., no date; LASL, 1980; Machover, 1979; Meinel, 1982; Negroponte, 1979; Sigel, 1978; Tri-County Goal Development Project, 1979; Waite, 1979; Wohlwill & Wills, 1987; Zandi, 1985).

In educational computing, numerous beginning students have learned the image-based language of Logo turtle graphics. Turtle graphics provides opportunities for the user to experience the communicative function of computer graphics. Logo engages the user in generating numbers, letters, and corresponding images -- the tools of literacy in computer culture. The linguistic conventions of Logo turtle graphics involve visual and verbal lexicons, syntax, and semantics within a body-syntonic system of logic. Logo environments provide opportunities to convey visual-verbal information about natural conditions and their meaning (Foley & Van Dam, 1983; Papert, 1971, 1980, 1984; Weir, Russell & Valente, 1982).

Research about the computer language Logo has been on-going since its inception in the 1960s. The results of these investigations point to various competencies associated with the Logo learning and programming experience; the subjects studied range from preschoolers to adults. The overall research tends to support the idea that Logo learners improve their problem solving skills, although some researchers report that students with learning disabilities do not. The Logo experience promotes the acquisiton of conditional problem solving skills as well as improves computational and cognitive ability. Several studies report, however, that Logo does not enhance general thinking skills even though others report that it does improve the use of recursion in daily communication. Students reportedly acquired top-down planning logic as a result of their Logo experience as well as increased analysis and evaluation abilities, quantitative reasoning, and reflective thinking. Logo does not, however, help concrete operational students to think abstractly better than traditional science instruction (Banerji, 1988; Bradley, 1988; Brous, 1986; Evans, 1985; Fickel, 1986; Forte, 1985; Glim, 1988; Horan, 1986; Horner, 1984; Leonard, 1983; Mann, 1986; Martin, 1985; Mohamed, 1986; Odom, 1985; Statz, 1974; Young, 1983).

Research indicates that Logo instruction is useful in learning mathematics, including geometry and spatial visualization skills. One reason being that turtle graphics helps users experience geometric shapes. It also improves attitudes towards learning mathematics although not necessarily toward problem solving. Learning disabled students, however, did not improve their attitudes toward mathematics as a result of Logo training. And, no significant relationship has yet been drawn between developmental mathematics knowledge and the mathematics of problem solving in Logo. Generally, male subjects improved their computing skills and attitudes toward mathematics as a result of Logo instruction, whereas female subjects improved their math skills and felt success in non-competitive Logo environments. Gender has reportedly had no effect on students' Logo ability. Learner pride and self-confidence about the Logo experience are often reported (Akdag, 1986; Assaf, 1986; Bamberger, 1985; Banerji, 1988; Billings, 1987; Blackwelder, 1987; Evans, 1985; Hamada, 1987; Horner, 1984; Martin, 1985; Olson, 1986; Pateman, 1986; Young, 1983).

Direct and indirect methods of Logo instruction are apparently equally as motivating and do not affect learning performance, although adult learners have experienced difficiulities learning Logo without teacher intervention. Some of this difficulty is reportedly due to problems in programming because of Logo's structure and command logic. Generally adult Logo learners grasp the concepts, feel competent, and continue their Logo training. No age or gender differences were reported among adults learning BASIC or Logo and critical thinking skills. Teachers learning Logo are often willing to introduce it to their students; teachers with over sixteen years of experience, however, are not (Abramson, 1986; Ferres, 1984; Gilbreath, 1986; Lee, 1987; Mitchell, 1984; Murphy, 1985; Potter, 1985; Sattler, 1987).

Preschoolers learning Logo must understand personal left/right, relativeness of left/right, and the concept of multiple points of view. Some individual five year old Logo learners are capable of writing programs, others capable of writing procedures, and some cannot do either. Logo training has reportedly helped prepare kindergarteners for first grade readiness and creativity. Whereas, third grade Logo learners have experienced improved revision and general overall writing ability as a result of word processing in Logo. Dependent students are product oriented and independent students process oriented in their Logo learning. Procedural thinking is also demonstrated through Logo experiences. It has been suggested that there is a correlation between Logo and creativity (Hines, 1985; Hopkins, 1984; Hyink, 1988; Kline, 1986; Loncar, 1988; Rampy, 1984; Reimer, 1987; Van Dyke, 1985).

Literature about general literacy in Western culture points to the urgent need to integrate conventional ideas about verbal literacy and the idea that "literacy is a technology for information transmittal" (Levine, 1986, p. 10). Herein the relative nature of literacy is obviously connected to innovations in communications technologies for any given culture. Looking at computer culture, the conventions for information transmittal are multimodal, requiring a multilinguistic approach to the human-computer interface. Computers in daily life necessitate that the traditional conventions of print culture and the innovative conventions of electronic imaging both be taught (Brown & Simon, 1980; Clanchy, 1983; Cressy, 1983; Ely, 1984; Hewes, 1978; Laqueur, 1983; Lennon, Cook & Jennings, 1986; Leroi-Gourhan, 1967; Papert, 1985; Resnick, 1983; Resnick & Resnick, 1977; Suhor, 1984).

> Whether visual literacy, media literacy, or visual communication is the best label, the concept needs to be considered an essential element of today's curriculum everywhere in the world. As educators consider a broader definition of literacy, it should include the study of symbols, message carriers, nonverbal language, communication channels and effects on human behavior. (Ely, 1984, p. 104)

Today, visual literacy is relatively defined as a cultural understanding of the visual symbolic mode. Traditionally, visual literacy concepts have evolved around visual competencies associated with making sense out of pictographic events and visual expressions. These competencies were felt to involve the processes of distinguishing, perceiving, grouping, recognizing, reading, and composing visual elements. Conventional visual elements associated with visual literacy skills were the presence or absence of light, dot, line, shape, color, texture, scale or proportion, dimension, direction, and motion. The principles of visual organization were nearness, similarity, intensity, common fate, contrast, and movement or directionality. The traditional techniques employed by visually literate individuals included: angle of vision, relationship of objects in space, effects of distortion, degree of detail, and depth of field. The governing principle of visual solutions was felt to be intended meaning at personal and cultural levels.

The Logo turtle graphics experience of reading and writing alphanumerics while drawing corresponding computer graphics provides an opportunity to focus traditional ideas about visual literacy upon electronic imaging. Logo is an educational computing philosophy that strives to build creative intelligence through self-knowledge about the way one's body moves in space and the transportation of that knowledge into programs that cause a turtle-like cursor to move around a display screen. Logo's design logic is to facillitate human-machine communications using the mathematics of dimensions -- measurements of width, length, and thickness in a particular direction, along an axis or a diameter. Logo turtle graphics is a diagrammatic dialect of Logo; it is also a problem solving technique in software. Two symbol systems for human-machine communications are used when Logo turtle graphics software is being run. The first symbolic mode uses alphanumerics to express human ideas to and from the computer. The second symbol system is composed of visual-spatial language used by the designer to create screen displays for others to see. Each of these symbolic languages builds upon the logistics of an oral conversation. The linguistic conventions of turtle graphics involve visual and verbal lexicons [point, line, shape, color, primitives, and resulting procedures including numbers and mathematical symbols]; visual and verbal syntax [geometry and procedural logic with list processing capabilities]; as well as visual and verbal semantics [composition and user-defined meanings within a geometric model]. Logo engages the user in generating numbers, letters, and corresponding images -- the tools of literacy in computer culture. As a result, the image-based language of Logo turtle graphics provides opportunities for the user to experience the communicative function of computer graphics which synthesizes traditional ideas about visual literacy.

Research Question #2

The second research question explored is: do the literature and "hands-on" experience with turtle graphics indicate that Debes' (1970) visual competencies are pertinent to graphics-based electronic communications in computer culture? Debes refers to visual literacy as a group of visual competencies implicit in the attributes and skills of a visually educated person:

- Read visuals with skill
- Write with visuals, expressing oneself effectively
- Know the grammar and syntaxes of visual language and be able to apply them
- Be familiar with the tools of visual literacy and their use
- Appreciate the masterworks of visual literacy, and
- Be able to translate from visual language to verbal language and vice versa. (pp. 13-14)

Specifically, the visually literate individual should be able to (a) distinguish visual events, (b) perceive distance, height, depth, and movement, (c) group, recognize, and "read" visual phenomena, and (d) be able to compose an utterance equivalent to its pictographic form and vice versa (pp. 11-13).

Fransecky and Debes (1972) argue that the basic structure of visual language is a set of relationships between visual thinking, reading, and writing -- the structure of discourse itself. They stress the importance of making connections between the logical structure, knowledge base, and skills associated with visual competence (p. 7). Capabilities in visual organization, however, depend upon an understanding of the principles of spatial relationships: nearness, similarity, intensity, common fate, contrast, and movement or directionality (Combs et al, 1976, pp. 34-35). The elements of the visual process are identified as tone [presence or absence of light], color, dot, line, shape, texture, direction, scale or proportion, dimension, and motion (Dondis, 1973, pp. 15-16). Visually articulate students use angle of vision, object relationships in space, and the effects of distortion, as well as varying degrees of detail and depth of field (Pltt, 1975, p. 16).

The review of related literature about visual perception demonstrates a natural basis for consistency in visual literacy education. The process of visual perception is built upon figure-ground relationships within a field of vision -- "invariants of organization, pattern, or meaning, which can be conveyed from source to destinations even though represented by different symbols and in different kinds of physical energies in the communication process" (Uttal, 1973, p. 207). Gouras (1985) points out that figure-ground relationships are determined through the perception of brightness, hue, saturation, contour, and pattern (pp. 384-394). Perceptions developed from visual experiences involve sensory integration, space perception, and the perception of form and pattern (Van Geert, 1983). Perceptual growth is reflected in the different ways that people handle information. Research shows that the ability to observe and organize visual information can be developed by perceptual training (McFee, 1961, p. 309).

The review of related literature about computer graphics presents the technology as a tool for literacy in computer culture. The linguistic conventions of interactive graphics have evolved from defining points, lines, and alphanumeric characters on early television technology to designing realistically colored, animated solids on personal computers. Today, picture construction involves defining points and lines as well as moving, rotating, and scaling three-dimensional objects. "Interactive graphics can be used to understand complex phenomena, to design technological artifacts, and to amuse -- it is an extremely versatile, aesthetically pleasing and instructive medium" (Foley & Van Dam, 1983, p. xi). The majority of computerized information is reported for human review in some readable form, frequently including computer graphics. The icon-based system of visual language implemented in computer graphics exploits the user's natural sense of spatial organization (Negroponte, 1979).

Computer graphics instruction has been directly and indirectly included in computer education since its beginnings. Graphics course goals designed for the Tri-County Goal Development Project in 1979, were among the first. Core concepts involved knowing: (a) that computers can generate and display drawings, graphics, and charts, (b) which conventional programming steps are involved in creating and transforming a picture into computer output,

(c) examples of computer graphics applications, (d) graphics systems hardware and software characteristics and limitations, and (e) depth cues and techniques used to program three-dimensional graphics (pp. 109-111).

The graphics turtle was introduced into the Logo language in the late 1960s, thereby enabling children to easily generate alphanumerics and corresponding computer graphics. The review of related literature about Logo turtle graphics presents introductory course content, methods, and activities implicit in the research. Logo's problem solving logic is such that students' analysis and evaluation abilities, quantitative and conditional reasoning, as well as spatial visualization skills improved with Logo training (Mohamed, 1986; Odom, 1985; Seidman, 1980). Logo activities through which these skills develop involve fundamental knowledge about programming and algorithmic logic (Statz, 1974). Herein, course content is designed to teach computer concepts, Logo's structure and command logic, and a basic appreciation of computing (Abramson, 1986; Bradley, 1988; Lee, 1987). The resulting computer competence is reflected in a set of heuristics and a problem solving model useful in other situations (Meckley, 1985; Statz). Mathematics, geometry, and higher computational skills are central to Logo training; language arts skills may also be taught in Logo (Akdag, 1986; Assaf, 1986; Banerji, 1988; Billings, 1987; Kline, 1986; Olson, 1986). The instructional approaches taken in teaching Logo vary from open-ended methods, incorporating self-directed logic, to teacher-directed activities. Logo subjects have experienced difficulty learning Logo without teacher intervention; problem solving success stems from child-centered, teacher-directed methods (Herman, 1987; Martin, 1985; Papert, 1979; Roderfer, 1986; Shore, 1987; Watt, 1979). Typical Logo activities involve writing procedures, "whole task" programming as opposed to sequential programming, designing graphic or verbal compositions, and physically experiencing geometric shapes. Before a user can implement Logo turtle graphics, he or she must have an understanding of personal left and right, the relativeness of left and right, and understand the concept of multiple points of view (Hines, 1986; Kline, 1986; Leonard, 1983; Loncar, 1988; Pateman, 1986).

The review of related literature about literacy in general highlights the cultural consequences of a shift in media dominance from print media to electronic imaging during the twentieth century. Practical considerations relating to global communications using visual signs include (a) teaching about visuals, (b) the relationship between visual learning/literacy and verbal learning/literacy, (c) visuals in classroom teaching, and (d) the influence of visual media on human behavior (Hitchens, 1984, pp. 319-321). As Paivio (1978) points out, a dual coding approach to verbal and nonverbal information processing that treats the two systems as interconnected but functionally independent is essential (p. 115). And, Harste, Woodward, and Burke (1984) report that the relationship between learning to draw and reading and writing is increasingly interconnected. In the literacy event, language users shift linguistic perspectives among verbal and nonverbal points of view enabling them to verify their knowing though multisensory modes. Literacy strategies apparently change with the need to express increasing details (p. x).

In sum, the literature reviewed to explore the second research question indicates that Debes' (1970) visual literacy competencies are perceptually universal enough to be generally pertinent to graphics-based electronic communications in computer culture. The literature also tends to support the expansion of traditional visual literacy competencies to include visual events unique to computer graphics, and herein the Logo turtle graphics experience. The literature about visual perception research says that neurological events enable the brain to see figure-ground contrasts in the visual realm through brightness, hue, saturation, contour, and pattern. These sensations or visual elements within a field of vision are called points, lines, colors, and such. Spatial descriptors are also associated with the process of visual perception. Debes proposed that the visually literate individual should be able to (a) distinguish visual events, (b) perceive distance, height, depth, and movement, (c) group, recognize, and "read" visual phenomena, and (d) be able to compose an utterance equivalent to its pictographic form and vice versa (pp. 11-13). Comparatively, these ideas find correspondence throughout the literature and provide a natural basis for consistency in visual literacy training for any culture.

An expansion of these traditional visual literacy competencies to include visual events unique to computer culture is also suggested in the reviewed literature. Herein and paraphrasing Debes (1970), a visually literate person in computerized society would also be able to:

- Read computer generated visuals with skill
- Write with computer graphics, expressing oneself effectively
- Know the grammar and syntaxes of computer generated visual language and be able to apply them
- Be familiar with visual technologies and their use
- Appreciate the masterworks of computer related visual literacy, and
- Be able to translate from visual language to verbal language and vice versa using human and/or computerized symbols. (pp. 13-14)

<u>Hands-on Experience</u>

Efforts to find correspondence between traditional visual literacy competencies and real world visual events in computer culture focus upon the Logo turtle graphics experience. Turtle graphics serves as a representational model of the computer graphics experience in this study. A visual analysis and interpretation of Logo related assignments was made to determine the presence or absence of traditional visual literacy competencies in turtle graphics activities.

Six hundred and sixty-nine information-bearing elements were identified during a visual analysis of fifty Logo related assignments chosen from approximately five hundred examples produced by twenty-seven subjects. Of this total, two hundred and ninety-four elements (44% of the data collected) demonstrate conceptual knowledge used in composing visual solutions to Logo assignments. One hundred and ninety-three elements (29% of the data) were identified as linguistic tools used when reading, writing, and/or drawing visual solutions in or about Logo. The balance of the data, one hundred and eighty-two elements (27%), demonstrates the logic implemented by the subjects while solving Logo problems.

Looking first at the knowledge category presented in Table 3, the main ideas seen in the subjects' compositions were representative of knowledge about two concepts: (a) location and (b) shape (60% of the observed knowledge base applied by the subjects to Logo solutions). The data were identified in response to the question: what are the main things that you see in the composition? Demonstrations of other conceptual knowledge seen constitute less than 10% of the data per element analyzed in this category. Specifically, the category of knowledge demonstrated by the subjects is seen to include the concepts of location (49%), shape (11%), process (9%), encode (7%), proportion (6%), symmetry (6%), color (5%), implied motion (4%), and line (3%) in that order by frequency of observation within the sample. Of these concepts, location, shape, proportion, symmetry, color, implied motion, and line are ideas traditionally associated with visual literacy. The concept of process, which is central to visual perception, is less directly associated with visual competence in the published litrature. Whereas, the concept of encoding information is not specifically addressed in the published literature about traditional visual literacy competencies.

Table 3

<u>Conceptual Knowledge 44% [294 ELEMENTS]</u>

1. <u>location 49%</u> (including key points along a line) [145 elements]
2. <u>shape 11%</u> [33 elements]
3. <u>process 9%</u> [25 elements]
4. <u>encode 7%</u> [19 elements]
5. <u>proportion 6%</u> [18 elements]
6. <u>symmetry 6%</u> [17 elements]
7. <u>color 5%</u> [16 elements]
8. <u>implied motion 4%</u> [11 elements]
9. <u>line 3%</u> (including contour) [10 elements]

The detailed data set collected to illustrate the knowledge base used by the subjects to compose solutions in Logo is presented in Table 4. The material is arranged in diminishing semantic frequency from key concept through its related idea to the next key concept and so on. The number in parentheses indicates the number of times that the element was observed within the sample of fifty assignments. The underlined word or phrase is a key concept; any words or phrases that follow constitute a subset of the same idea.

Table 4

Conceptual Knowledge and Related Ideas

(a) proportion (9): degrees (9)

(b) implied motion (8): forward movement (2), rotation (1)

(c) color (5): contrast (6), coding (4), highlighting (1)

(d) symmetry (5): repetition (4), bilateral (3), pattern (3), asymmetrical (2)

(e) key points along a line (4)

(f) process (3): end (5), procedural logic (4), left to right (3), vertical format (3), word processing (3), checking-off (1), extra information (1), Logo code (1), right to left (1)

(g) shape (3): triangle (7), letter and number codes (6), square (6), related shapes (1), rectangle (4), circle (3), specific letter (3)

(h) line (2): pen down (2), pen up (2), horizon (1)

(i) location (2): forward (27), left (25), right (25), point of origin (22), out of view (14), angle (11), backward (7), turn (7), proximity (1)

(j) contour (1): incomplete outline (1), outline (1)

(k) encode (1): correspondence (8), representational equivalence (7), cause and effect (2), words and their meaning (1)

The ways in which the subjects for this research represented their ideas for others to see are presented in Table 5 and include the conventions of lines, colors, codes, symbols, verbals, shapes, points, numbers, and changes in value. The data were identified in response to the question: what kinds of marks were made on the drawing/writing surface? Within the category of linguistic tools, lines (26%), colors (22%), and codes (14%) amount to 62% of the techniques used to express Logo concepts. The use of symbols (12%), verbals (11%), and shapes (9%) to describe Logo solutions amounts to an additional 32% of the observed tools. Whereas, points (3%), numbers (2%), and changes in value (1%) are represented as infrequent events of 3% or less. Three of the nine communicative techniques which manifested in the subjects' products are not associated with traditional visual literacy: codes, verbals, and numbers. The remaining conventions for visual expression of lines, colors, symbols, shapes, points, and change in value are widely supported in the published literature about visual perception and visual litracy.

Table 5

Linguistic Tools 29% [193 ELEMENTS]

1. lines 26% [51 elements]
2. colors 22% [42 elements]
3. codes 14% [27 elements]
4. symbols 12% [23 elements]
5. verbals 11% [22 elements]
6. shapes 9% [17 elements]
7. points 3% [5 elements]
8. numbers 2% [4 elements]
9. change in value 1% [2 elements]

Table 6 lists the most frequently seen linguistic tools used to represent conceptual knowledge applied by the subjects in designing Logo solutions. The observed qualities of these communicative events are listed as related ideas, like those for lines: colored, outlines, erased, dark over-hatching, overdrawn, motion lines, and scribbles. Keynote words or phrases are underlined and arranged in descending order of frequency. Subsets, if any, follow and are also arranged by diminishing frequency.

Table 6

Linguistic Tools and Related Ideas

(a) lines (17): colored (19), outlines (5), erased (4), dark over-hatching (2), overdrawn (2), motion lines (1), scribbles (1)

(b) verbals (8): descriptions (9), letters (2), geometric letter (1), labels (1), words (1)

(c) points (5)

(d) numbers (4)

(e) symbols (4): arrows with tails (6), check marks (4), X (4), H (2), circle, brackets (1), punctuation (1)

(f) change in value (2)

(g) codes (1): Logo-coded list (20), Logo-coded labels (3), Logo text (3)

(h) colors (1): colored-in shapes (23), key shapes (10), points (8)

(i) shapes (1): key shapes (10), object shapes (3), circle (1), color patterned (1), square to diamond (1)

Looking at the logic category, the problem solving procedures illustrated through the subjects' Logo assignments include a variety of thinking techniques. In answer to the question: what did the subject do to arrange the visual information seen?, 68% of the logistics demonstrated in the subjects' solutions involve coloring (22%), drawing (20%), writing (14%), and erasing (12%). The process of modifying the visual solution was observed in 9% of the data collected for this category. Other elements were seen with 6% or less frequency. Of the strategies identified, only coloring and drawing per se, are associated with traditional visual literacy competencies. Writing, erasing, modifying, describing verbally, expanding a concept, approximating, checking-off, and reading are logistics historically associated with reading and writing alphanumerics. The logic data set is presented in Table 7.

Table 7

Procedural Logic 27% [182 ELEMENTS]

---

1. color 22% [40 elements]
2. draw 20% [37 elements]
3. write 14% [25 elements]
4. erase 12% [22 elements]
5. modify 9% [17 elements]
6. code 6% [11 elements]
7. describe verbally 4% [8 elements]
8. expand a concept 4% [7 elements]
9. approximate 3%, check-off 3%, and read 3%
   [5 elements each]

To color, draw, write, erase, modify, code, describe verbally, expand a concept, and approximate are logistics demonstrated in the subjects' visuals. These action verbs and their related ideas illustrate the problem solving techniques of the subjects and are presented in a full set in Table 8. Words and phrases are listed that describe the problem solving logistics observed in the subjects' Logo solutions. These action verbs are arranged in descending order by frequency. The number in parentheses indicates the number of times subjects employed the technique.

Table 8

Procedural Logic and Related Ideas

(a) draw (21): outline edges (5), redraw (2), brackets (1), circle (1), dash (1), overdraw (1), scratch-out (1), scribble (1), trace (1), underline (1), X (1)

(b) erase (21): correct (1)

(c) write (15): letters (7), code (2), numbers (1)

(d) modify (12): insert information (2), accentuate matrix (1), ignore matrix (1), turn paper (1)

(e) color (9): key shapes (12), corresponding line (6), color code (5), connecting line (4), for contrast (4)

(f) describe verbally (7): geometry (1)

(g) check-off (5)

(h) approximate (1): correspondence (1), layering (1), no correspondence (1), simplify (1)

(i) code (1): enter (5), describe in list (2), label results (2), divide lists (1)

(j) expand a concept (1): embellish (3), change point of view (2), increased variation (1)

(k) read (1): code (3), shape (1)

In summary, it was determined that 21% of all the information-bearing qualities demonstrated through the subjects' Logo products involve the concept of location [not including key points along a line]; 15% of the elements incorporate the concept of color, the act of coloring, and/or the logic of implementing color; and, 8% of the visual data collected relates to lines and their application in Logo [not including contour]. Except for the logic of drawing, which constitutes 6% of the total data collected, all other elements in the collective set appear in diminishing frequencies of less than 5% as illustrated in Table 9. These percentages point to the strength of Logo's visual-spatial language built, as demonstrated by the subjects, upon the concepts of location, color, and line -- powerful ideas in the reviewed literature about visual perception, visual literacy, computer graphics, and Logo.

Table 9

Information-Bearing Visual Events 100% [669 ELEMENTS]

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1. location 21% [141 elements]
2. lines 8% [51 elements]
3. colors (tools) 6% [42 elements]
4. color (logic) 6% [40 elements]
5. draw 6% [37 elements]
6. shape 5% [33 elements]
7. codes 4% [27 elements]
8. process 4% and write 4% [25 elements each]
9. symbols 3% [23 elements]
10. erase 3% and verbals 3% [22 elements each]
11. encode 3% [19 elements]
12. proportion 3% [18 elements]
13. modify 3%, shapes 3%, and symmetry 3% [17 elements]
14. color (knowledge) 2% [16 elements]
15. code 2% and implied motion 2% [11 elements each]
16. describe verbally 1% [8 elements]
17. expand a concept 1% and line 1% [7 elements each]
18. approximate 1%, check-off 1%, points 1%, and read 1% [5 elements each]
19. numbers 1% and key points along a line 1% [4 each]
20. contour 1% [3 elements]
21. change in value 1% [2 elements]

<u>Logo Related Written Statements</u>

An additional source of data was also analyzed in response to the second research question: do the literature and "hands-on" experience with turtle grphics indicate that Debes' (1970) visual competencies are pertinent to graphics-based electronic communications in computer culture? Compositions about Logo written by the subjects were read and semantically analyzed for frequency counts of similar key concepts, words or phrases, and competencies. These statements about what each subject learned demonstrate concepts about Logo significant to the subjects at the time of the writing. Once-used words and/or phrases are not included and the word Logo is not tallied. It is interesting to note that all but six of the elements identified in the subjects' visual solutions find direct correspondence through their written language; these exceptions are knowledge of proportion and line, the linguistic tools of lines, points, and changes in value, and the logic of approximation. One hundred and forty-two words, phrases, and Logo code seen to have the same semantic frequency in the subjects' written statements about what was learned were extracted and are arranged in Table 10 in sets with diminishing frequency from seven to two. The majority of the data translates directly into Logo keyboard events at which time the linguistic equivalence of the words, numbers, code, and images becomes obvious.

Table 10

Written Concepts

(a) computer, repeat, reset (7 each)

(b) pen color (learned; doing), pen down, pen up, return, shift (6 each)

(c) to load (5)

(d) BK, ESC, FD, LT, maze, PD, power (key), PU, RT, +, -, *, / (4 each)

(e) to save, space bar (3 each)

(f) background colors, to correct my math, CTRL C, CTRL G, forward (to go), LOAD, Logo words, to read Logo, word(s), to write Logo, write in Logo (2 each)

Fundamental ideas about the Logo language find linguistic correspondence in the form of words and phrases about Logo turtle graphics used in the subjects' written statements. Herein, English words translate directly into events in Logo. The data in Table 11 are arranged alphabetically and no priorities are established; they describe the linguistic equivalence among alphanumerics, visual images and turtle events experienced by the Logo user.

Table 11

<u>Linguistic Correspondence</u>

(a) back and forward

(b) code itself (primitives and procedures)

(c) color in Logo

(d) colors of: violet, black, white, blue, green, orange

(e) erase

(f) left and right

(g) left circle

(h) lettters

(i) Logo turtle graphics

(j) Logo words

(k) math in Logo

(l) numbers

(m) right circle

Logo transactions, indicative of essential competencies, are also documented through the subjects' choice of words for their written statements. Once again, the subjects' written language translates directly into their Logo experience and demonstrates the multimodal nature of Logo's problem solving logic. Table 12 lists Logo related action verbs noted in the subjects' statements about what was learned during their turtle graphics experience. They are arranged in groups with the same semantic frequency and are in descending order.

Table 12

Logo Transactions

(a) to change, to make (5 each)

(b) to do, to draw, to move, to read, to write (3 each)

(c) to save, to type, to use (2 each)

(d) to color, to correct, to figure out, to go off a screen, to load, to turn (1 each)

Looking at the overall data extracted from the subjects' "hands-on" experience with Logo turtle graphics, two ideas are supported. The first is that traditional visual literacy competencies and associated concepts manifested in the course of the subjects completing their Logo related assignments. The second idea is that the relationship between the visual events of Logo, which finds correspondence in the published literature about visual literacy, is built upon linguistic equivalence among alphanumeric and pictographic elements. The implication is that the Logo turtle graphics experience synthesizes traditional visual literacy competencies, which are pertinent to graphics-based electronic communications in computer culture.

Summary of Findings

The findings of this research illustrate that Logo turtle graphics is a self-contained model to teach visual literacy skills pertinent to computer culture. This model is drawn from synthesizing related published literature and the classroom experience of third-grade Logo learners.

Literature

Published literature about visual perception, visual literacy, computer graphics, Logo turtle graphics, and literacy in general was reviewed to address both of the research questions being examined in this study.

Research Question #1

The first question explored is: can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? When looking at reading, writing, and drawing viual information, the reviewed literature points to a multilinguistic relationship between a viewer and the visual realm best described in terms of figure-ground organization. Literature about visual perception identifies figure-ground relationships according to the information-bearing qualities of: (a) brightness, (b) hue, (c) saturation, (d) contour, and (e) pattern. Visual perception involves a phenomenal visible field, which is defined by its perimeter, interior space, and the visual elements or sensations within that space. Culturally agreed interpretation of a visual event are learned.

Traditional visual literacy concepts involve competencies associated with reading, writing, and drawing visual information about space, its contents, and their organizational meaning. Visual literacy competencies proposed by Debes (1970) involve distinguishing, perceiving, grouping, recognizing, reading, and composing visual elements, like Dondis' (1973) brightness, dot, line, shape, color, texture, scale or proportion, dimension, direction, and motion. The principles for organizing visual information involve nearness, similarity, intensity, common fate, contrast, and movement or directionality.

Computer graphics is a dominant medium in global computer culture. The related literature about computer graphics technology reviewed to address the first research question, indicates that rapid cultural change in the visual realm modified what and how people can visualize ideas. Techniques for implementing the technology involve an icon-based interface built upon the figure-ground relationships seen on display technologies. The visual elements in image-based electronic communications have evolved from simple lines and alphanumerics to complex, multiview compositions in realistic color with options for motion. The cultural impact of computer graphics, which began in research laboratories, was first felt in military settings, the technology then moved into corporate manufacturing environments, professional services, educational research facilities, and small business ventures. The impact of computer graphics today focuses upon the transmittal of image-based electronic information to and from the private individual. Widespread use of a visual interface in computing has changed the literacy event. The inability to read, write, or draw computer generated visual messages has become a functional disability in computer culture.

The research about Logo reviewed to address the question: can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? describes a generation of multiliterate children. These Logo learners are skilled in: (a) problem solving with computers, (b) using different linguistic systems to express the same spatial idea, and (c) translating spatial events from the visual language to the verbal language and vice versa using the logic of geometry. The Logo culture shares a mathematically logical mind set. The Logo user employs computational models for visual ideas and visual-verbal symbols for spatial ideas. The body-syntonic logic of turtle geometry involves the figure-ground experiences of up, down, left, right, forward, backward, and centered.

Research also shows that Logo training promotes the acquisition of various thinking skills, including conditional, quantitative, reflective, and procedural abilities. The development of analysis and evaluation skills, along with the acquisition of top-down planning abilities have been credited to Logo instruction. Logo language experiences have also resulted in improved student capabilities in the areas of mathematics, geometry, computing, writing, and spatial visualization. Some connections between Logo activities and creativity have been suggested in the research. A basic understanding of the concepts of (a) personal left/right, (b) the relativeness of left/right, and (c) the concept of multiple points of view is prerequisite to using Logo.

Literature about literacy trends in Western culture points to the multilingual nature of the literacy event in computer culture. There is general agreement among current literacy researchers that electronic media threaten print culture and the traditional relationship between verbal information and the reader. A contemporary study of the literacy event "should include the study of symbols, message carriers, non-verbal language, communication channels, and effects on human behavior" (Ely, 1984, p. 104).

In sum, the review of related literature applicable to the question: can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? indicates that the relationship between visual literacy and Logo turtle graphics may be synthesized through figure-ground perceptions. The need for modifying conventional ideas about literacy to include computer literacy and visual literacy is a recurrent theme in the literature. The reviewed research also suggests that visual literacy skills do not have a fixed developmental order. Rather, the development of visual literacy skills appears to evolve through an accumulation of multilingual experiences with cultural tools for visual communication.

Research Question #2

The second question examined in this study poses: do the literature and "hands-on" experience with turtle graphics indicate that Debes' (1970) visual literacy competencies are pertenent to graphics-based electronic communications in computer culture? The review of related literature about visual perception, visual literacy, computer graphics, Logo, and literacy in general points to a natural basis of consistency for visual education. Regardless of medium, the biophysics of visual information processing involve certain "invariants of organization, pattern, or meaning, which can be conveyed from sources to destinations even though represented by different symbols and in different kinds of physical energies in the communication process" (Uttal, 1973, p. 207). The biological events of visual experience build upon the perceptions of (a) brightness, (b) hue, (c) saturation, (d) contour, and (e) pattern in the field of vision. The phenomenal relationship between a viewer and visual perception involves three phases of spatiotemporal organization: (a) diffusion, (b) differentiation, and (c) integration. The elements or sensatons within the visual field are called brightness, dot, line, shape, color, texture, scale or proportion, dimension, direction, and motion.

The related literature about visual literacy reviewed to address the question: which Logo related visual literacy competencies are applicable to culturally agreed upon interpretations of computer generated visual information? indicates that Debes' (1970) visual literacy competencies are inherent in the experience of reading, writing, and drawing Logo turtle graphics. Two ideas, central to Debes' logic, are that visually literate individuals can: (a) compose an "utterance" equivalent to a pictographic event as well as (b) translate ideas from verbal language to visual language and vice versa. Literature about the Logo programming and learning environment indicates that the visual and verbal lexicons of the language are equivalent. Logo graphics users read, write, and draw alphanumerics and corresponding geometric images. As with other computer graphics systems, the principle of information transmittal through the user's visual perception is the essence of the human-machine interface in Logo.

Hands-on Experience

The compositions generated by the subjects for visual analysis provide the researcher with converging data describing the visual-verbal events of the "hands-on" Logo turtle graphics experience. Specifically, the data identify the conceptual knowledge, linguistic tools, and logic used by the subjects to solve Logo related problems. The results suggest a system for perceptual organization based upon the ideas of location, line, and color.

Data concerning knowledge about two concepts, location and shape, amount to 60% of the observed knowledge applied by the subjects in solving Logo problems. Other observed concepts constitute less than 10% of the data per element analyzed. Concepts demonstrated in or about turtle graphics by the subjects include knowledge of location (49%), shape (11%), process (9%), code (7%), proportion (6%), symmetry (6%), color (5%), implied motion (4%), and line (3%).

The data also identify the most frequently seen linguistic tools used by the subjects to represent conceptual knowledge in Logo. Within this category, lines, colors, and codes amount to 62% of the tools used to express Logo concepts. The use of symbols, verbals, and shapes to describe Logo solutions amounts to an additional 32% of the observations. Whereas, points, numbers, and changes in value are represented as infrequent events of 3% or less. The ways in which the subjects represented their Logo related knowledge for others to see include the conventions of lines (26%), colors (22%), codes (14%), symbols (12%), verbals (11%), shapes (9%), points (3%), numbers (2%), and changes in value (1%).

The data further identify the problem solving logic observed in the subjects' Logo solutions. 68% of the logistics demonstrated in the subjects' visual products involve coloring, drawing, writing, and erasing. The process of modifying the solution was observed in 9% of the data collected for this category. Other elements of logic were seen with 6% or less frequency. The complete set of demonstrated logistics include: coloring (22%), drawing (20%), writing (14%), erasing (12%), modifying (9%), encoding (6%), describing verbally (4%), expanding a concept (4%), approximating (3%), checking-off (3%), and reading (3%).

Looking at the above data collectively, 21% of the information-bearing visuals demonstrated through the subjects' visual solutions to Logo assignments involve the concept of location; 15% of the visuals incorporate the concept of color, the act of coloring, and/or the logic of implementing color; and, 8% of the visual data collected relates to lines and their application in Logo. Except for the logic of drawing, which constitutes 6% of the total data extracted, all other elements appear in diminishing frequencies of less than 5%.

The findings also identify the frequency with which groups of words, phrases, and Logo code were used by the subjects writing about Logo. These alphanumerics demonstrate concepts significant to the subjects at the end of their Logo instruction. Fundamentals about the Logo language find linguistic correspondence through the subjects' written statements. Additionally, Logo transactions, indicative of essential competencies, are documented through the subjects' choice of action verbs for their written statements.

Discussion of Findings

The findings of this research illustrate that Logo turtle graphics is a self-contained model to teach visual literacy skills pertinent to computer culture. This model is defined by synthesizing the literature related to traditional visual literacy skills and the classroom experience of Logo turtle graphics end-users. To date, no other research appears to have investigated the relationship between the visual language of turtle graphics and visual literacy in computer culture.

Universal interaction with the icon-based interface of computer culture requires clear visual perceptions and logical spatial organization. Visual literacy in today's society involves translating and/or encoding a collectively visual-verbal, perceptual, and cognitive message. Computer graphics technology has made literacy a visually based phenomenon which depends upon electronically generated images for the comprehension of representational information. This being the case, the urgency for teaching visual literacy pertinent to graphics-based electronic communications is obvious.

Visual literacy events within an interactive computer graphics environment involve the process of picture construction, during which a model of an object being viewed on a display screen is created and indirectly manipulated. Techniques for interacting with computer generated visual information commonly mean reading, writing, drawing, and pointing to pictographic and/or alphanumeric data. Points, lines, colors, shading, rotation, scaling, and motion are user-designated visual events. The communicative function of these conveying qualities is representational equivalence through the mathematics of dimensions. Measurements of length, width, and thickness in a particular direction, along a diameter or axis are directly and indirectly used to compose a computer generated image. Picture recognition and comprehension are learned from cultural conventions for conveying visual information.

According to Debes (1970), a visually literate individual should be able to (a) distinguish visual elements, (b) perceive distance, height, depth, and movement, (c) group, recognize, and "read" visual phenomena, and (d) be able to compose an utterance equivalent to its pictographic form and vice versa (pp. 11-14). The correspondence that exists between the reviewed literature and the graphics dialect of turtle graphics is demonstrated by the subjects who manifested traditional visual literacy skills in completing their Logo assignments. Herein, location, shape, proportion, symmetry, color(s), implied motion, line(s), symbols, shapes, points, changes in value, coloring, and drawing, as found in the published literature, are demonstrated in the course of the Logo turtle graphics experience.

A visual analysis and interpretation of the subjects' compositions identified a multilinguistic system for visual communication that was implemented during their Logo training. This visual-verbal literacy set, which essentially maps the visual literacy set proposed by Debes (1970), is composed of: (a) conceptual knowledge about location and process, (b) the linguistic tools of line, English, Logo code, numbers, and the names of special function computer keyboard keys, and (c) the logic of coloring, modifying, coding, reading, and expanding a concept. Body language and body-syntonic logic are also common to Debes' competencies and the Logo turtle graphics experience. Elements not specifically considered by Debes, but represented in the Logo learning literacy set, are English, Logo code, numbers, and the names of special function computer keyboard keys as well as the logic of modifying, coding, and expanding a concept.

Paraphrasing Debes (pp. 11-14), it was apparent from a visual analysis and interpretation of selected Logo related assignments that the subjects for this study could distinguish light from dark and hues from greys; recognize differences in brightness; and recognize differences and similarities in hue and saturation. It was also determined that the subjects could recognize differences and similarities in shape and size as well as recognize a whole shape even when partially occluded. The subjects' compositions illustrated their abilities to perceive distance, height, and depth recognizing differences and similarities in distance, height, and depth. They also demonstrated the capability to perceive movement and to recognize differences and similarities in rates of movement. The subjects' assignments further demonstrated the abilities to recognize groups of objects commonly seen together, to "read" a spatial arrangement of objects commonly seen together, as well as the ability to group objects related by process.

The relationship between body language and objects or events, specifically self knowledge about the way one's body moves in space, is central to the Logo language and pedagogy. The compositions completed by the subjects for this research demonstrated that these Logo students could "read" simple body language and make simple body language utterances as well as "read" and compose a sequence of body-syntonic events. The process of ordering Logo events was perceived to include chronology as well as idealized arrangements. The concept of cogent order is inherent in Logo procedures. "Original" yet "significant" order was demonstrated in the majority of Logo related assignments. Although the communicative function of Logo is to transmit intended ideas about a process, nonphysical concepts, fictional narration, and emotions were also demonstrated by the subjects implementing Logo's word processing capabilities.

Specifically, once again paraphrasing Debes (1970), the visual products prepared by the subjects demonstrated the students capabilities to read Logo related visuals with skill; to write with Logo related visuals, expressing themselves effectively; to know the grammar and syntaxes of Logo's visual language and to be able to apply them; to be familiar with the visual technology of Logo turtle graphics; to appreciate the "masterworks" of Logo relative to their experience; and, most importantly, to be able to translate from visual language to verbal language and vice versa (pp. 13-14).

The findings of this study also demonstrate the multilingual dimensions of the Logo learner in computer culture who uses natural language [English], Logo code [alphanumerics], natural delineation, computer graphics, geometry, and mathematical symbols in an equivalent way. They illustrate how Logo users read, write, draw, and understand a diagrammatic language composed of visual-spatial elements. Their visual products demonstrate ways in which Logo logic can be implemented to create, generate, and regenerate visual models of spatial ideas. Their Logo related compositions also demonstrate the correspondence that exists between the mathematics of dimensions and visualizing ideas. These computational models are mathematically logical and suggest a new cultural event in the world's educational community as children represent spatial ideas using electronically generated images.

Additional findings, related to the second research question, indicate that Debes' (1970) visual literacy competencies correspond to the biology of visual perception and are sufficiently universal to apply to essentially any visual event, including image-based electronic communications. They do not, however, specifically include those visual features unique to computer graphics technology. Recurrent ideas in the reviewed literature are: (a) the interconnected relationship between culture, education, and visual information technologies, (b) the biological logic of figure-ground organization, and (c) the multimodal nature of the visual system of language. The icon-based interface used at this time in computer culture synthesizes these concepts through the visual perceptions of the end-user and the technology of computer graphics.

Throughout this study, computer graphics technology has been treated as a worldwide cultural event with pedagogical implications for literacy training in computer culture.

Much of the reviewed literature supports the idea of visual-verbal literacy necessitated by a twentieth century shift in media dominance from print media to visual technologies. The findings in the published literature about visual perception, however, bring several questions to mind concerning visual education for computer culture:

1. If as Gouras (1985) states, "The only way in which we can see anything is by brightness contrast (effective light energy) and by spectral contrast (wavelength) formed by an object related to its background" (p. 394), should figure-ground knowledge and intentional visual searching of computer display technologies be developed in educational settings?

2. If the biophysics of the visual perceptual process involves figure-ground relationships determined through (a) brightness, (b) hue, (c) saturation, (d) contour, and (e) pattern (Gouras, pp. 356-365), should computer generated visual phenomena be taught and researched in terms of these visual structures?

3. If "visual perception [per se] resides largely in the abstracting capabilities of the neurons of the brain" (Kandel, 1985, p. 302), should the process of abstraction be taught and applied to language learning -- "our highest cognitive function" (Mayeaux & Kandel, 1985, p. 699)?

4. If perceptual growth is reflected in the different ways that people handle information, should the

intelligence-based "ability to handle detail and asymmetrical material (more complex organized detail)" (McFee, 1961, p. 308) be incorporated into general curricula?

5. If we "move objects outside-our-skin into patterns that have a prescribed left-to-right or up-to-down order in space" (Fabun, 1960, p. 19), should pattern recognition based upon spatial descriptors like up, down, left, right, forward, backward, and centered be taught?, and

6. If the ability to organize visual information can be developed by perceptual training (McFee, 1961, p. 309), should the multimodal nature of the icon-based interface be stressed and the linguistic functions of visual structures in computer culture be explained to the learner?

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CHAPTER V

Summary and Conclusions

Restatement of the Problem

The visual literacy movement is traditionally concerned with visual language, logic, learning, and communication -- with understanding visual organization and its intended meaning. The purpose of this research project was to explore visual literacy in computer culture by determining if traditional visual literacy concepts, as found in the published literature, could be synthesized in terms of Logo turtle graphics. If they could, the second question was: do the literature and "hands-on" experience with turtle graphics indicate that Debes' (1970) visual literacy competencies are pertinent to graphics-based electronic communications in computer culture? The focus of this study was to illustrate the visual, perceptual, and cognitive events of a computer graphics experience through the representational model of Logo turtle graphics. Specifically, the research has sought to demonstrate a linguistic relationship between the educational computing language of Logo turtle graphics and visual literacy.

Summary of the Literature

The review of related literature examined for this study included the literature and research about visual perception, visual literacy, computer graphics, and the language of Logo turtle graphics. Literature about general literacy in Western culture was also reviewed for historical trends toward popular literacy.

The review of literature about visual perception demonstrated a natural basis for consistency in visual education by: (a) describing the visual system and its elements in perceptual terms, (b) defining the phenomenal relationship between a viewer and his or her field of vision, and (c) identifying the information-bearing qualities of visual information.

The review of related literature about visual literacy described competencies associated with reading, writing, and drawing visual information and their development by: (a) identifying traditional visual litracy concepts and associated competencies, focusing upon Debes' (1970) "Hierarchy of Visual Literacy Skills," (b) emphasizing mainstream thinking about visual literacy in the United States, (c) identifying international efforts toward visual literacy, and (d) describing visual literacy as a cultural event necessitated by the mass presence of visual technologies, specifically computer graphics.

The reveiw of related literature about computer graphics presented visual technology as a tool for literacy in computer culture by: (a) identifying the newest and best innovations in computer graphics technology relative to the time of their invention [hardware, software, and images], (b) describing the cultural impact of computer graphics in today's society, (c) describing the role of computer graphics in educational computing, and (d) describing interactive computer graphics imaging techniques.

The review of related literature about Logo language research described features of the Logo culture by: (a) explaining the turtle graphics experience, (b) describing educational research issues associated with who? what? where? and when? about Logo, and (c) identifying introductory course content, methods, and activities implicit in the research.

The review of related literature about literacy in general, interjected throughout the study, presented trends toward visual-verbal literacy in computer culture by: (a) describing the evolving needs for universal literacy in Western culture, (b) identifying the current state of literacy in the United States, and (c) describing the impact of information techologies on literacy needs in computer culture.

Summary of Methods

Which conventional ideas about visual literacy are relevant to the Logo experience of reading, writing, and drawing turtle graphics?, and which Logo related visual competencies are applicable to culturally agreed upon interpretations of computer generated visual information? The procedural steps taken in answering these questions included: (a) an exhaustive review of published and unpublished literature about the visual dimensions of perception, visual literacy, computer graphics technology, the computer language Logo, and literacy in general, (b) Logo turtle graphics classroom instruction and the resulting drawn and written assignments, and (c) the subsequent content and/or semantic and/or process analysis of the data. Assumptions affecting a research bias are the researched opinions that: (a) visual perception is fundamental to normal learning, (b) line is a visual tool used to describe ideas, and (c) it is important for people to understand the icon-based idiom of computerized visual information.

Summary of Findings

Literature

Related literature about visual perception, visual literacy, computer graphics, Logo turtle graphics, and literacy in general was reviewed to address both of the research questions examined in this study.

Research Question #1

The first question posed was: can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? The reviewed literature points to a multilinguistic relationship between a viewer and the visual realm best described in terms of figure-ground organization. Literature reviewed about visual perception identified figure-ground relationships according to the information-bearing qualities of: (a) brightness, (b) hue, (c) saturation, (d) contour, and (e) pattern. Visual perception involves a phenomenal visible field, which is defined by its perimeter, interior space, and the visual elements or sensations within that space. Culturally agreed interpretation of a visual event are learned.

Traditional visual literacy concepts involve competencies associated with reading, writing, and drawing visual information about space, its contents, and their organizational meaning. The visual literacy competencies proposed by Debes (1970) include distinguishing, perceiving, grouping, recognizing, reading, and composing visual elements [brightness, dot, line, shape, color, texture, scale or proportion, dimension, direction, and motion]. The principles for organizing visual information involve nearness, similarity, intensity, common fate, contrast, and movement or directionality.

Computer graphics is a dominant medium in global computer culture. The related literature about computer graphics technology reviewed to address the first research question, indicated that rapid cultural change in the visual realm has modified what and how people visualize ideas. Techniques for implementing the technology involve an icon-based interface build upon the figure-ground relationships seen on display technologies. The visual elements in image-based electronic communications have evolved from simple lines and alphanumerics to complex, multiview compositions in realistic color with options for motion. The cultural impact of computer graphics, which began in research laboratories, was first felt in military settings; the technology then moved into corporate manufacturing environments, professional services, educational research facilities, and small business ventures. The impact of computer graphics today focuses upon the transmittal of image-based electronic information to and from the private individual. Widespread use of a visual interface in computing has changed the literacy event. The inability to read, write, or draw computer generated visual messages has become a functional disability in computer culture.

The research about Logo reviewed to address the question: which conventional ideas about visual literacy are possibly relevant to the Logo experience of reading, writing, and drawing turtle graphics? described a generation of multiliterate children. These Logo learners are skilled in: (a) problem solving with computers, (b) using different linguistic systems to express the same spatial idea, and (c) translating spatial events from the visual language to the verbal language and vice versa using the logic of geometry. The Logo culture shares a mathematically logical mind set. The Logo user employs computational models for visual ideas and visual-verbal symbols for spatial ideas. The body-syntonic logic of turtle geometry involves the figure-ground experiences of up, down, left, right, forward, backward, and centered.

Research also showed that Logo training promotes the acquisition of various thinking skills, including conditional, quantitative, reflective, and procedural abilities. The development of analysis and evaluation skills, along with the acquisition of top-down planning abilities have been credited to Logo instruction. Logo language experiences have also resulted in improved student capabilities in the areas of mathematics, geometry, computing, writing, and spatial visualization. Some connections between Logo activities and creativity have been suggested in the research. A basic understanding of the concepts of (a) personal left/right, (b) the relativeness of left/right, and (c) the concept of multiple points of view is prerequisite to using Logo.

Literature about literacy trends in Western culture relative to the first question explored in this study, points to the multilingual nature of the literacy event in computer culture. There is general agreement among current literacy researchers that electronic media threaten print culture and the traditional relationship between verbal information and the reader. A contemporary study of the literacy event "should include the study of symbols, message carriers, non-verbal language, communication channels, and effects on human behavior" (Ely, 1984, p. 104).

In sum, the review of related literature applicable to the question: can traditional visual literacy concepts, as found in the published literature, be synthesized in terms of Logo turtle graphics? indicated that the relationship between visual literacy and Logo turtle graphics may be synthesized through the figure-ground relationships of visual information. Such synthesis is possible through the biological logic of perceptual organization. Herein, traditional visual literacy concepts expand to include the principles and elements of computer graphics [alphanumeric and pictographic]. The need for synthesizing conventional ideas about visual literacy in terms of Logo, however, was not implicit in the literature. Whereas, the need for modifying conventional ideas about literacy to include computer literacy and visual literacy concepts was a recurrent theme in the literature. The reviewed research also suggested that visual literacy skills do not have a fixed developmental order. Rather, the development of visual literacy skills appears to evolve through an accumulation of multilingual experiences with cultural tools for visual communication.

Research Question #2

The second question addressed in this study asks: do the literature and "hands-on" experience with turtle graphics indicate that Debes' (1970) visual competencies are pertenent to graphics-based electronic communications in computer culture? The review of related literature about visual perception, visual literacy, computer graphics, Logo, and literacy in general points to a natural basis of consistency for visual education in computer culture. Regardless of medium, the biophysics of visual information processing involve certain "invariants of organization, pattern, or meaning, which can be conveyed from sources to destinations even though represented by different symbols and in different kinds of physical energies in the communication process" (Uttal, 1973, p. 207). The biological events of visual experience build upon the perceptions of (a) brightness, (b) hue, (c) saturation, (d) contour, and (e) pattern in the field of vision. The phenomenal relationship between a viewer and visual perception involves three phases of spatiotemporal organization: (a) diffusion, (b) differentiation, and (c) integration. The elements or sensatons within the visual field are called brightness, dot, line, shape, color, texture, scale or proportion, dimension, direction, and motion.

The related literature about visual literacy reviewed to address the question: which Logo related visual literacy competencies are applicable to culturally agreed upon interpretations of computer generated visual information? indicates that Debes' (1970) visual literacy competencies are inherent in the experience of reading, writing, and drawing Logo turtle graphics. Two ideas, central to Debes' logic, are that visually literate individuals can: (a) compose an "utterance" equivalent to a pictographic event as well as (b) translate ideas from verbal language to visual language and vice versa. Literature about the Logo programming and learning environment indicates that the visual and verbal lexicons of the language are equivalent. Logo graphics users read, write, and draw alphanumerics and corresponding geometric images. As with other computer graphics systems, the principle of information transmittal through the user's visual perception is the essence of the human-machine interface in Logo.

Hands-on Experience

Literature and hands-on experience with Logo were the combined sources of information collected to determine whether or not Debes' (1970) visual literacy competencies were pertinent to graphics-based electronic communications in computer culture. The compositions generated by the subjects provided the researcher with converging data describing the visual-verbal events of their "hands-on" Logo turtle graphics experience. Specifically, the data identified the conceptual knowledge, linguistic tools, and logic used by the subjects to solve Logo related problems. These findings were obtained in answer to three questions about each sample assignment analyzed: (a) what are the main things that you see in the composition? (b) what kinds of marks were made on the drawing/writing surface? and (c) what did the subject do to arrange the visual information that you see? The resulting data describe a visual perceptual-cognitive relationship between the Logo turtle graphics experience and visual literacy.

Looking at the subjects' assignments, 35% of the demonstrated events in their compositions involved knowledge of location, skills in using lines, and the logic of color. The rest of the identified data (65%) were essentially variations of this basic theme. The exceptions, those elements which could not be sorted into subsets of location, line, or color, were: conceptual knowledge of process and the logistics of modifying, coding, reading, and expanding a concept. The verbal elements of the Logo culture extracted from the subjects' written statements about turtle graphics were: English [the majority of which translates directly into Logo code or events], Logo code [primitives and procedures], numbers, and the names of special function computer keyboard keys. The mind set demonstrated by the subjects is presented in Table 13.

Table 13

<u>The Demonstrated Mind Set</u>

<u>Conceptual Knowledge Base:</u> Location and Process

<u>Linguistic Tools:</u> Line, English, Logo Code, Numbers, and the Names of Special Function Computer Keyboard Keys

<u>Logic:</u> Color, Modify, Code, Read, and Expand a Concept

Data concerning knowledge about two concepts, location and shape, amounted to 60% of the observed knowledge applied by the subjects in solving Logo problems. Other observed concepts constituted less than 10% of the data per element analyzed. Concepts demonstrated in or about turtle graphics by the subjects included knowledge of location (49%), shape (11%), process (9%), code (7%), proportion (6%), symmetry (6%), color (5%), implied motion (4%), and line (3%).

The data also identified the most frequently seen linguistic tools used by the subjects to represent conceptual knowledge in Logo assignments. Within this category, lines, colors, and codes amounted to 62% of the tools used to express Logo concepts. The use of symbols, verbals, and shapes to describe Logo solutions amounted to an additional 32% of the observations. Whereas, points, numbers, and changes in value were represented as infrequent events of 3% or less. The ways in which the subjects represented their Logo related knowledge for others to see included the conventions of lines (26%), colors (22%), codes (14%), symbols (12%), verbals (11%), shapes (9%), points (3%), numbers (2%), and changes in value (1%).

The data further identified the problem solving logic observed in the subjects' Logo solutions. 68% of the logistics demonstrated in the subjects' visual products involved coloring, drawing, writing, and erasing. The process of modifying the solution was observed in 9% of the data collected for this category. Other elements of logic were seen with 6% or less frequency. The complete set of demonstrated logistics included: coloring (22%), drawing (20%), writing (14%), erasing (12%), modifying (9%), encoding (6%), describing verbally (4%), expanding a concept (4%), approximating (3%), checking-off (3%), and reading (3%).

Looking at the above data collectively, 21% of the information-bearing visuals demonstrated through the subjects' visual solutions involved the concept of location; 15% of the visuals incorporated the concept of color, the act of coloring, and/or the logic of implementing color; and, 8% of the visual data collected related to lines and their application in Logo. Except for the logic of drawing, which constituted 6% of the total data extracted, all other elements appeared in diminishing frequencies of less than 5%.

The data also identified the frequency with which groups of words, phrases, and Logo code were used by the subjects writing about Logo. These alphanumerics demonstrated concepts significant to the subjects at the end of their Logo instruction. Fundamentals about the Logo language found linguistic correspondence through the subjects' written statements. Additionally, Logo transactions, indicative of essential competencies, were documented through the subjects' choice of action verbs for their written statements.

Conclusions

Computer graphics technology is a worldwide linguistic event that has changed literacy competencies for computer culture. Literacy skills in today's society involve translating and/or encoding image-based electronic communications. Culturally universal interaction with an icon-based interface is learned, requiring clear visual perceptions and logical spatial organization. The findings of this study describe the visual events common to conventional visual literacy concepts and the Logo turtle graphics experience as well as literacy events unique to Logo. Specifically, the findings indicate that traditional visual literacy concepts may be expanded in the course of the turtle graphics experience to include alphanumerics and Logo code. A synthetic reorganization of the conventional concepts that specifically includes accessing, reading, and generating computer graphics is suggested by the data from the subjects' "hands-on" experience in Logo.

The findings of this research also suggested a visual-verbal literacy set built upon conceptual knowledge about location and an understanding of process. The linguistic tools demonstrated by the subjects at this time in computer culture included: line, English, Logo code, numbers, and the names of special function keyboard keys. The logic demonstrated through the subjects' Logo learning activities included: coloring, modifying, coding, reading, and expanding a concept -- their strategies for reading, writing, drawing, and understanding diagrammatic language composed of visual-spatial elements.

As to the pertinence of Debes' (1970) visual literacy competencies in computer culture, the findings indicate that the Logo users for this study applied traditional visual literacy skills in completing their turtle graphics assignments. Their visual products demonstrate the ways in which their literacy set can be implemented to create, generate, and regenerate visual models of spatial ideas. These computational models are mathematically logical and suggest a new cultural event in the world's educational community as children represent spatial ideas using electronically generated visual images.

Two major conclusions may, therefore, be drawn from this research. First, the findings support the idea that traditional visual literacy concepts, as found in the published literature, may be synthesized in terms of the Logo turtle graphics experience when looking at the perceptual organization of figure-ground relationships. This does not, however, preclude the possibility that any interactive graphics experience synthesizes pertinent visual literacy competencies applicable to the moment. Second, according to the researched relationship between visual literacy and Logo turtle graphics, Debes' (1970) competencies are pertinent to graphics-based electronic communications in computer culture from a linguistic point of view. An expansion of Debes' visual literacy skills to support visual events unique to computer graphics technology is implied. As the subjects have demonstrated, they used a multilingual approach to composing visual information for their Logo related assignments. The information-bearing qualities of this system are visual and verbal with an apparent emphasis placed upon the body-syntonic logic and spatial descriptors of up, down, left, right, forward, backward, and centered. The fundamental relationship of linguistic equivalence between computational models for visual ideas and visual symbols for spatial ideas is also demonstrated through their products.

Recommendations

The findings of this study indicate that there is a natural basis for consistency in visual experience that builds upon the biological logic of figure-ground perceptions. The research also shows that the relationship between a visual literacy event and high technology is extensible as evidenced by the visual-verbal literacy set extracted from the subjects' Logo related assignments. Herein, conventional visual literacy competencies become modified to accomodate the perceptual demands of the visual interface. In light of these findings, the pedagogical implications of computer graphics technology as a worldwide cultural event need to be addressed.

The primary recommendation resulting from this study is a call for interdisciplinary research about visual-verbal literacy in computer culture that explores the multilingual dimensions of today's literacy event. The findings presented herein suggest educational reform appropriate to the intellectual needs of multiliterate children -- children who understand the symbolic equivalence of natural language, mathematics, computer code, natural delineation, and computer generated information.

The findings of this research also suggest six basic questions that need to be addressed in the immediate future:

1. Should figure-ground knowledge and intentional visual searching of computer display technologies be developed in educational settings?

2. Should computer generated visual phenomena be taught and researched in terms of the contrasting visual structures of brightness, hue, saturation, contour, and pattern?

3. Should the process of abstraction be taught and applied to language learning in general?

4. Should the ability to handle increasingly complex organized visual information be incorporated into general curricula?

5. Should pattern recognition based upon spatial

descriptors like up, down, left, right, forward, backward, and centered be taught?, and

6. Should the multimodal nature of the icon-based interface be stressed and the linguistic function of visual structures in computer culture be explained to the learner?

References

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Ely, D. P. (1984). The two worlds of today's learners. In Z. Morsy (Ed.), _Media education_ (pp. 97-110). Paris: United Nations Educational, Scientific and Cultural Organization.

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APPENDIX A

INSTRUCTIONAL METHODS

APPENDIX A

Instructional Methods

The instructional logic implemented during the "hands-on" phase of this study is similar to that found in a design studio setting in which the instructor facilitates the discovery of unique visual solutions while students solve the same set of problems. Classroom activities were developed to document how Logo turtle graphics relates to the traditional domain of visual literacy. Drawing, whether on paper, the chalkboard, or at the computer, was presented "as a form of thinking, understanding and communication rather than just expression" (Hanks, Belliston, & Edwards, 1978, p. 64). The system for collecting data was designed to provide a framework for identifying the visual perceptual-cognitive aspects of Logo turtle graphics. The assignments that follow complement the Logo instructional content in COM-LIT: Computer Literacy for Kids (Horn & Collins, 1984), which was used as the instructional guide.

Assignment 1.1 - A Look at the Future

After an open class discussion about the future and several stories about intelligent machines, each subject was given a preprinted worksheet and told to draw a picture about the future. They were told to choose drawing tools, that they could use words, and that they could put an "X" in the "DIRECTIONS" box of the worksheet, because they had been told what to do. No written instructions given (see Figures 1 and 2).

Assignment 1.2 - Real Turtles

After an open class question and answer session about natural turtles, the subjects were given a blank worksheet and told to draw a picture of a "real" turtle. As drawings were in-progress, turtle shells, bones, dried feet, tails and such were passed around for all to see, feel, and discuss. No written instructions were given (see Figures 3, 4, 5 and 6).

Assignment 1.3 - Class Demonstration

The subjects were shown and told about the Apple Logo graphics turtle using monitor screen displays. No written materials were distributed.

Assignment 2.1 - Angle Dial

Prepared cardboard components (an arrow and backboard with preprinted angle guidelines drawn onto a sectioned circle) and a brad fastener were distributed to the class. The subjects were told to construct and label their dials, using LEFT, RIGHT, FORWARD, BACKWARD, 45, 90, 135, and 180, as demonstrated at the blackboard. Upon completion, the class acted-out the angles while using the dial to visualize them. No written instructions were given.

Assignment 2.2 - Angle Pie

Each subject was given a preprinted worksheet with explicit written directions to color various sections of the angle figure. Crayons were selected and used to color-in the shapes.

Assignment 2.3 - Square and Triangle Plus

Each subject was given a preprinted worksheet on grid paper and told to draw and/or color-in the appropriate line segment of the design as we wrote the Logo code for it and drew a picture of it on the board and saw it on the computer display screen. The subjects were told they could do or draw anything else that they wanted on the worksheet after our drawing was done. No written instructions were given (see Figures 10, 11 and 12).

Assignment 2.4 - Anything Drawing

The subjects were given a piece of grid paper with the center square colored-in green, representing HOME on the computer screen, and told to draw the picture of their choice starting at HOME. No written instructions were given (see Figures 13, 14 and 15).

Assignment 3.1 - Vocabulary Words

Logo and English words, phrases, and symbols were reviewed in class orally and in written form on the board. Logo was presented in capital letters only; English in upper and lower case letters. The vocabulary was: machine, computer, turtle, point, line, corner, angle, shape, square, triangle, design, draw, bracket, graphics, return key, cursor, monitor, diskette, disk drive, keyboard, software, shift key, space bar, BACKWARD (BK), FORWARD (FD), LEFT (LT), RIGHT (RT), HOME, SHOWTURTLE (ST), HIDETURTLE (HT), REPEAT, and CLEARSCREEN (CS).

Assignment 3.2 - Upside Down T

Prepared worksheets on grid paper with words and the outline of an upside down "T" shape were given to the subjects who were told to designate HOME and write the code to make the "T" shape. Solutions were entered and run at the computer by the parent volunteer with each subject as problems were solved to see if they worked. Points of origin and solutions varied widely. No written instrucions were given (see Figures 16 and 17).

Assignment 3.3 - What To Do When

The subjects were given lined notebook paper upon which to make a list of "what to do when" in Logo as procedures were explained at the chalkboard and displayed on the computer screen (see Figures 18, 19 and 20).

Assignment 3.4 - Index Card Triangles

Each subject was given index cards with procedures written on them to generate a triangle and told to draw the triangle described in code onto grid paper. Solutions were entered and run by the student for the class to see as each was completed; they were saved onto disk by the parent volunteer. The class decided if the drawn triangle "looks different" or "looks similar" compared to the coded shape (see Figures 21 and 22).

Assignment 3.5 - Bigfoot

Each subject was given a preprinted worksheet on grid paper with words, one rectangular shape and two triangles for which code was to be written as a class. The shapes and code were presented on the chalkboard, on the computer screen, and on the worksheets. HOME was designated as the point at which the shapes meet. The class named the completed procedure "BIGFOOT" which was saved onto disk for all to run later. No written instructions were given (see Figures 23 and 24).

Assignment 4.1 - Letter to Parents

The subjects were given and read a letter to take home explaining about our Logo project and encouraging parents to be interested in their child's work.

Assignemnt 4.2 - Coding Triangle and Rectangle

The subjects given a preprinted worksheet on grid paper with words, one rectangle, one triangle, and a connecting line then told to write code for the previously drawn shapes. Each subject designated HOME for his or her drawing which was entered by the parent volunteer as each subject watched and then run by the subject for the class to see. No written instructions were given (see Figures 25 and 26).

Assignment 4.3 - Coding Rectangle and Steps

Each subject was given a preprinted worksheet on grid paper with words, one rectangle, and a series of diagonal steps to encode in Logo as the above assignment was completed. Once again, the subject designated HOME, wrote the code, watched it be entered into the computer, and then ran it for the class to see. No written instructions were given (see Figures 27 and 28).

Assignment 4.4 - Code Your Drawing

Each subject was given a piece of grid paper and told to draw something of choice, select HOME for the drawing, and then encode the image. Completed code was entered by the subject and the parent volunteer working together then run and saved by the subject for later debugging. No written instructions were given (see Figures 29 and 30).

Assignment 4.5 - Color Demonstration

The subjects were given a demonstration and explanation of how to use color in Apple Logo turtle graphics at the chalkboard and on the display screen. They were also taught how to change the speed at which a display is made in Logo.

Assignment 5.1 - Circles and Squares

Each subject was given a preprinted worksheet with written directions to draw a design using circles and rectangles and then to write the code for that drawing. Code was entered at the computer, run, and debugged by the subject with the instructors help (see Figures 31, 32 and 33).

Assignment 5.2 - Running Logo

The process of accessing, running, and saving Logo procedures was reviewed for the class at the board and at the computer workstation. No written materials were distributed.

Assignment 5.3 - Keyboard Review

The subjects were given a mimeographed handout of the Apple II microcomputer keyboard and told about important keys and procedures used in Logo. They were told that they could color or otherwise mark on their handout. No written instructions were given (see Figures 34, 35 and 36).

Assignment 5.4 - Slides

The subjects were shown a collection of "state-of-the-art" computer graphics slides and asked to identify the projected images. No written materials were distributed.

Assignment 5.5 - Maze

The subjects were given a demonstration of the maze on disk that was designed by the researcher and told that each was to take turns at the computer making the turtle travel the maze. Each student was given three minutes at the computer to negotiate the 90 degree turns, after which the class was told to see how far that student had gotten in the maze. No written instructions were given.

Assignment 6.1 - Alphabet Shapes

Each student was given a preprinted grid paper with the letters of the alphabet drawn in grid. A demonstration and explanation of how to draw letters in Logo was presented at the board, during which the subjects colored-in the letters being discussed. "HAPPY THANKSGIVING" was encoded at the chalkboard by the entire class. No written instructions were given (see Figures 37, 38 and 39).

Assignment 6.2 - Alphabet Letter

Each subject was given a predrawn letter to encode, enter, run, and save to disk when debugged. The subject was told to designate HOME. No written instructions were given (see Figures 40, 41 and 42).

Assignment 6.3 - Holiday Message

The subjects were told to draw a holiday related picture of their choice on grid paper. No written instructions were given (see Figure 43).

Assignment 6.4 - Repeat

The subjects were given a demonstration of how to use the REPEAT command in Logo using their previously encoded procedures. Procedures were given orally by the subjects to the instructor who entered and ran them for the class to see.

Assignment 7.1 - Math Symbols

The subjects were given a demonstration of how to check and correct their math using Logo procedures. The computer symbols for addition (+), subtraction (-), multiplication (*), and division (/) were compared to "regular" arithematic symbols. Subjects took turns at the computer workstation experimenting with the new symbols. No written instructions were given.

<u>Assignment 7.2 - Word Processing Demonstration</u>

The subjects were given a demonstration and explanation of how to process words in Logo using the PRINT (PR) command. No written material was distributed.

<u>Assignment 7.3 - Short Stories</u>

Each subject was given a preprinted worksheet and instructed to write a short story or poem "in Logo" and then to illustrate it using turtle graphics. No written instructions were given (see Figures 44, 45 and 46).

<u>Assignment 7.4 - Class Mural</u>

The subjects took turns contributing to a class mural of Logo related ideas using crayons. No written instructions were given.

<u>Assignment 8.1 - Edit Stories</u>

Each subject entered and corrected his or her word processing assignment with the help of the parent volunteer. Corrected procedures were saved to disk.

<u>Assignment 8.2 - Letters to the Principal</u>

The subjects were directed to write a letter to the school principal inviting him to attend a final presentation of their Logo work in a program scheduled for the last day of Logo instruction. During the letter writing, numerous questions about spelling in English and in Logo were answered at the chalkboard.

Assignment 8.3 - Run Letter Patterns

The subjects were shown a presentation of all of their procedures for alphabetic letters using various REPEAT strategies of their own design. Decisions were then made by the class about how and what to show the principal during their Logo program.

Assignment 9.1 - Reading Logo

Each subject was given a preprinted worksheet with three programs for designs in Logo code, told to read the procedures and then draw the Logo lines on grid paper. No additional instruction were given (see Figures 47 through 54).

Assignment 9.2 - "What I Learned" Letters

Each subject was given a piece of lined notebook paper and told to write down what he or she had learned about Logo for the researcher. No additional instructions were given (see Figures 55 through 74).

Assignment 9.3 - Program and Presentation

The subjects presented their principal, teacher, and parent volunteers with a classroom program about Logo by showing their graphics, reading their poems, and demonstrating their maze "techniques."

References

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Horn, C. E., & Collins, C. L. (1984). COM-LIT: Computer literacy for kids. Austin: Sterling Swift.

APPENDIX B

SUBJECTS' ASSIGNMENTS

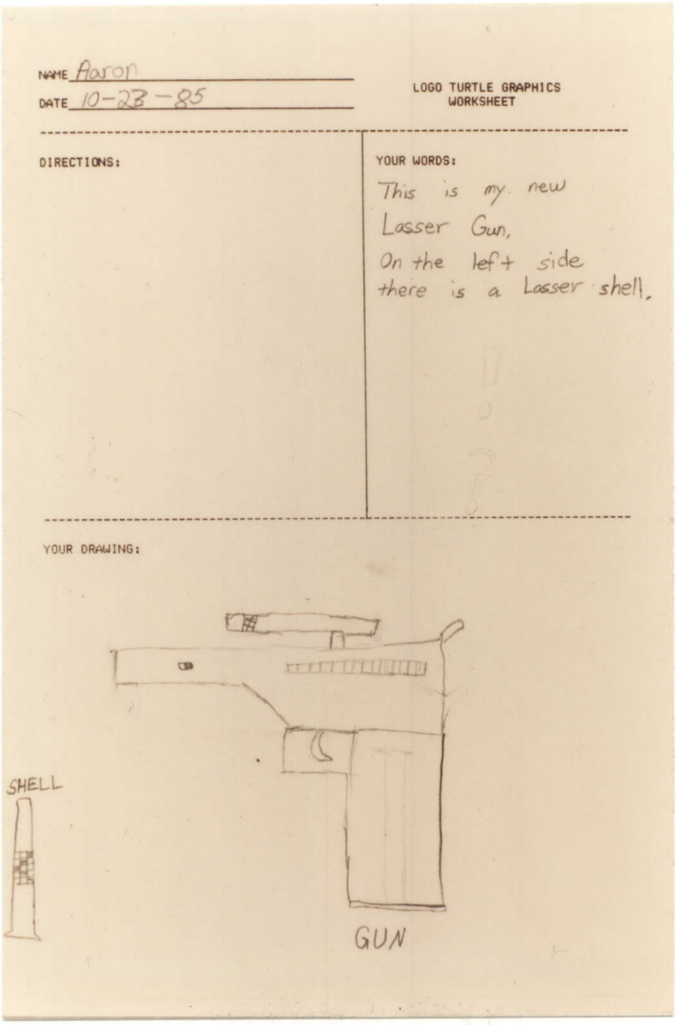
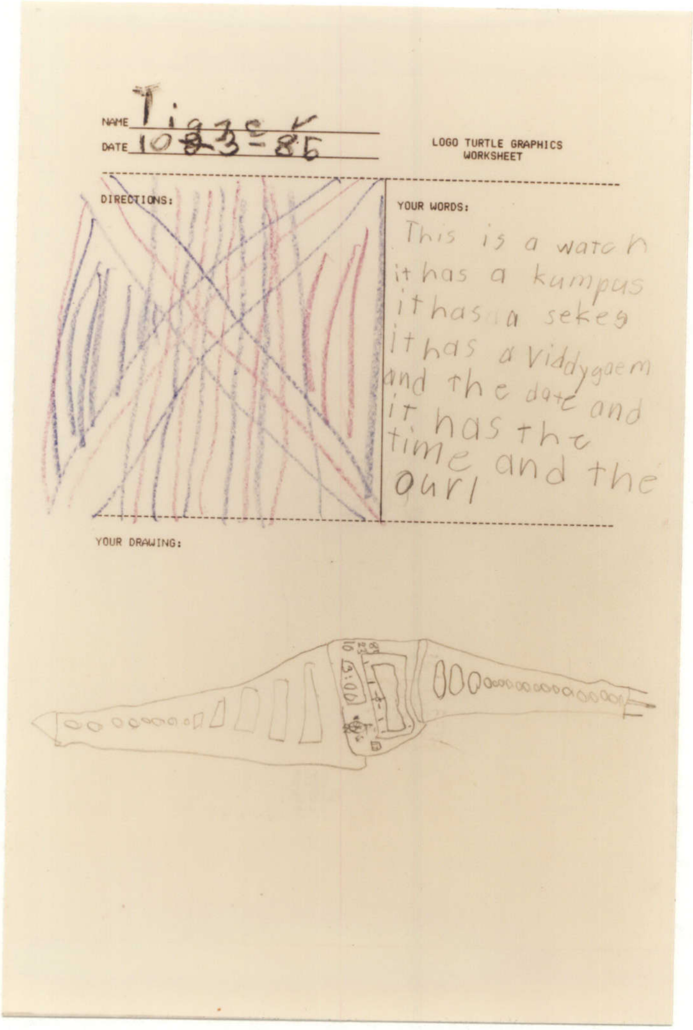
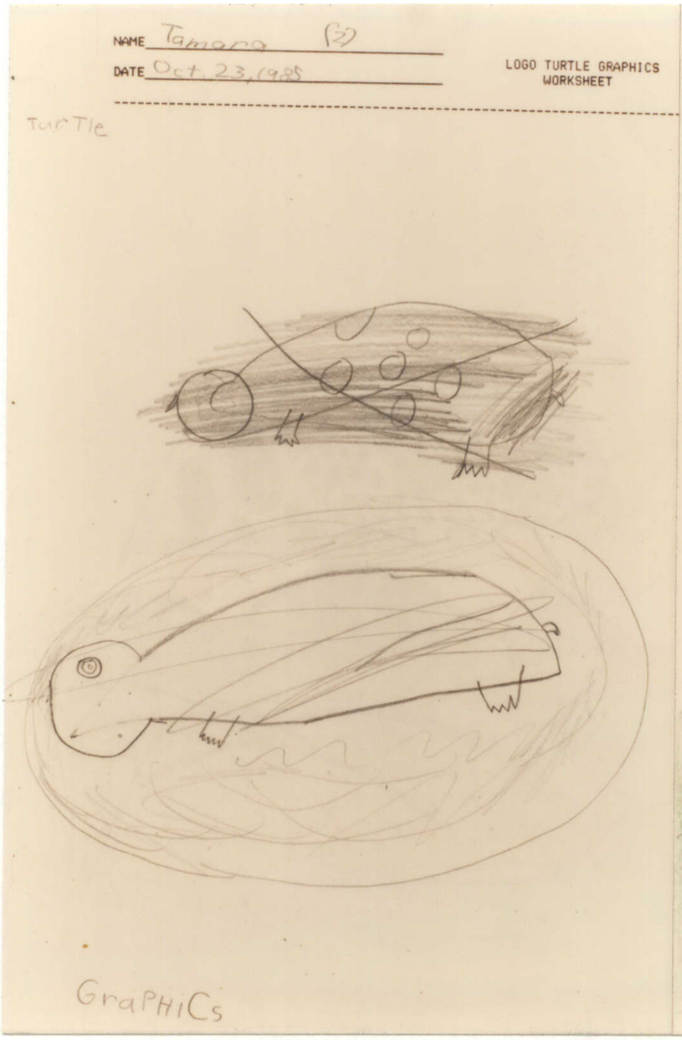


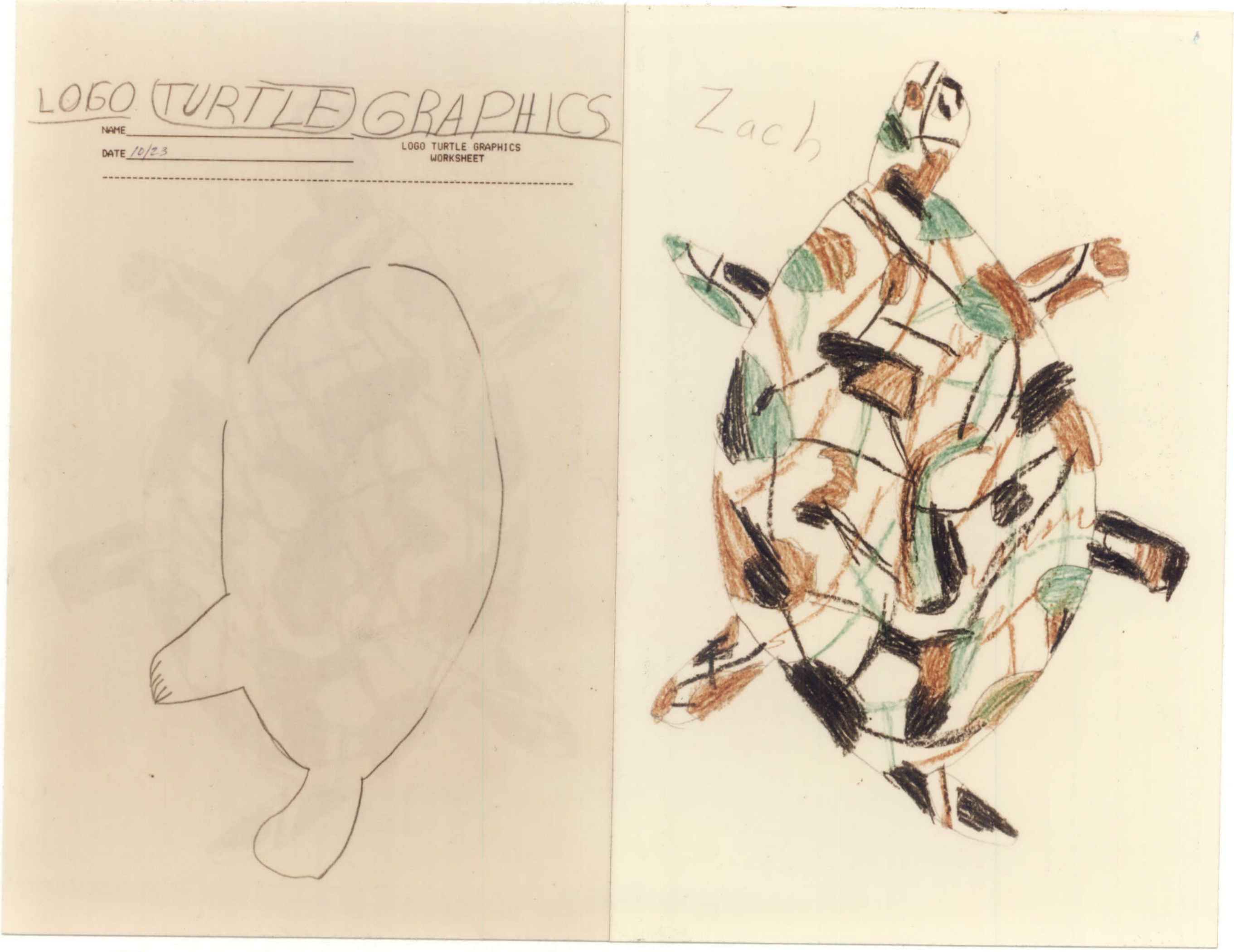
Figure 1. Assignment 1.1A. Knowledge used: concepts of a laser gun and its shell, proportion, and location (with verbal cue); Linguistic tools: lines, verbal labels, verbal description, and colored-in shapes; Logic: draw, erase, modify then color-in shapes for contrast and describe verbally. (46% of original size)



<u>Figure 2.</u> Assignment 1.1B. Knowledge used: concepts of proportion and of a digital watch with compass, seconds, video game, date, time, and the hour; Linguistic tools: lines, numbers, and detailed verbal description; Logic: draw, erase, and modify then describe verbally. (44% of original size)



Figures 3 and 4. Assignment 1.2A. Knowledge used: concepts of proportion and a real (natural) turtle; Linguistic tools: lines (light and dark), lines (crayon over pencil) and colored-in shapes; Logic: draw, negate, redraw, negate, redraw and color with minimal use of erasing (apparent lack of acceptable visual knowledge indicated with scribbles, an X, and dark over-hatching of drawings). (Both 50% of original size)



Figures 5 and 6. Assignment 1.2B. Knowledge used: concepts of contour, proportion, incomplete line, and a real (natural) turtle; Linguistic tools: lines (pencil), lines (pencil with imposed crayon), and colored-in shapes; Logic: draw, erase, redraw and color. (Figure 5 is 41% of original size and Figure 6 is 46% of original size)

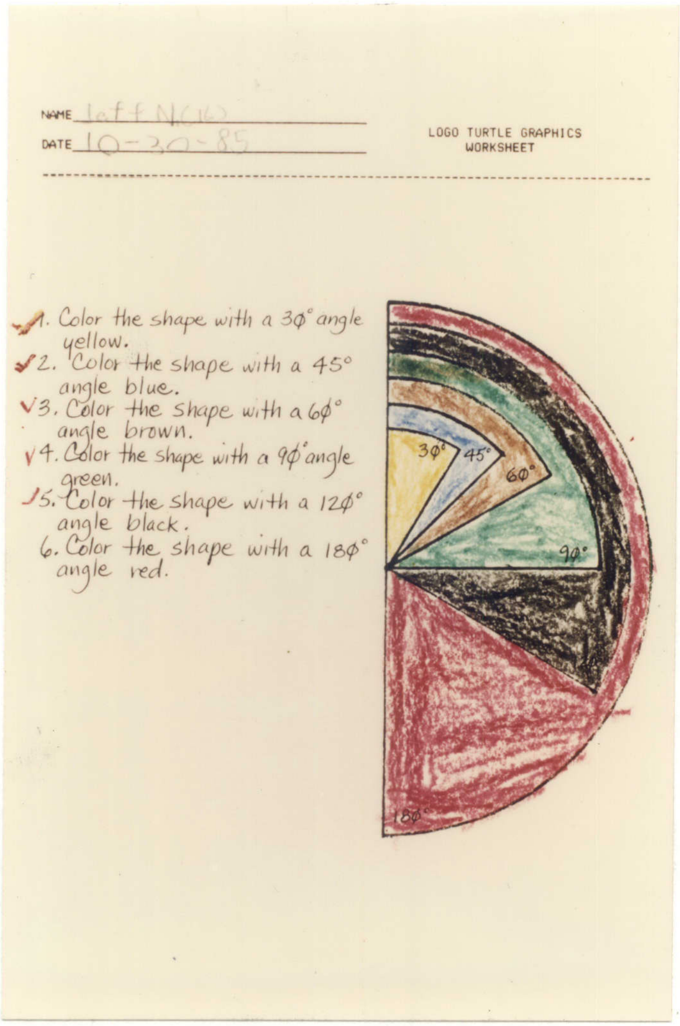


Figure 7. Assignment 2.2A. Knowledge used: concepts of shape, process, and the colors of yellow, blue, brown, green, black, and red; Linguistic tools: colored-in crayon shapes; Logic: color-in then check (✓) repeated until the last step then color-in shape (no check). (48% of original size)

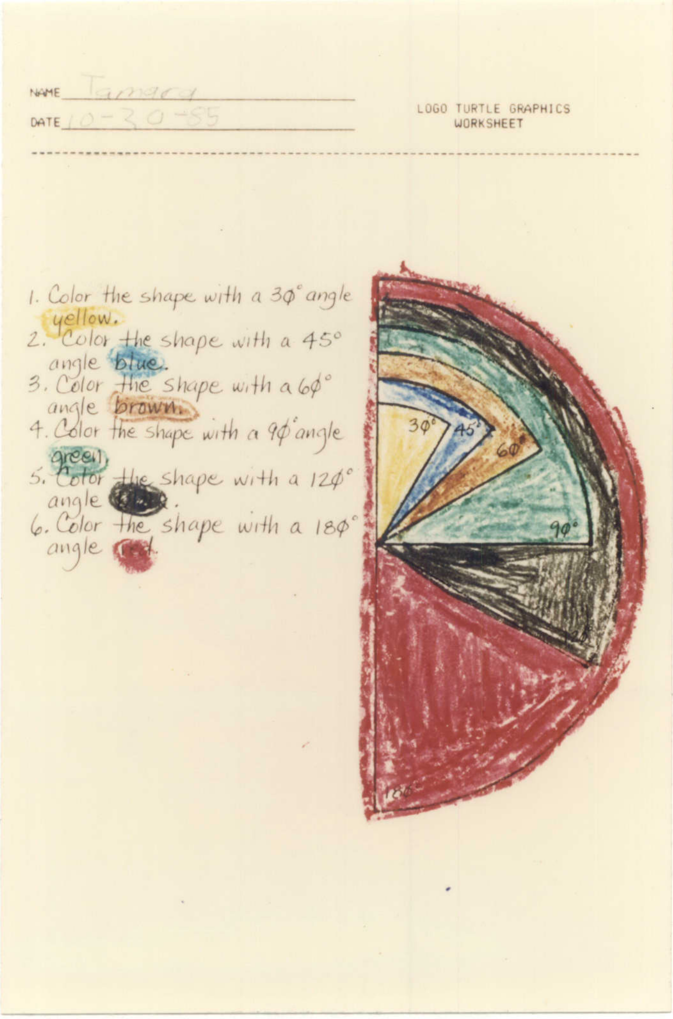


Figure 8. Assignment 2.2B. Knowledge used: concepts of shape, process, and the colors of yellow, blue, brown, green, black, and red; Linguistic tools: colored-in crayon shapes; Logic: color-code the letter-code (words for colors) with an outline then color shape and then color-in all shapes. (48% of original size)

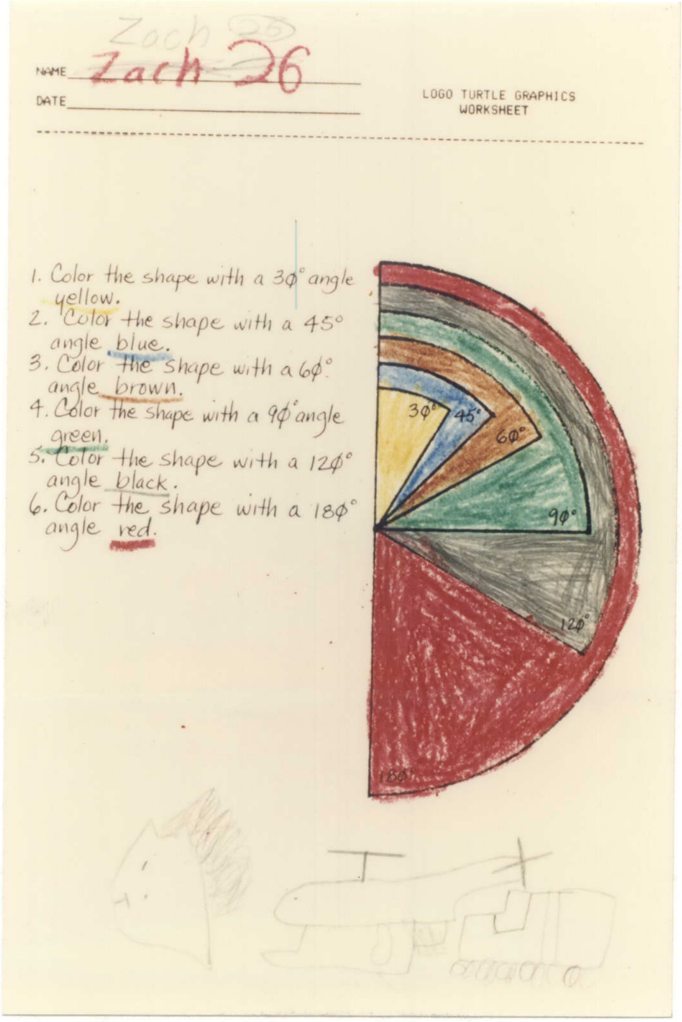


Figure 9. Assignment 2.2C. Knowledge used: concepts of shape, process, and the colors of yellow, blue, brown, green, black, and red; Linguistic tools: crayon and pencil colored-in shapes; Logic: sequentially underline the word with its corresponding colored crayon then color shape, except for black which was pencil and not crayon. (48% of original size)

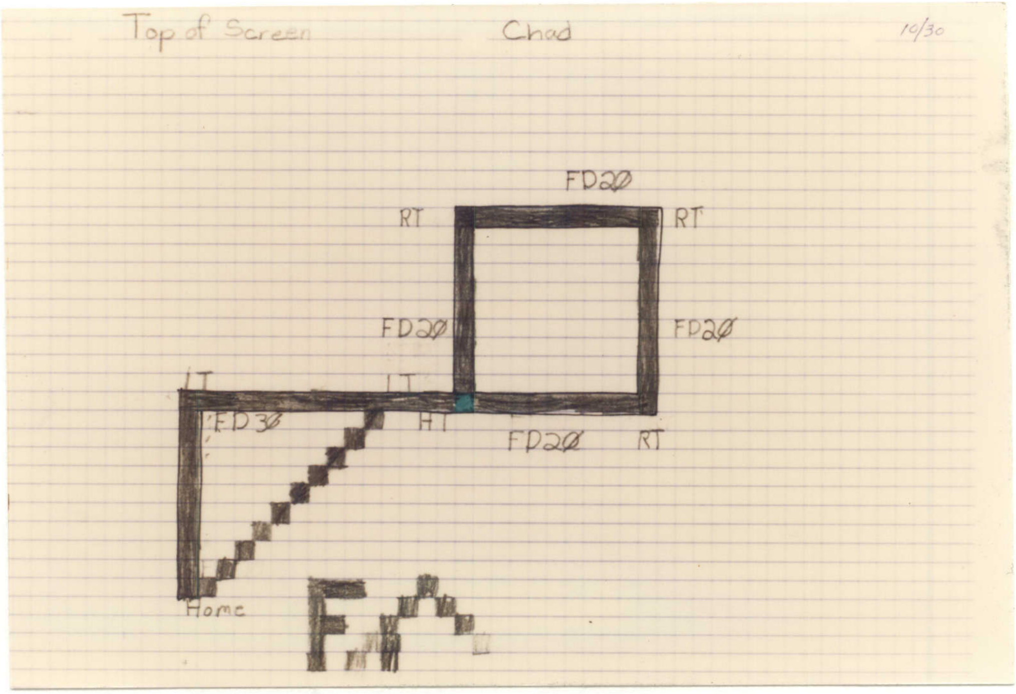


Figure 10. Assignment 2.3A. Knowledge used: concepts of forward, turn (left and right), angle, point of origin, square, and triangle; Linguistic tools: colored-in pencil shapes and lines, Logo-coded labels (some partial), verbal descriptions, and points; Logic: color-in key shapes, color-in connecting line, code-label results. (48% of original size)

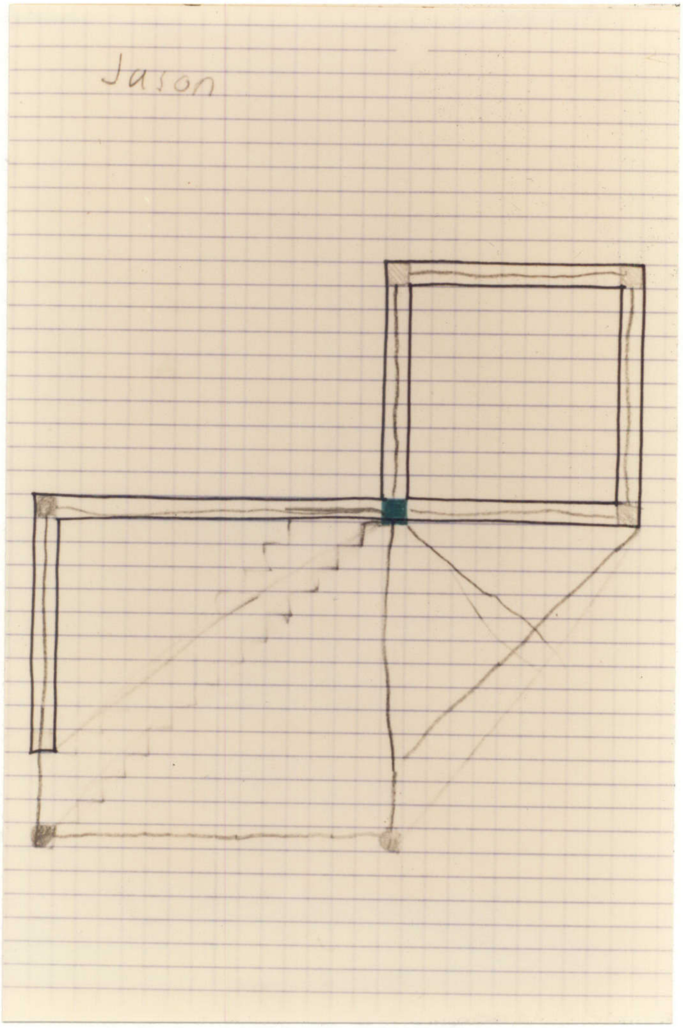


Figure 11. Assignment 2.3B. Knowledge used: concepts of forward, turn (left and right), angle, point of origin, square, and triangle; Linguistic tools: lines and colored-in pencil shapes functioning as points; Logic: draw, erase, modify, and draw (initiated variations of original square shape and incomplete triangle using erase and overdraw). (58% of original size)

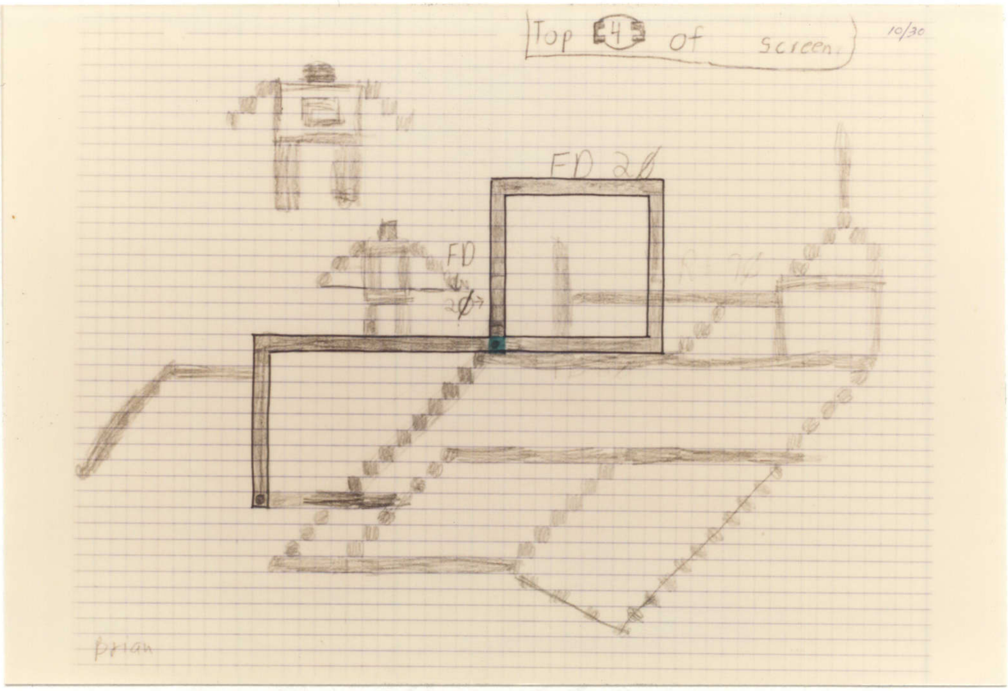


Figure 12. Assignment 2.3C. Knowledge used: concepts of forward, turn (left and right), angle, point of origin, square, and triangle as well as a spaceship, people in space, and implied motion; Linguistic tools: colored-in pencil lines and shapes, lines, Logo-coded labels (partial and erased), and a verbal descriptor; Logic: color-in key shapes, color-in connecting lines, expand creatively using colored-in shapes and lines (initiated full-blown concept of people in space). (41% of original size)

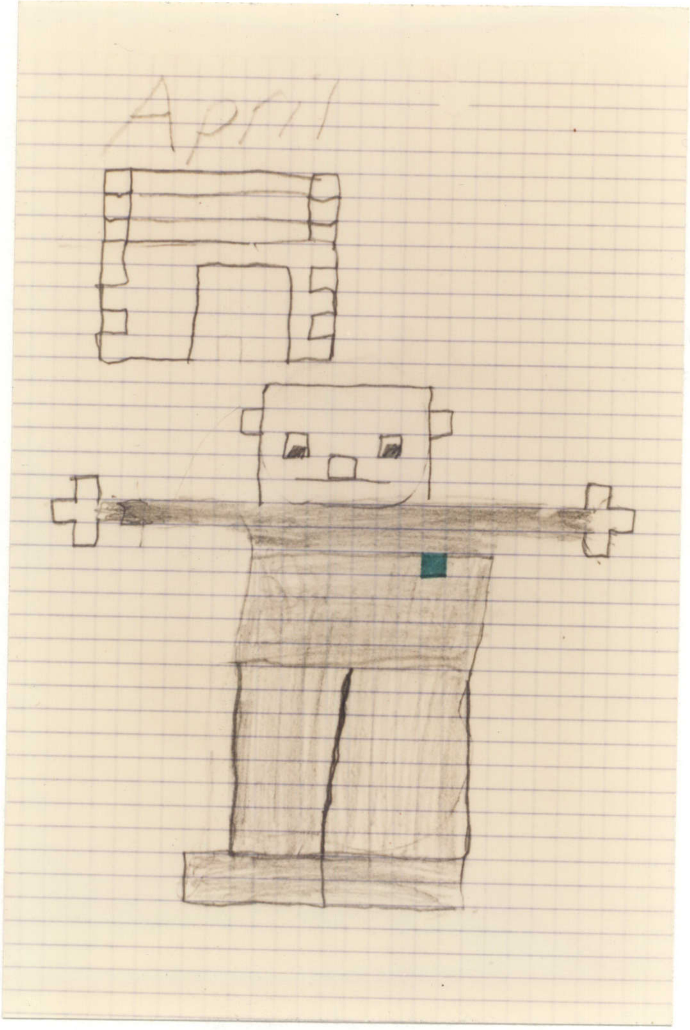


Figure 13. Assignment 2.4A. Knowledge used: concepts of a person, proportion, and bilateral symmetry; Linguistic tools: lines, colored-in shapes of differing value, and outlines; Logic: draw more natural schematic, erase, redraw in matrix then outline edges and color-in shapes. (58% of original size)

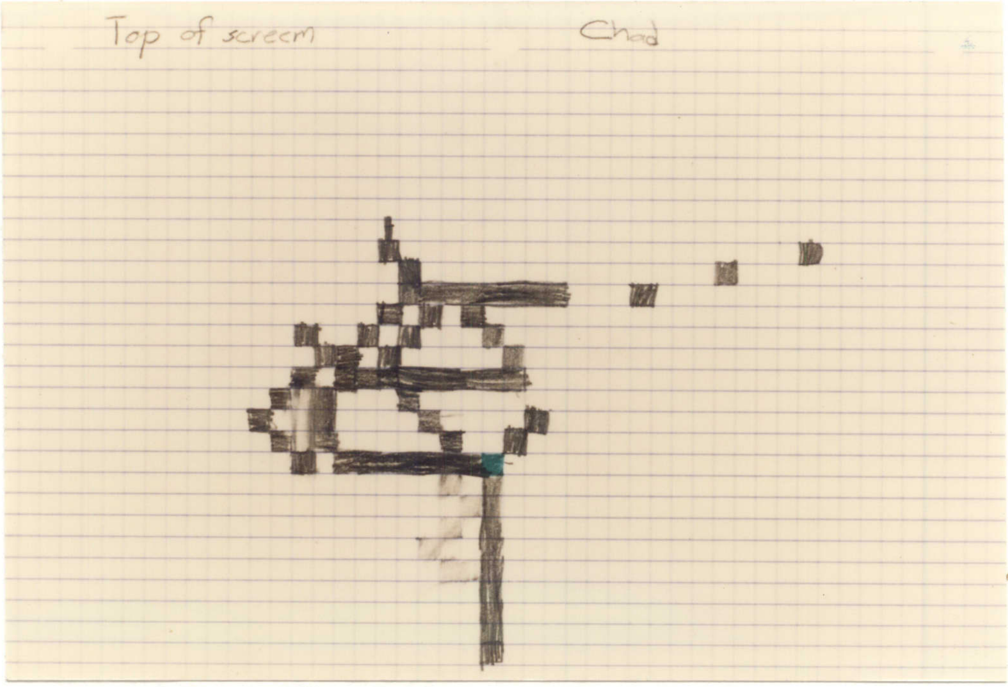


Figure 14. Assignment 2.4B. Knowledge used: concepts of abstraction, implied motion, and asymmetry; Linguistic tools: colored-in pencil shapes, horizontal and vertical hatching; Logic: draw, erase, modify, and draw. (57% of original size)

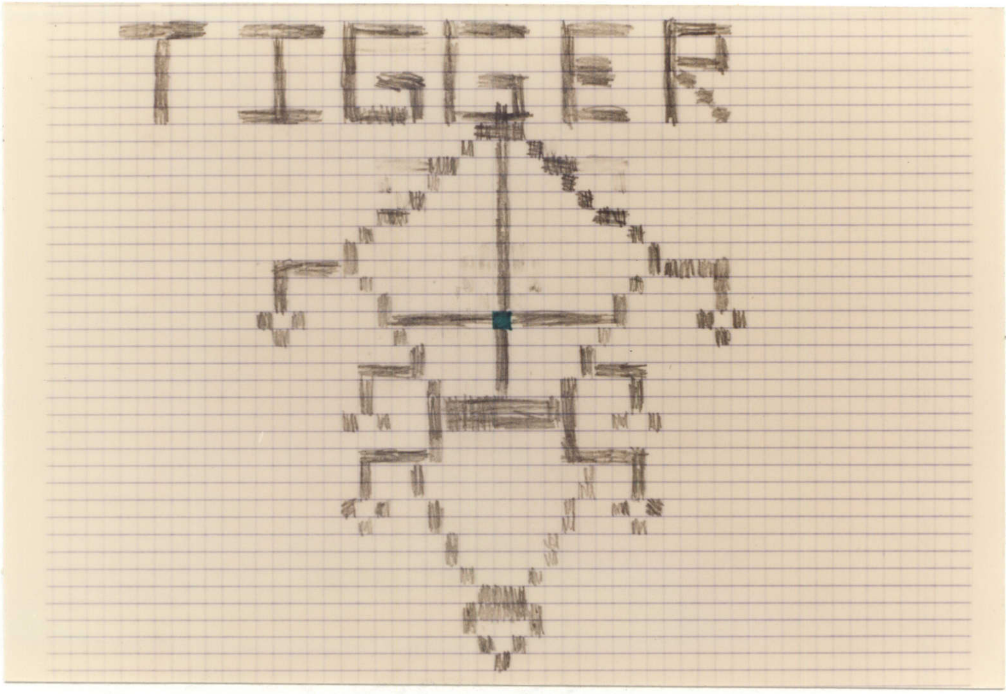


Figure 15. Assignment 2.4C. Knowledge used: concepts of a bug, proportion, and bilateral symmetry; Linguistic tools: colored-in pencil shapes as well as points; Logic: draw, erase, and draw. (43% of original size)

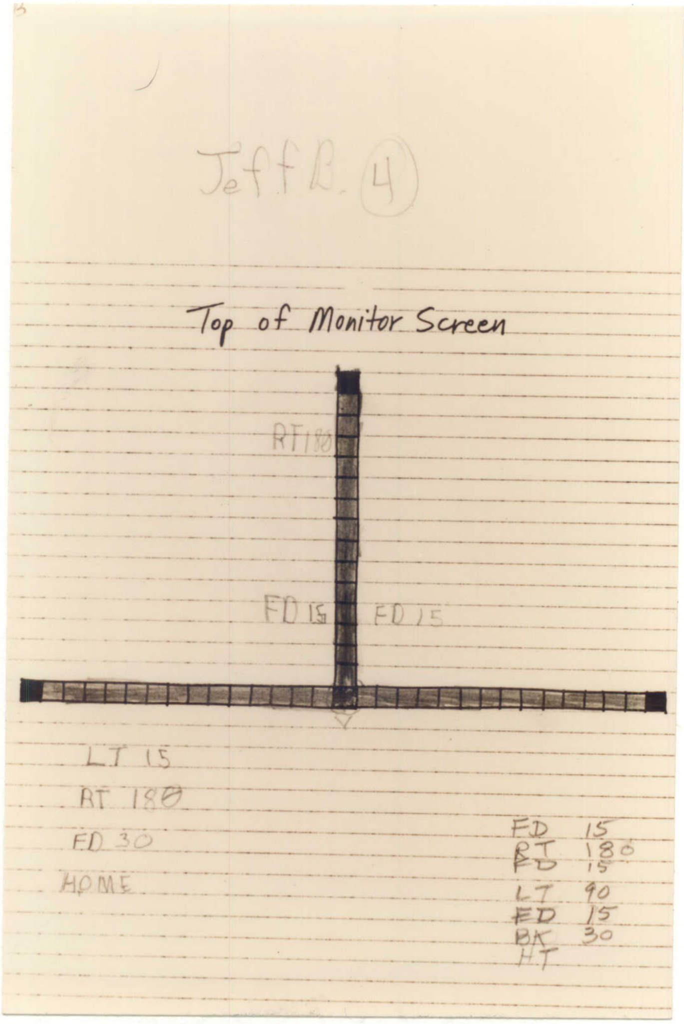
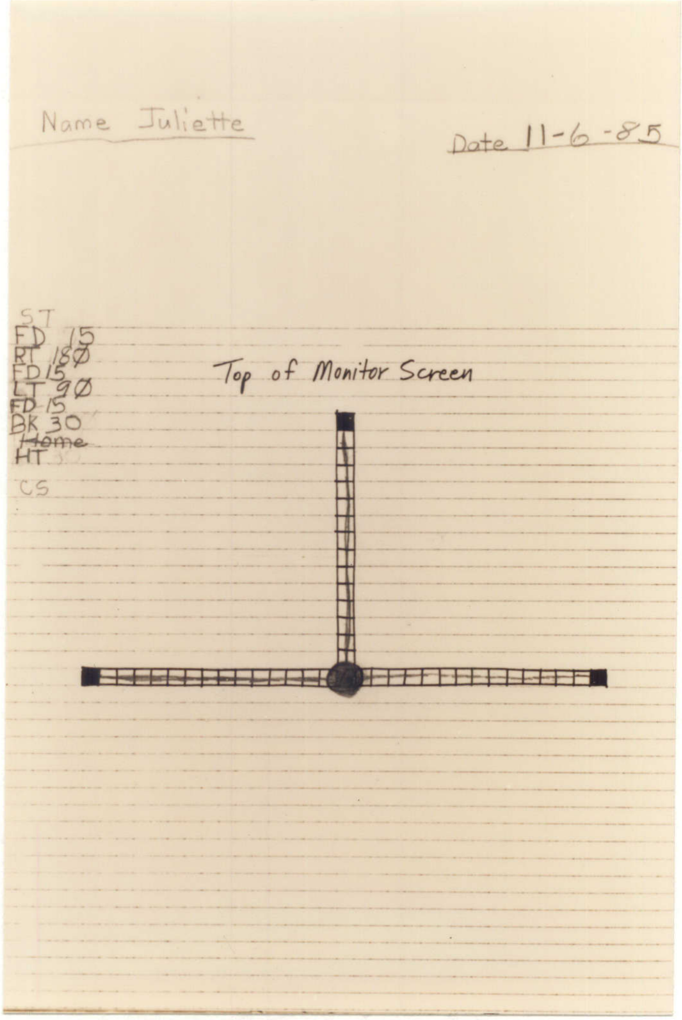


Figure 16. Assignment 3.2A. Knowledge used: concepts of forward, turn (left and right), backward, point of origin, and angle; Linguistic tools: colored-in pencil lines, Logo-coded labels, and Logo-coded list (top to bottom, left to right on page); Logic: color key shapes, color connecting line, label, connect rest of colored points in line then describe in code. (57% of original size)



<u>Figure 17.</u> Assignment 3.2B. Knowledge used: concepts of forward, turn (left and right), backward, point of origin, and angle; Linguistic tools: lines, colored-in pencil shapes, and Logo code in list; Logic: draw line, trace same, draw new line, trace same then draw new line (point of origin colored-in first as shape of circle). (44% of original size)

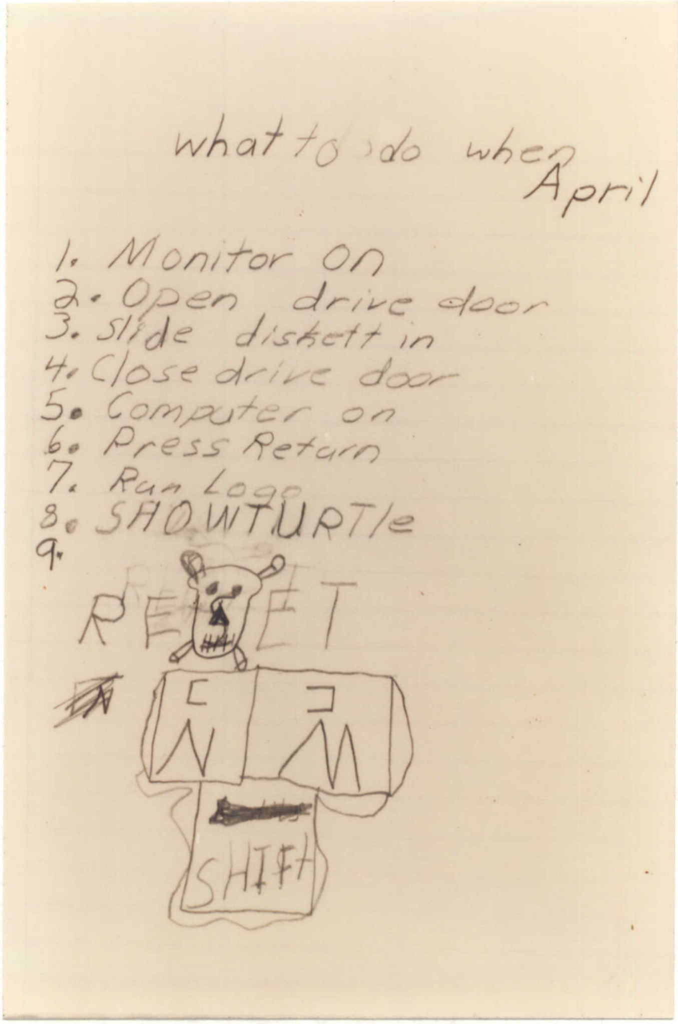
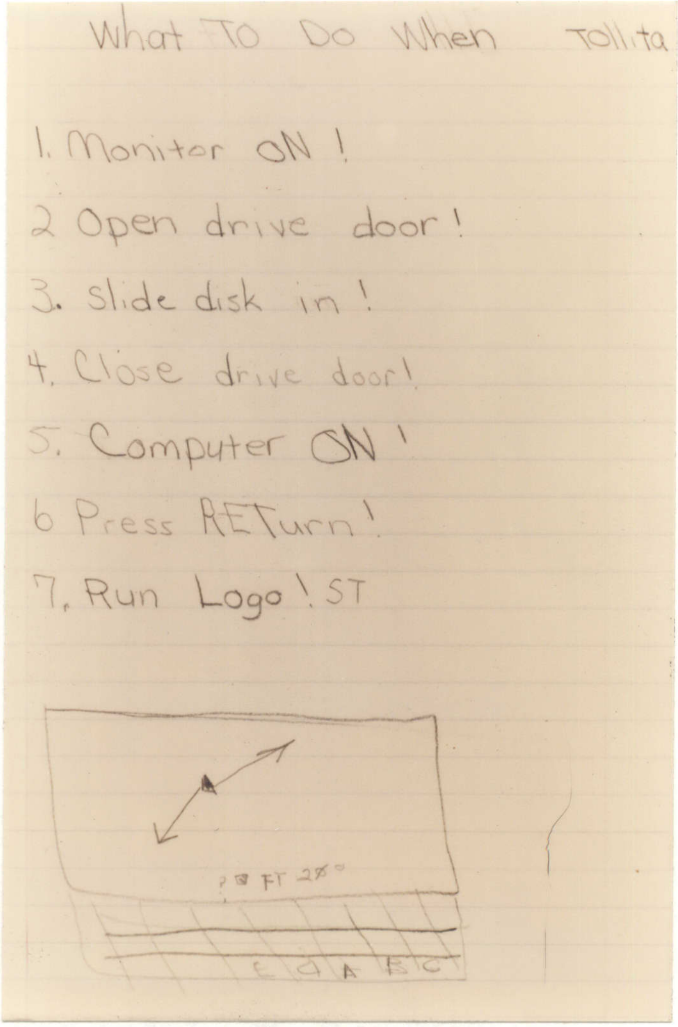


Figure 18. Assignment 3.3A. Knowledge used: concepts of a computer keyboard, vertical format, left to right reading conventions, as well as number and letter codes; Linguistic tools: numbers, verbal description of sequence, pencil drawn symbols, line representations of keys with labels (symbols and letters) and special relational key (shift); Logic: write, draw, erase, modify, draw, scratch-out then redraw. (58% of original size)



<u>Figure 19.</u> Assignment 3.3B. Knowledge used: concepts of a computer display, letter and number codes, left to right reading conventions, and vertical format; Linguistic tools: pencil colored-in key shapes, lines to represent operational computer, numbers, and verbal description of sequence; Logic: write and draw. (57% of original size)

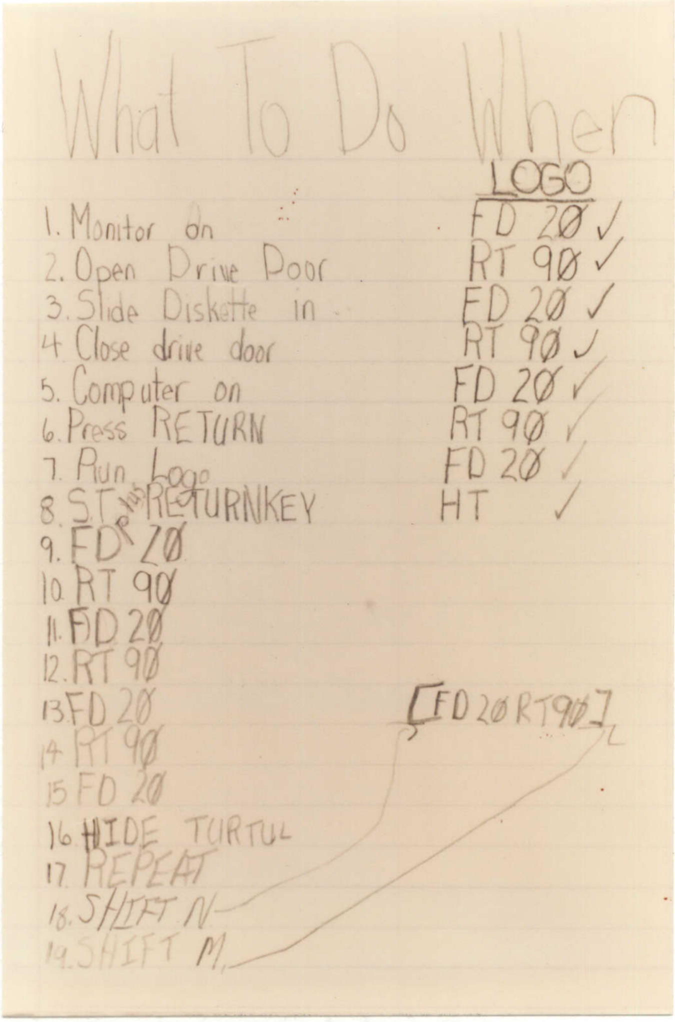


Figure 20. Assignment 3.3C. Knowledge used: concepts of extra information, a vertical format, top to bottom and left to right reading conventions, letters, numbers, and Logo code; Linguistic tools: verbal description of sequence in pencil, Logo code, arrows, and check marks; Logic: write, insert more information, erase, write, and check-off procedures as occurred. (58% of original size)

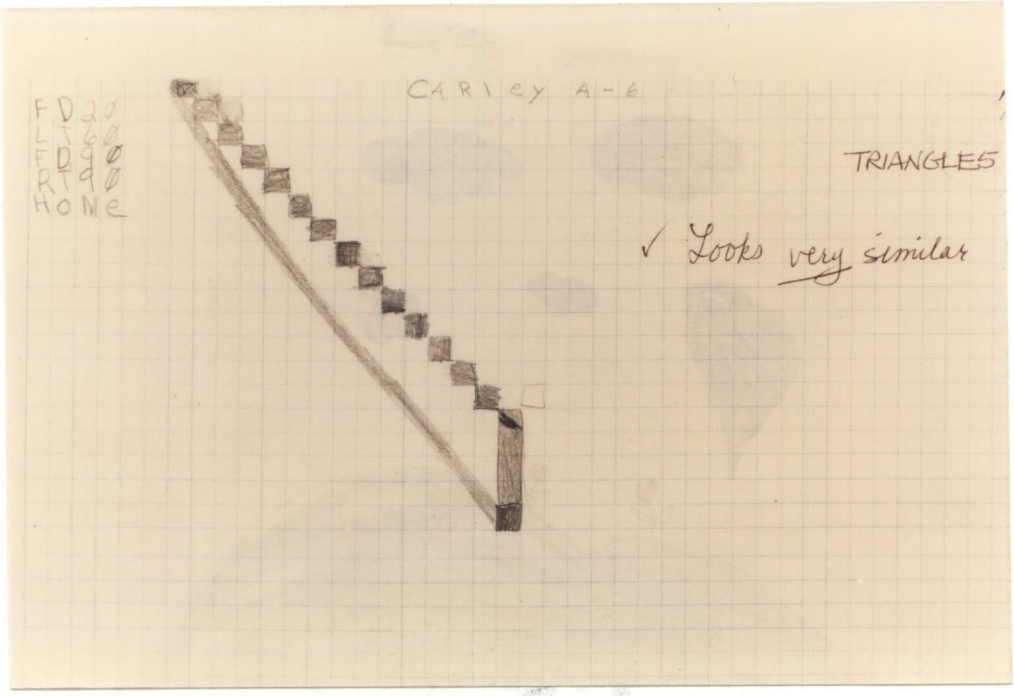


Figure 21. Assignment 3.4A. Knowledge used: concepts of triangle, forward, left, right, and "home" as point of origin; Linguistic tools: list of Logo code as well as pencil colored-in key shapes (points) and lines; Logic: draw, erase, modify, and draw. (50% of original size)

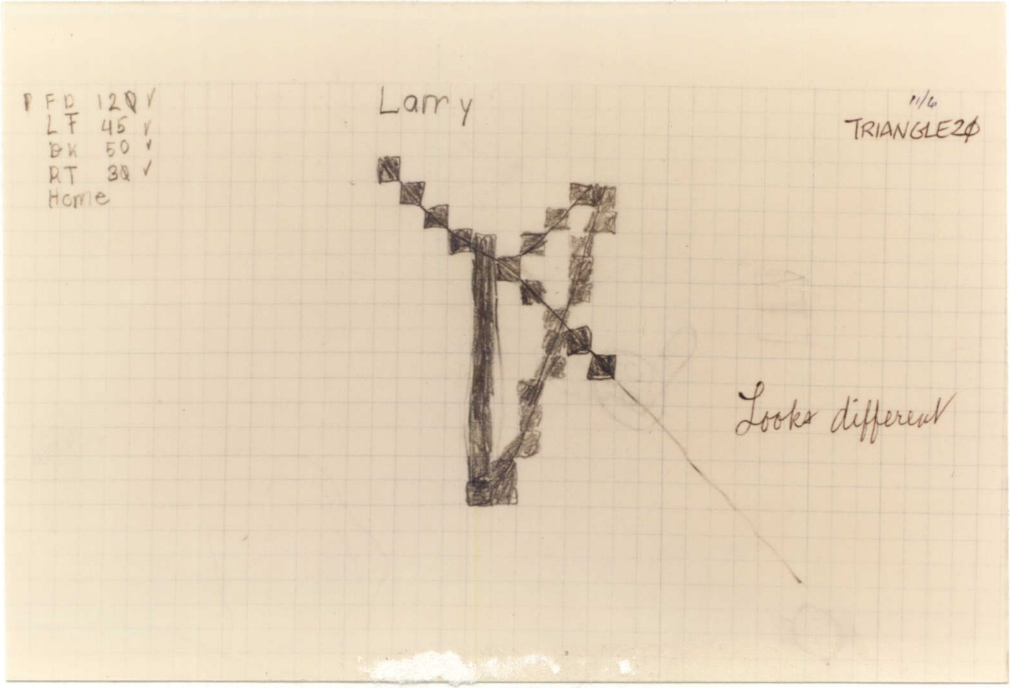


Figure 22. Assignment 3.4B. Knowledge used: concepts of triangle, forward, left, backward, right, and "home" as point of origin; Linguistic tools: pencil colored-in shapes (points) to make lines, drawn lines, Logo code in a list; Logic: draw, erase, draw then erase. (53% of original size)

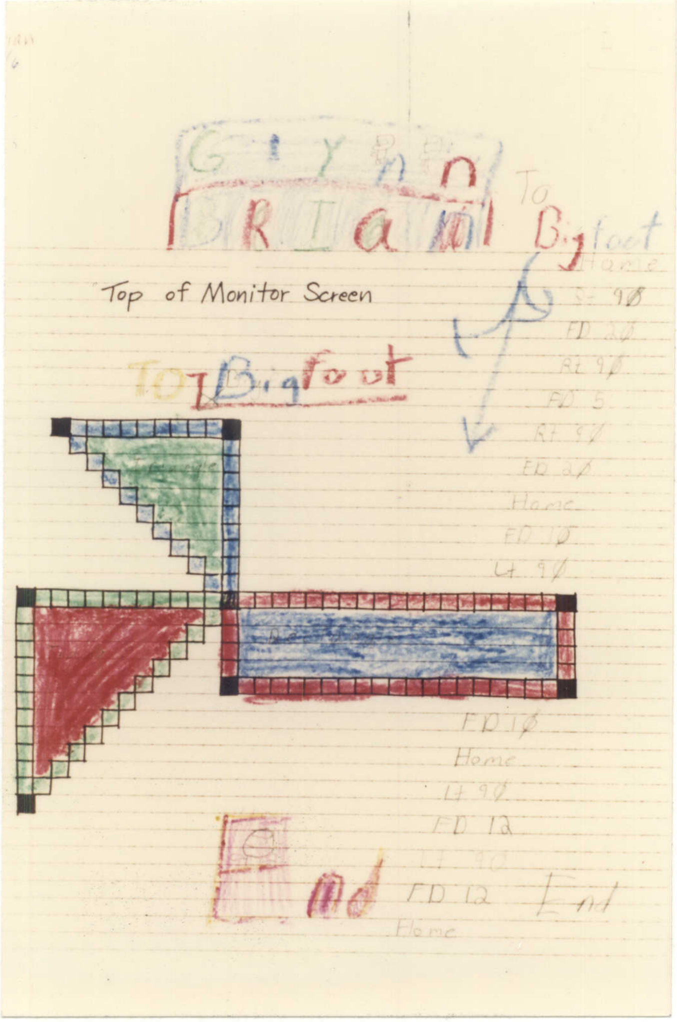
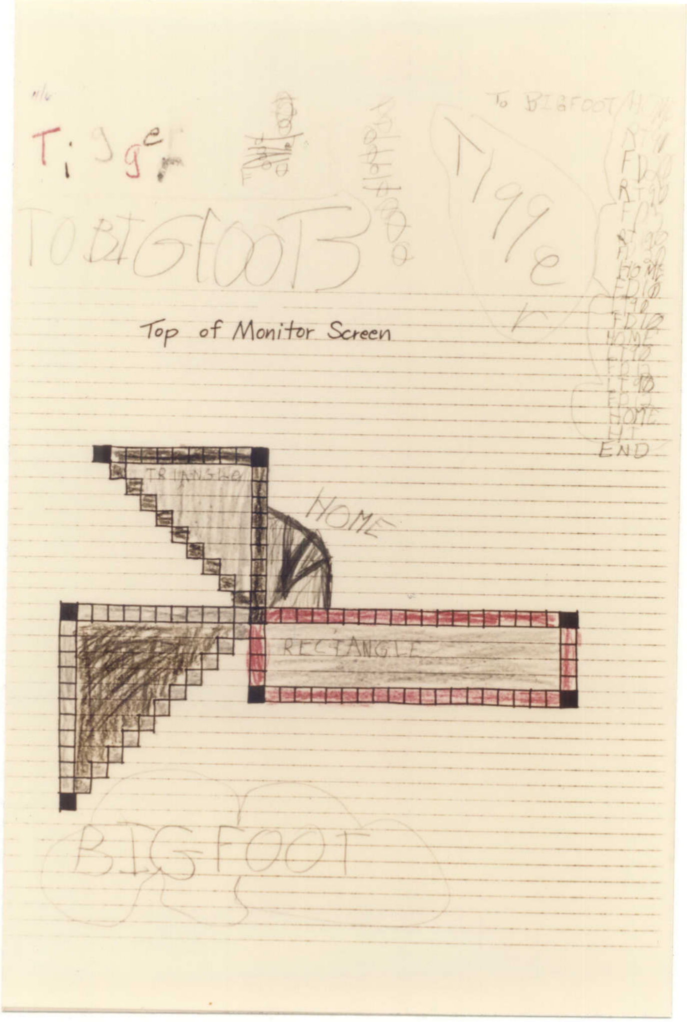


Figure 23. Assignment 3.5A. Knowledge used: concepts of point of origin, forward, right, left, and end as well as color, rectangle, and triangle; Linguistic tools: crayon colored-in lines and shapes, a list of Logo code in pencil, verbal labels, and arrows with long tails; Logic: write code, color-in corresponding line, repeat until finished then label resulting shape, color-in final outlined and labeled shape (initiated name enhancement using colors, added arrows then colored-in "End"). (44% of original size)



<u>Figure 24.</u> Assignment 3.5B. Knowledge used: concepts of rectangle, triangle, color (red, black, grey), point of origin, forward, left, right, and end as well as visible/invisible (HIDETURTLE); Linguistic tools: colored-in lines and shapes, verbal labels, and arrow, and list or Logo code; Logic: write code, color-in resulting lines, label shape and color-in interior shape (initiated use of opposite color schemes in coloring triangles). (41% of original size)

Figure 25. Assignment 4.2A. Knowledge used: concepts of implied motion, forward movement, right, forward, left, and invisible as well as of an animal-like creature; Linguistic tools: crayon colored-in lines and shapes as well as a list of Logo code in pencil; Logic: write code and color-in resulting design, embellish geometric design ignoring matrix with no erasing. (48% of original size)

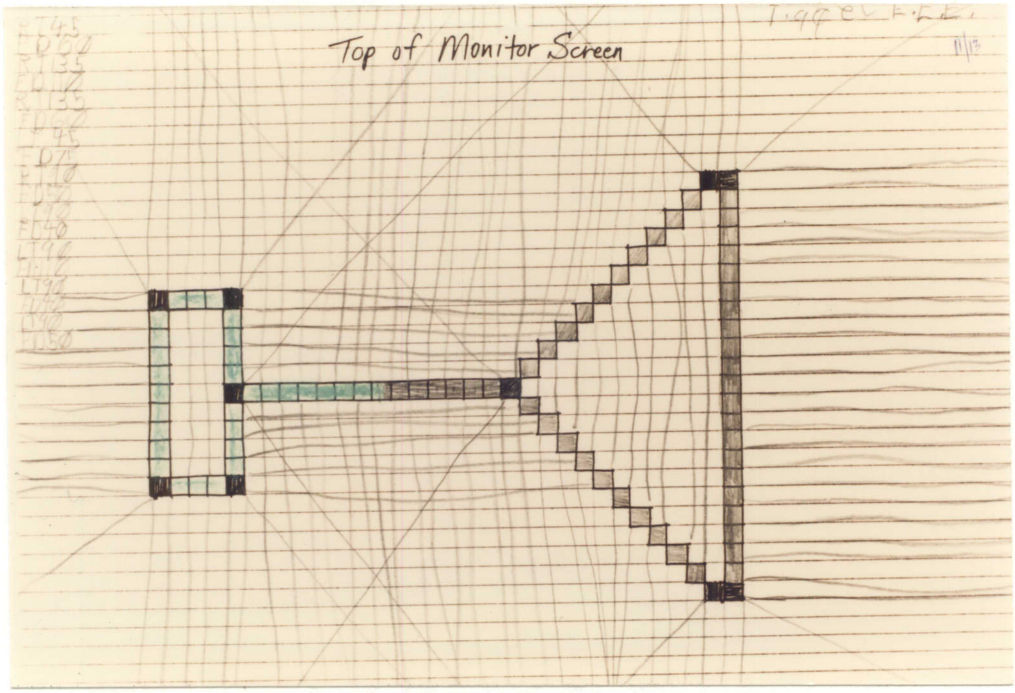
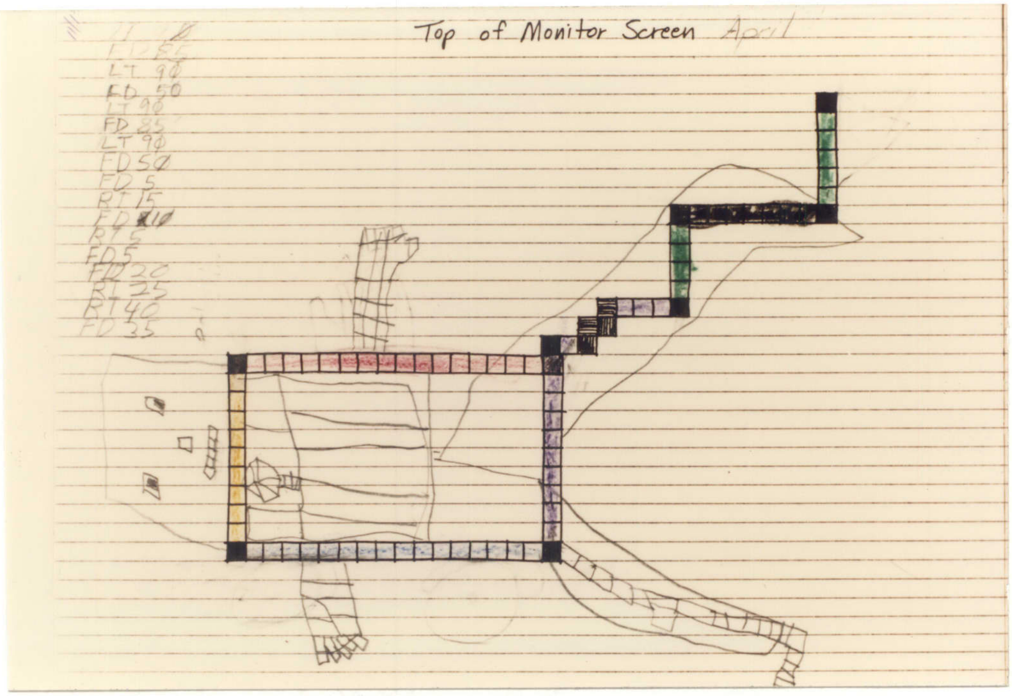
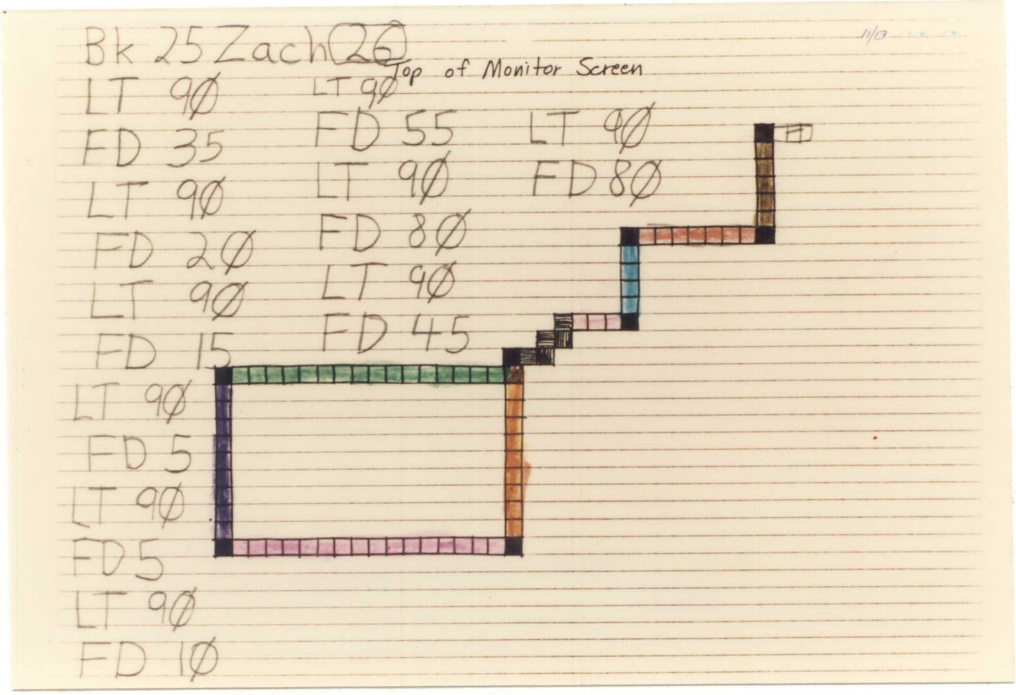


Figure 26. Assignment 4.2B. Knowledge used: concepts of implied motion, forward movement, right, forward, and left as well as a rocketship; Linguistic tools: Logo code in pencil list and colored-in lines (pencil or crayon); Logic: write code and color-in resulting design, embellish geometric design accentuating matrix without erasing. (48% of original size)



<u>Figure 27.</u> Assignment 4.3A. Knowledge used: concepts of a person, skeleton, rectangle, line, and angle; Linguistic tools: crayon colored-in lines, penciled-in eye shapes, and Logo code in a list; Logic: list code and color-in resulting line, embellish with pencil then erase and turn paper in opposite direction to draw a person using pencil and erasing. (48% of original size)



<u>Figure 28.</u> Assignment 4.3B. Knowledge used: concepts of rectangle, line, angle, and point of origin; Linguistic tools: Logo code in lists from left to right (length of list determined by placement of geometric shape on writing surface), colored-in crayon lines, and "H" to represent HOME; Logic: list code and color-in resulting line. (44% of original size)

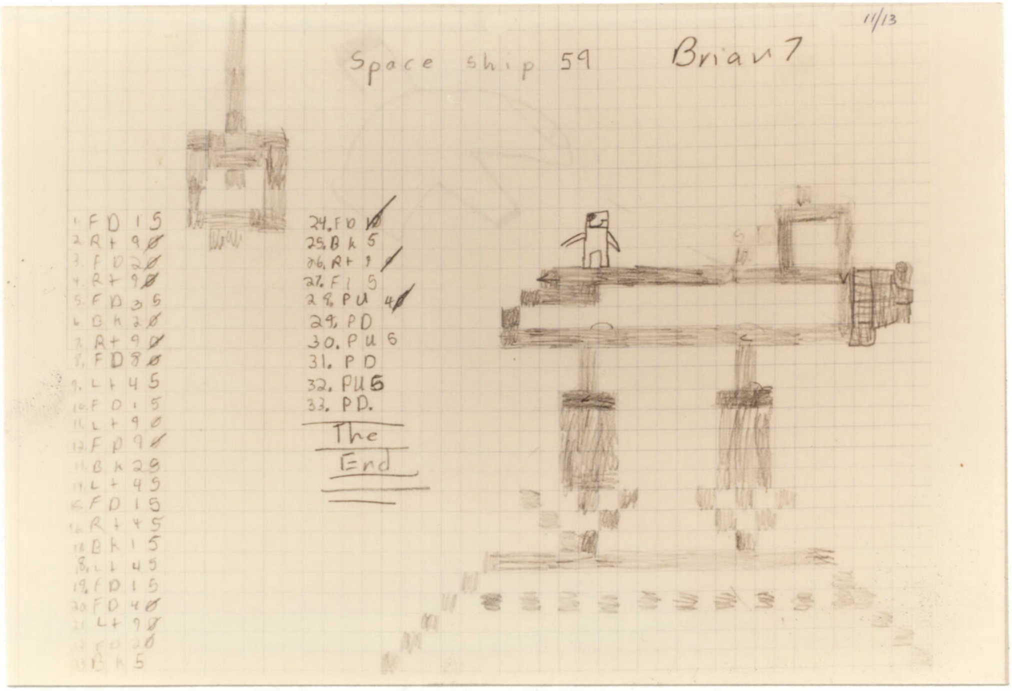
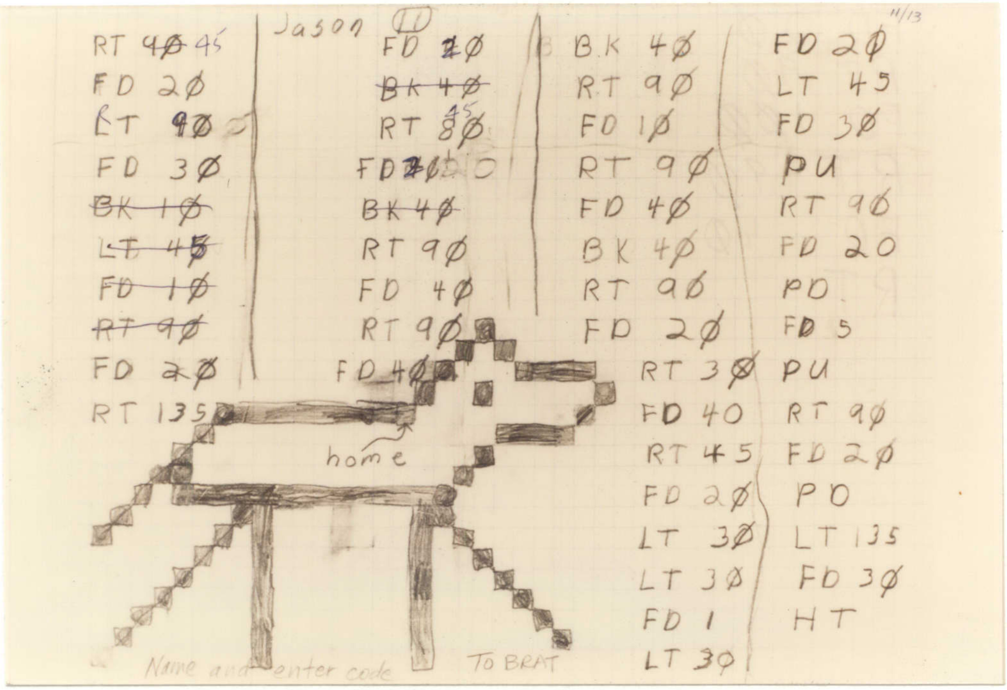
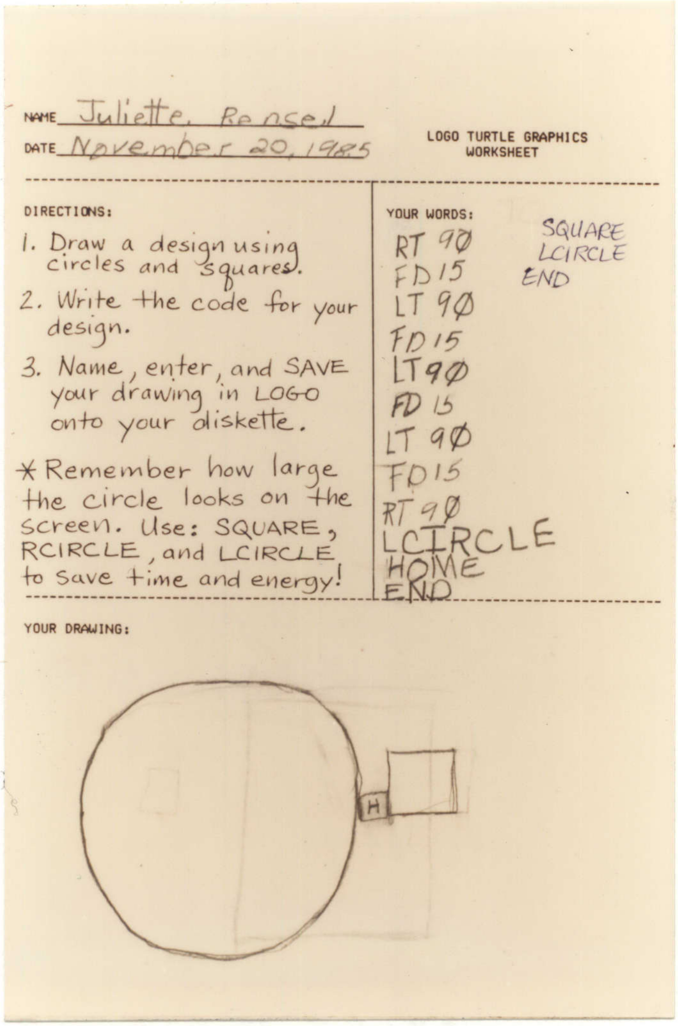


Figure 29. Assignment 4.4A. Knowledge used: concepts of proportion, implied motion (upward thrust), forward, right, back, left, pen up, pen down, and end as well as a spaceship with astronaut or robot; Linguistic tools: Logo code arranged in lists, numbers to indicate sequence, punctuation, descriptive verbal labels, colored-in points, lines, and shapes; Logic: draw line or shape, color it in then write code (Logo code was entered at the computer to determine approximation toward desired image, no correspondence, new drawing started on another sheet of paper). (41% of original size)



<u>Figure 30.</u> Assignment 4.4B. Knowledge used: concepts of point of origin, right, forward, backward, left, pen up, pen down, invisible (HT), implied motion, proportion, and a running or walking horse; Linguistic tools: Logo code in four lists separated by three vertical lines, colored-in pencil points and lines, verbal labels, and an arrow; Logic: draw using colored-in pencil points and lines, erase and modify then code and vice versa for some lines, divide code using vertical lines (Logo code was entered at the computer with no approximation past the shape of the head). (41% of original size)



NAME Juliette Rensel
DATE November 20, 1985

LOGO TURTLE GRAPHICS WORKSHEET

DIRECTIONS:

1. Draw a design using circles and squares.
2. Write the code for your design.
3. Name, enter, and SAVE your drawing in LOGO onto your diskette.

* Remember how large the circle looks on the screen. Use: SQUARE, RCIRCLE, and LCIRCLE to save time and energy!

YOUR WORDS:

RT 9Ø
FD 15
LT 9Ø
FD 15
LT 9Ø
FD 15
LT 9Ø
FD 15
RT 9Ø
LCIRCLE
HOME
END

SQUARE
LCIRCLE
END

YOUR DRAWING:

Figure 31. Assignment 5.1A. Knowledge used: concepts of square, circle, point of origin, right 90 degrees, left 90 degrees, forward, end, encoding, and drawing a circle from right to left; Linguistic tools: Logo code in a list, pencil lines, and colored-in shapes; Logic: draw, erase completely, draw new shape, and write code (detailed description of a square followed by an abstract description of a circle). (48% of original size)

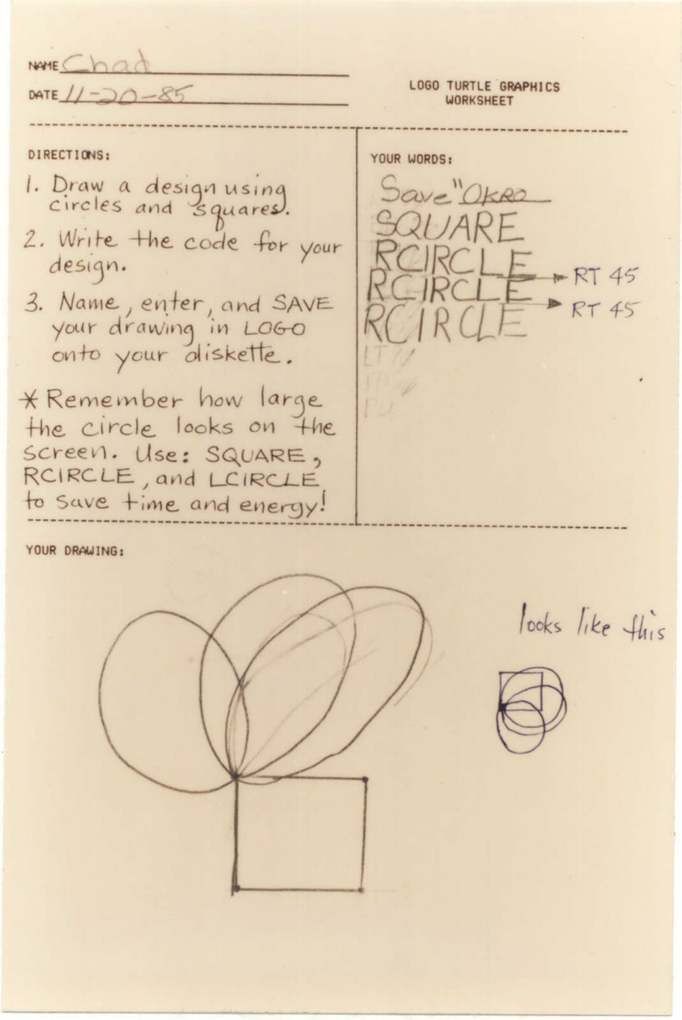
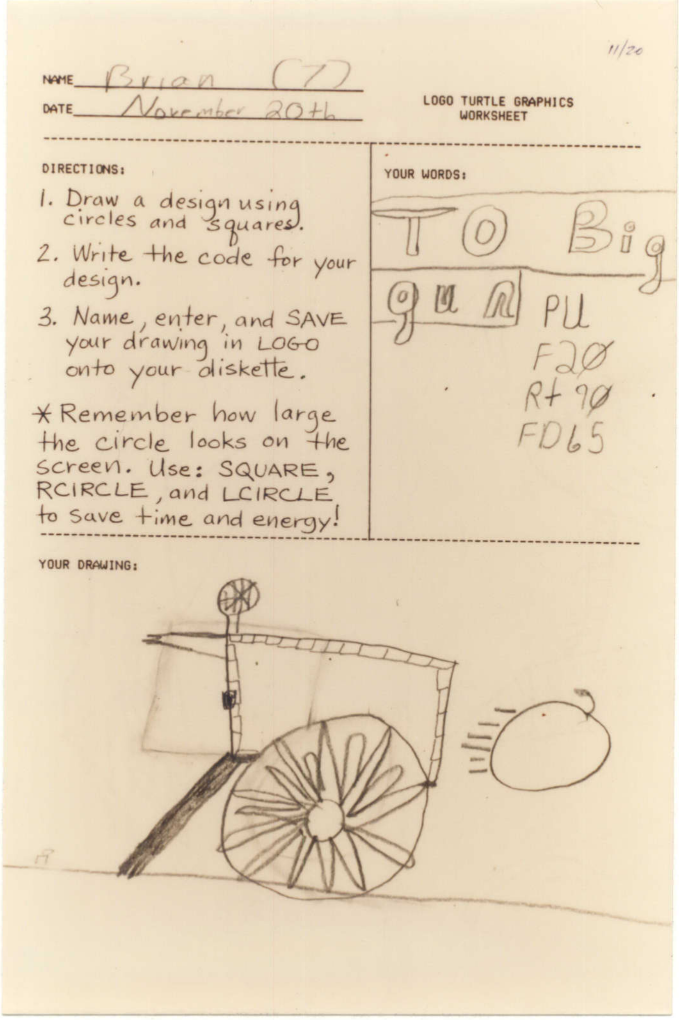


Figure 32. Assignment 5.1B. Knowledge used: concepts of a square, a circle, point of origin, and rotation; Linguistic tools: Logo code and contour or outline drawing; Logic: draw, write very detailed code, erase code then write the same in its short, abstract form. (48% of original size)



11/20

NAME Brian (Z)

DATE November 20th

LOGO TURTLE GRAPHICS
WORKSHEET

DIRECTIONS:

1. Draw a design using circles and squares.
2. Write the code for your design.
3. Name, enter, and SAVE your drawing in LOGO onto your diskette.

* Remember how large the circle looks on the screen. Use: SQUARE, RCIRCLE, and LCIRCLE to save time and energy!

YOUR WORDS:

TO Big gun
PU
F2Ø
Rt 9Ø
FD65

YOUR DRAWING:

Figure 33. Assignment 5.1C. Knowledge used: concepts of square, circles, implied motion, proportion, change of location, and a cannon-like gun; Linguistic tools: words, Logo code, lines, colored-in shapes, and motion lines; Logic: draw one square and one circle, erase completely then draw complex shape, label with descriptive words, write some code beginning by changing the point of view (HOME). (48% of original size)

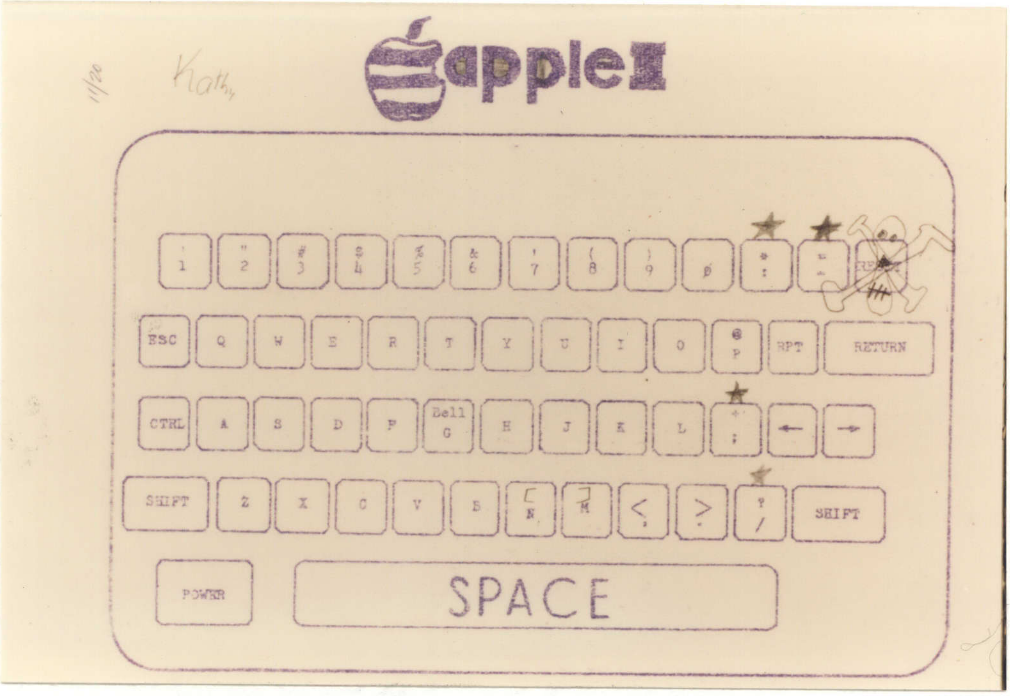


Figure 34. Assignment 5.3A. Knowledge used: concepts of contrast, proximity of related symbols, a star, and a poison warning symbol; Linguistic tools: colored-in pencil shape over significant visual information with a line drawing of a skull and crossbones over the RESET key; Logic: draw and color-in to accent. (46% of original size)

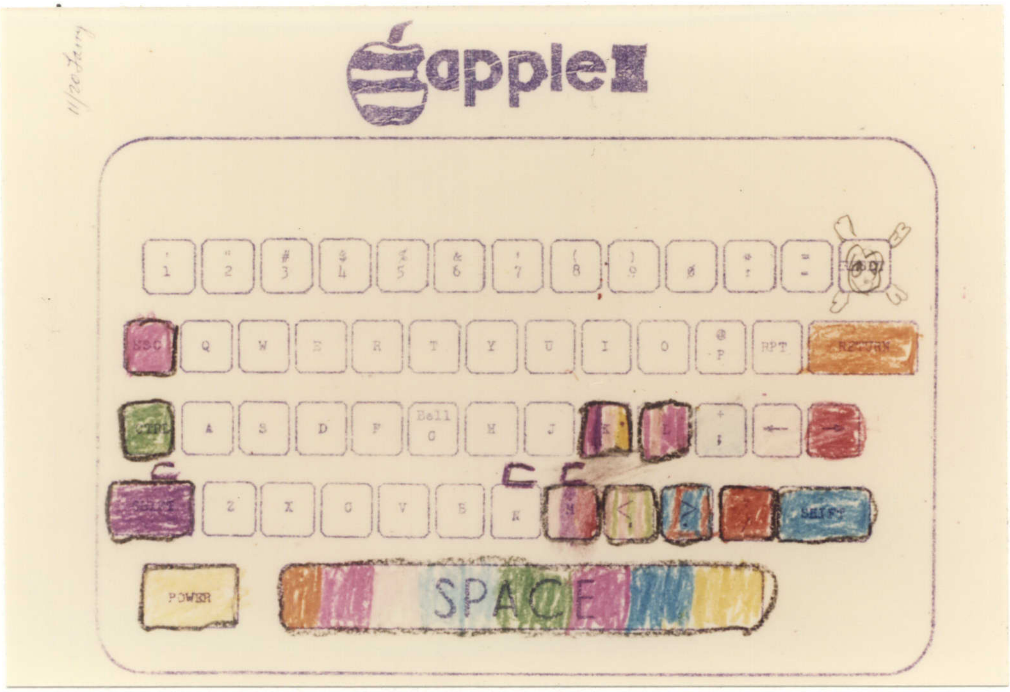


Figure 35. Assignment 5.3B. Knowledge used: concepts of contrast, color-coding, outlines, and poison warning symbol; Linguistic tools: lines, overdrawn lines, and colored-in crayon shapes (solid color, solid color with black outlines, and striped lines of symbol); Logic: color, erase once, modify, and color. (46% of original size)

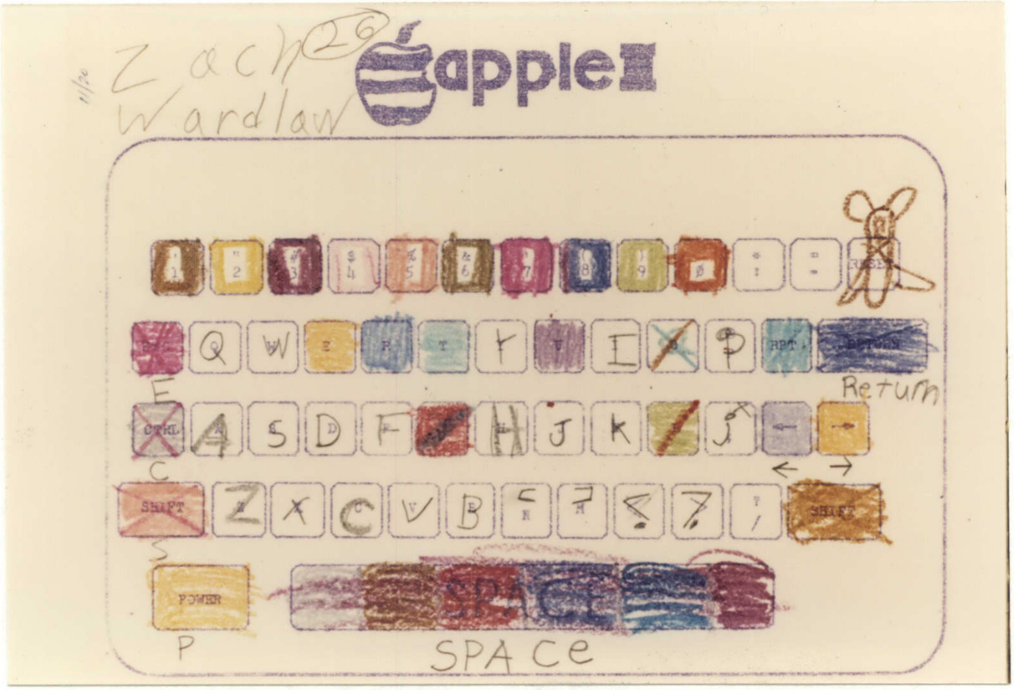


Figure 36. Assignment 5.3C. Knowledge used: concepts of contrast, color-coding, checking-off process, highlighting information, and a poison warning symbol; Linguistic tools: letters in pencil, "X" or "/" as checks, verbal labels, color, and modified poison symbol; Logic: pencil-in letters, erase, write, color, and label (words that had become unreadable through coloring were re-written). (46% of original size)

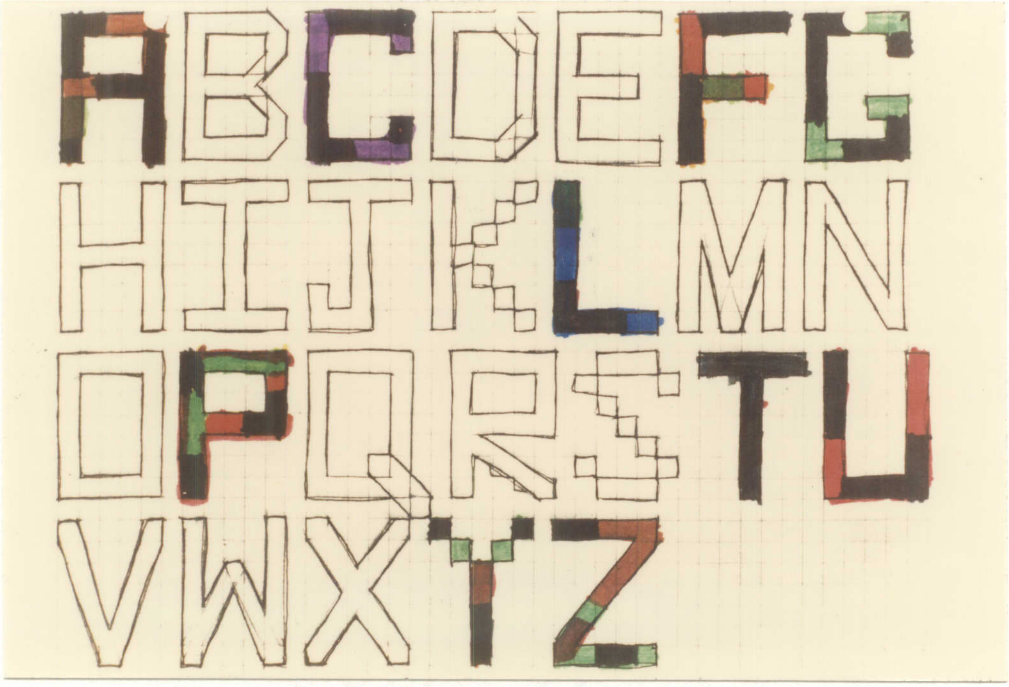
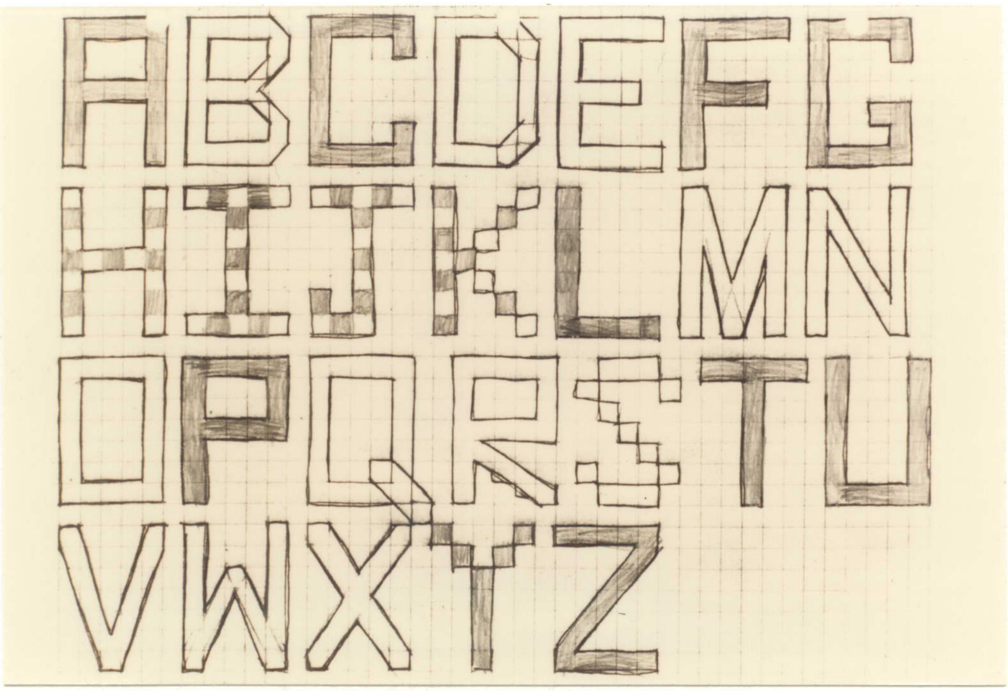


Figure 37. Assignment 6.1A. Knowledge used: concepts of color-coding, contrast, patterning, and letter shapes; Linguistic tools: six colors of felt pens (one solid colored-in letter, three bi-colored letters, six tri-colored letters, and the balance unchanged); Logic: alternating colors, bleeding inks to make new colors, then increased variation (colored-in assigned letters only). (44% of original size)



<u>Figure 38.</u> Assignment 6.1B. Knowledge used: concepts of patterning, contrast, and letter shapes; Linguistic tools: colored-in pencil points within shapes or colored-in entire letter shape; Logic: colored assigned letters (solid) then colored-in every other point (square) in letters not yet 'approved.' (44% of original size)

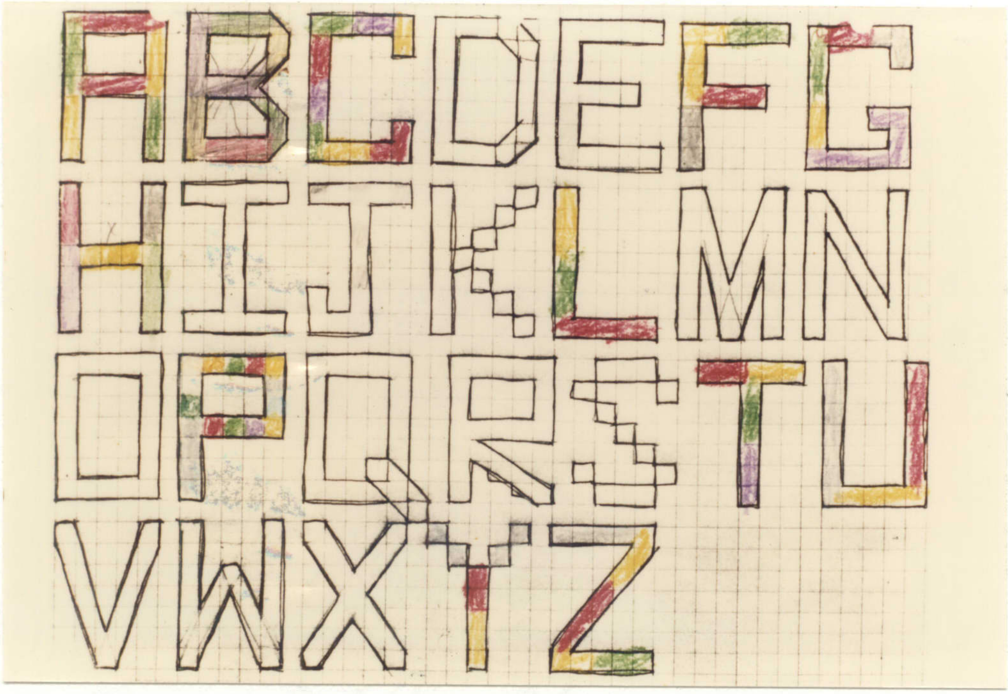


Figure 39. Assignment 6.1C. Knowledge used: concepts of color-coding, contrast, patterning, and letter shapes; Linguistic tools: color-pattern the letter shapes, "X" on letters not part of assignment, and partially colored shapes; Logic: color in sequence (A then B only to realize B was not yet mentioned, cross-out B then over-color with pencil, continue to color-in as assigned). (44% of original size)

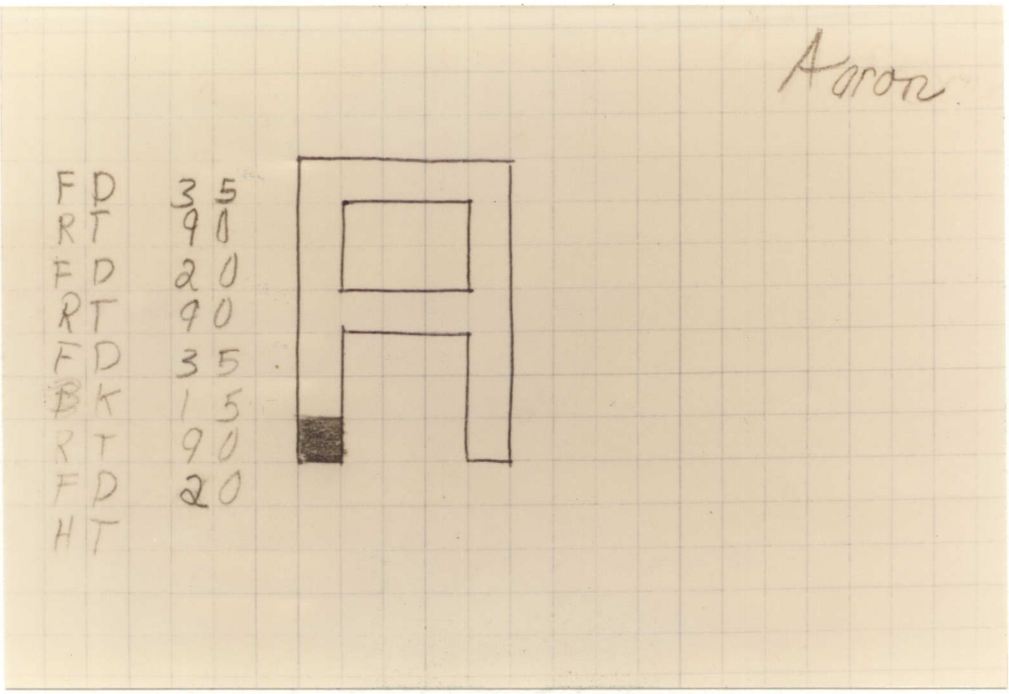


Figure 40. Assignment 6.2A. Knowledge used: concepts of forward, right, backward, 90 degrees, and invisible (HT) as well as representational equivalence (correspondence), point of view, and the letter "A"; Linguistic tools: Logo code in list, geometric styling, and color; Logic: draw letter then write code by reading the shape, indicate point of origin, enter code, and run on computer (no corrections). (88% of original size)

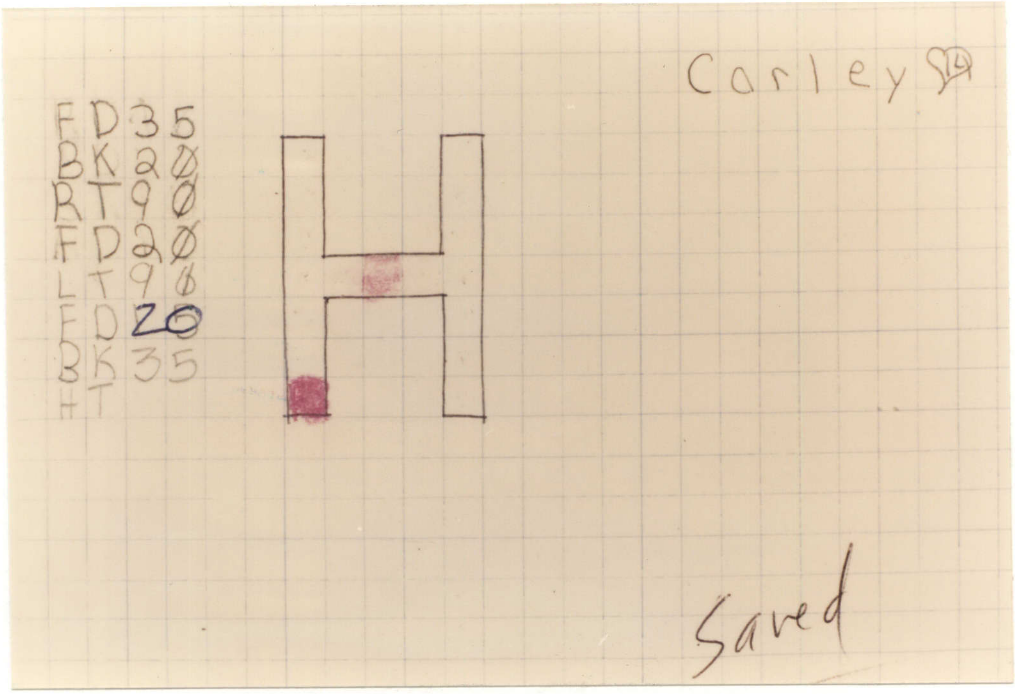


Figure 41. Assignment 6.2B. Knowledge used: concepts of point of origin, the letter "H", forward, backward, right, left, 90 degrees, invisible, and representational equivalence (correspondence); Linguistic tools: colored-in crayon shape of importance and Logo code in a list; Logic: color origin, erase, move origin, write code, enter code, correct, and run on computer. (84% of original size)

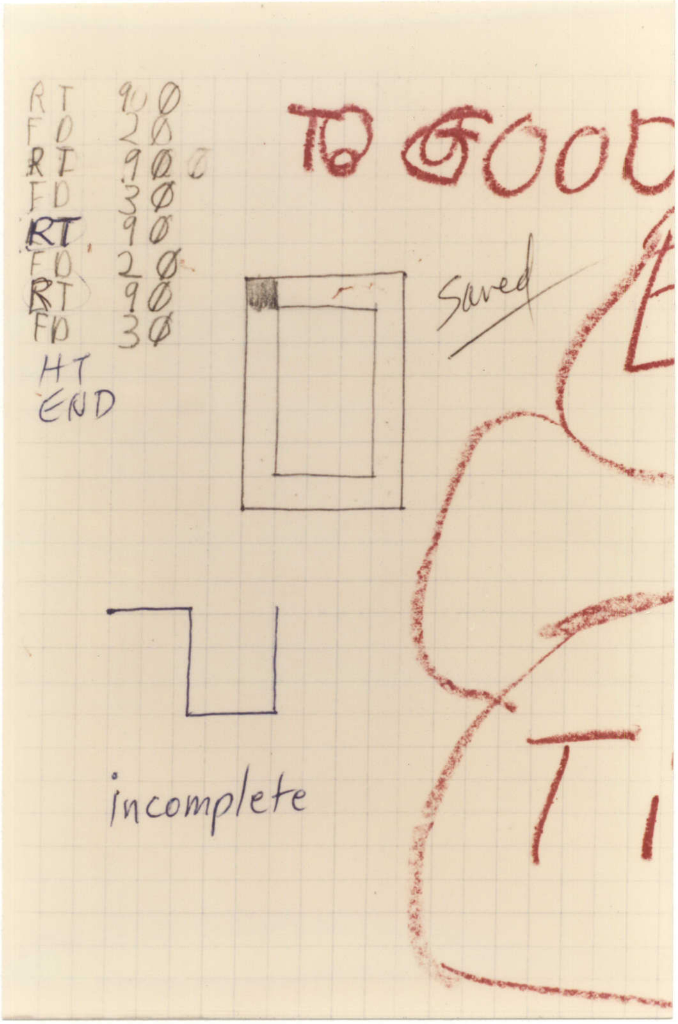


Figure 42. Assignment 6.2C. Knowledge used: concepts of the letter "O", right, forward, left, invisible (HT), point of origin, and representational equivalence (correspondence); Linguistic tools: colored point of origin and Logo code in a list; Logic: color origin, write code, enter code, see and correct code to correspond with letter shape error. (67% of original size)

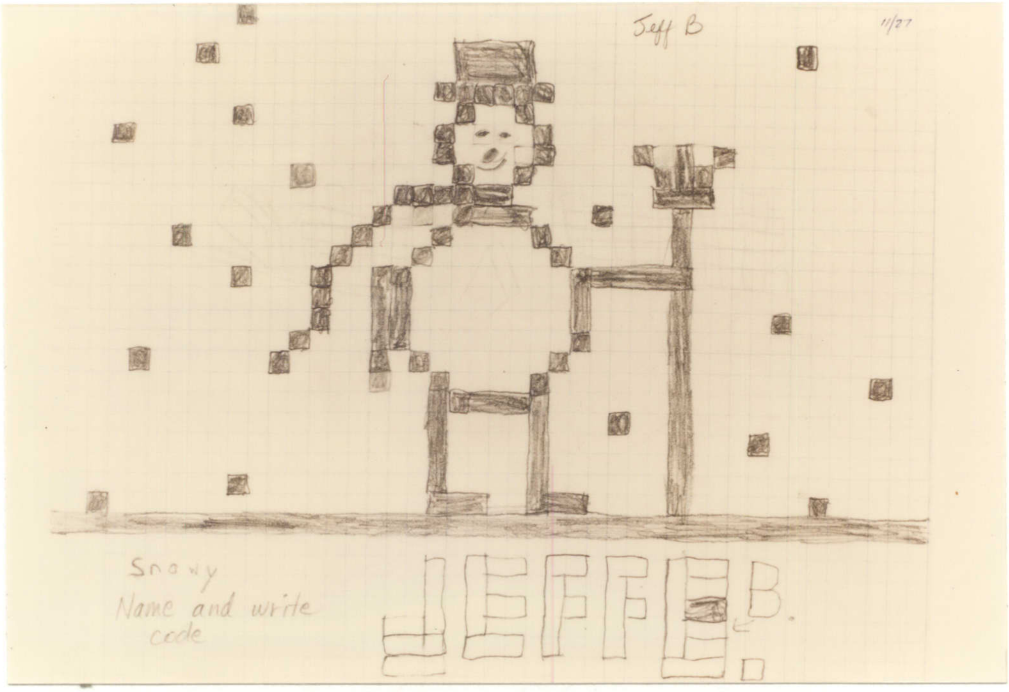
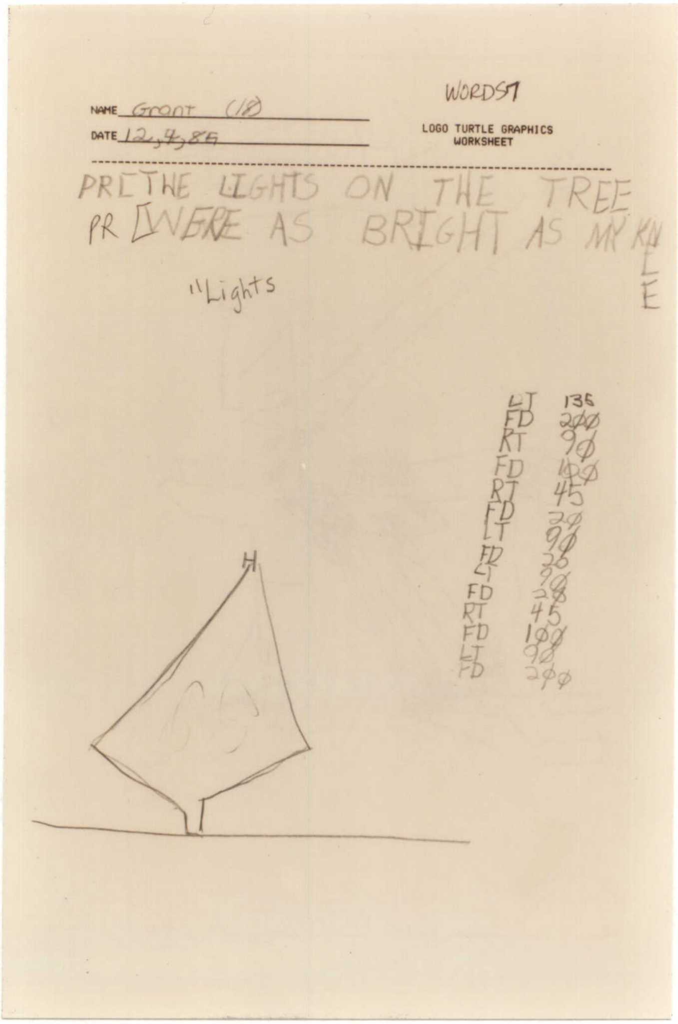


Figure 43. Assignment 6.3. Knowledge used: concepts of bilateral symmetry, implied motion, horizon line, snow, and conventional snowman; Linguistic tools: colored-in shapes and lines, verbal descriptor, and letters; Logic: draw shapes then color-in with pencil, correct difficult letter shapes using arrow. (41% of original size)



<u>Figure 44.</u> Assignment 7.3A. Knowledge used: concepts of word processing, rhyming, point of origin, left, right, forward, degrees, and equivalence (correspondence) as well as bright lights, tree, and knee; Linguistic tools: Logo code for text, Logo code for graphics, erased lines, shape of a tree, and the letter "H"; Logic: write words, draw, simplify shape, and write Logo code. (41% of original size)

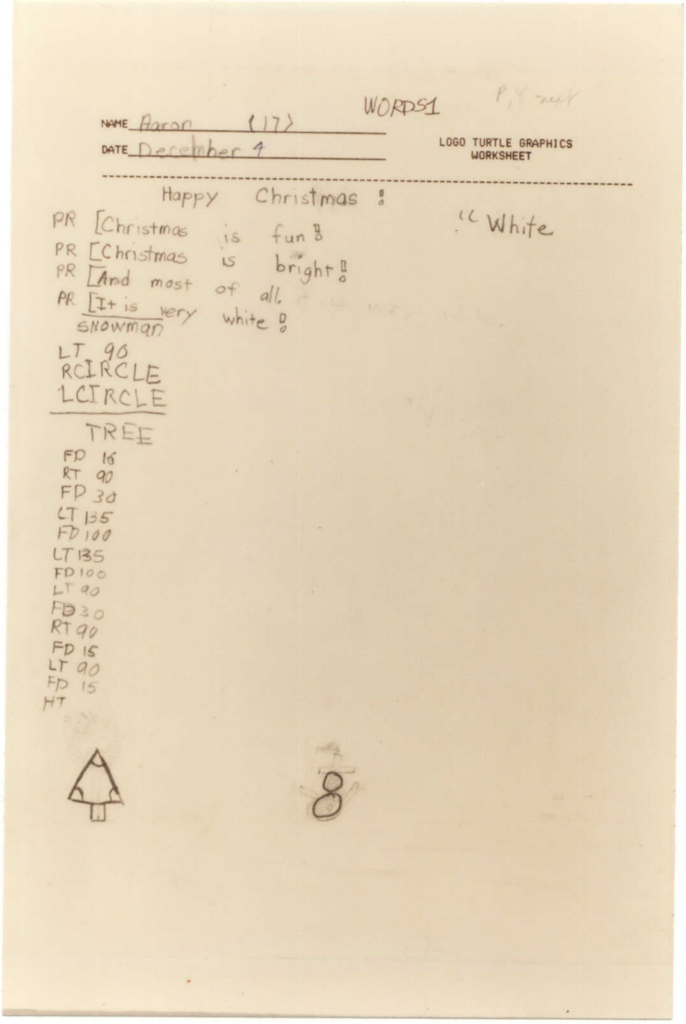


Figure 45. Assignment 7.3B. Knowledge used: concepts of word processing, rhyming, circle, left, right, forward, degrees, invisible, and equivalence (correspondence), as well as words and their meaning, a tree and snowman; Linguistic tools: Logo code for text, Logo code for graphics, names, abstraction through simplification of tree and snowman shapes; Logic: write words in sentence form, erase, correct format for output, add Logo text code, draw illustrations then write graphics code (easy shape first, detailed shape next). (41% of original size)

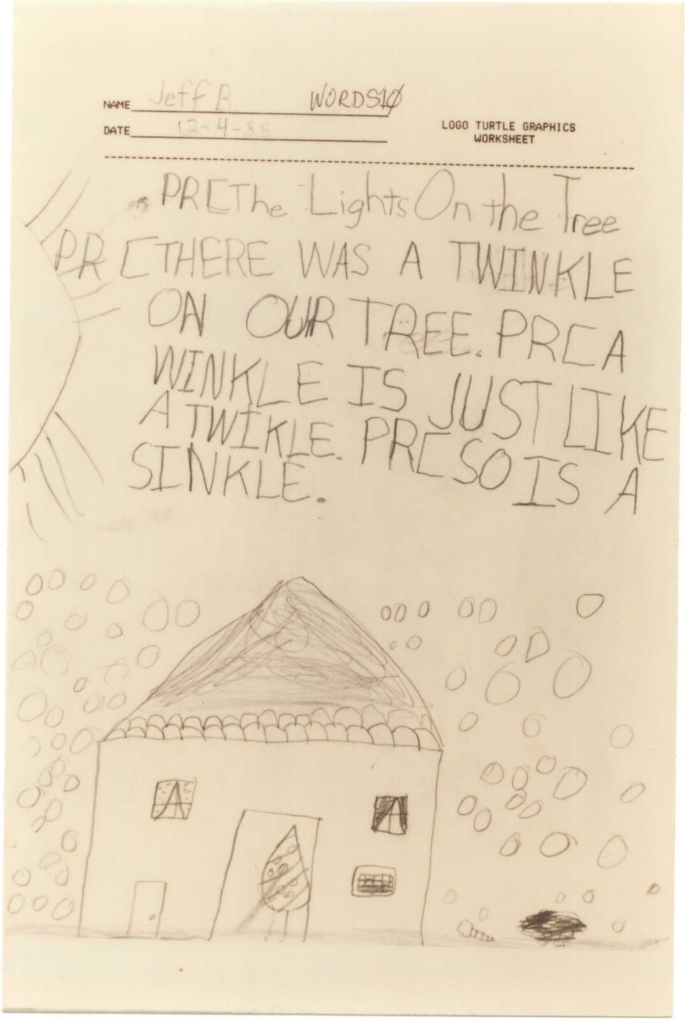
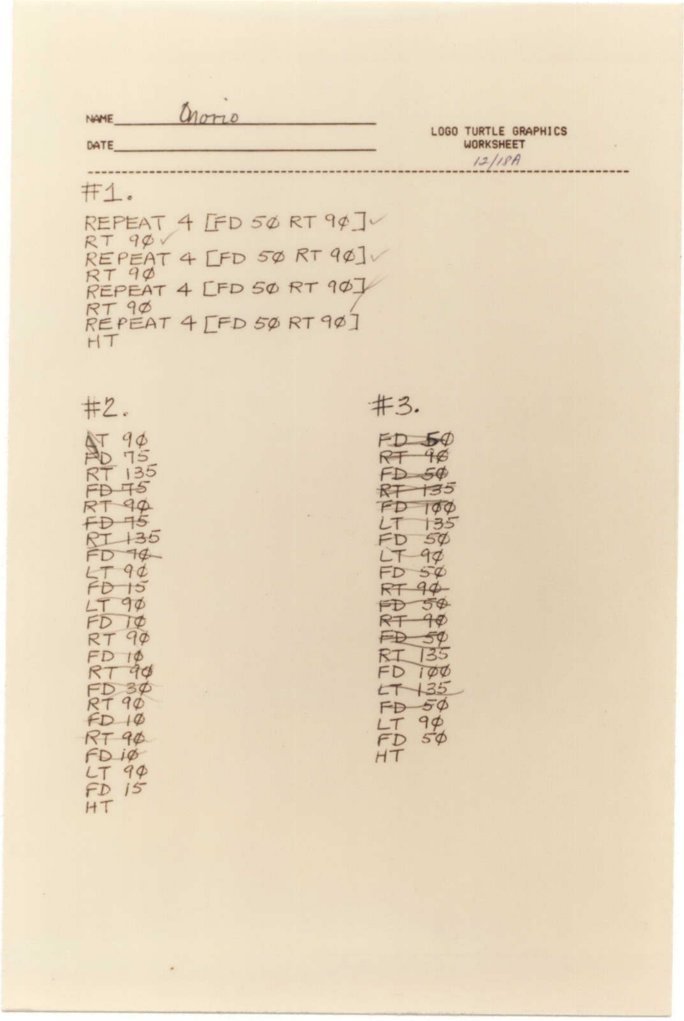


Figure 46. Assignment 7.3C. Knowledge used: concepts of word processing, equivalence (correspondence), rhyming, lights, sun, snow, house, and tree; Linguistic tools: words in sentences, Logo text code, lines, colored-in pencil shapes, and scratched-out error; Logic: write sentences using "PR[" convention then draw complex scene to illustrate words (no graphics code). (41% of original size)



NAME Chorio
DATE

LOGO TURTLE GRAPHICS
WORKSHEET
12/18A

#1.

REPEAT 4 [FD 5Ø RT 9Ø]
RT 9Ø
REPEAT 4 [FD 5Ø RT 9Ø]
RT 9Ø
REPEAT 4 [FD 5Ø RT 9Ø]
RT 9Ø
REPEAT 4 [FD 5Ø RT 9Ø]
HT

#2.

RT 9Ø
FD 75
RT 135
FD 75
RT 9Ø
FD 75
RT 135
FD 9Ø
LT 9Ø
FD 15
LT 9Ø
FD 1Ø
RT 9Ø
FD 1Ø
RT 9Ø
FD 3Ø
RT 9Ø
FD 1Ø
RT 9Ø
FD 1Ø
LT 9Ø
FD 15
HT

#3.

FD 5Ø
RT 9Ø
FD 5Ø
RT 135
FD 1ØØ
LT 135
FD 5Ø
LT 9Ø
FD 5Ø
RT 9Ø
FD 5Ø
RT 9Ø
FD 5Ø
RT 135
FD 1ØØ
LT 135
FD 5Ø
LT 9Ø
FD 5Ø
HT

<u>Figure 47.</u> Assignment 9.1A. Knowledge used: concepts of procedural logic, forward, right, 90 and 135 degrees, left, "gone from view," repetition, cause and effect, and equivalence (correspondence); Linguistic tools: checked-off or scratched-off code from the list; Logic: making sequential checks and lines to indicate process completion. (41% of original size)

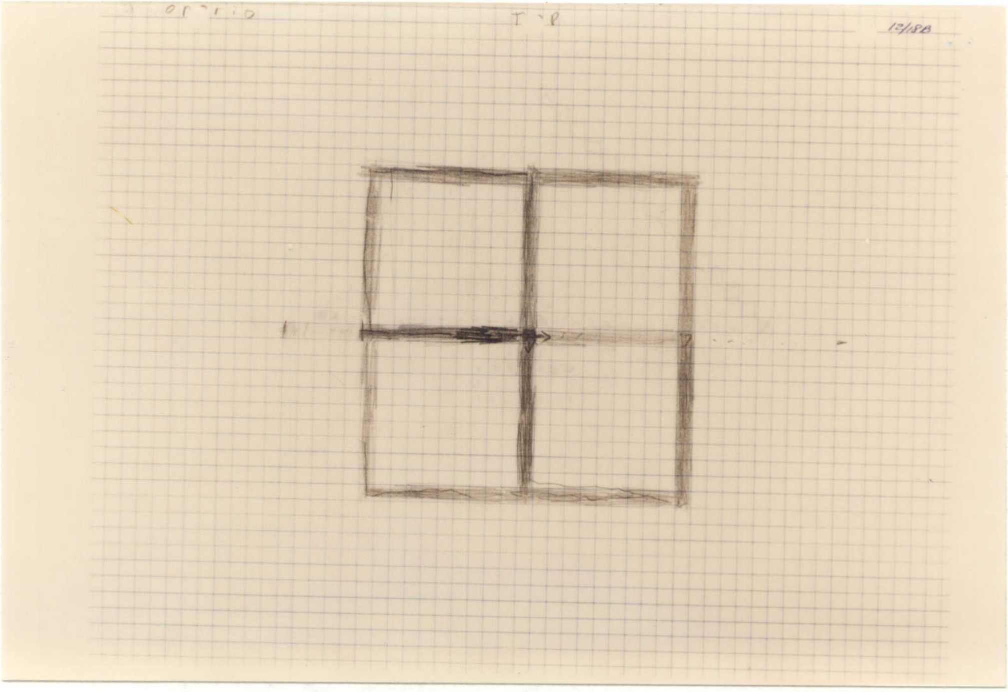


Figure 48. Assignment 9.1B. Knowledge used: concepts of procedural logic, point of origin, repetition, 90 degree turn, forward, out of view, and symmetry; Linguistic tools: dots, arrow points, colored-in lines, and some erasing; Logic: read code, color-in code as lines on paper, check-off code as completed, read next line, repeat until done. (41% of original size)

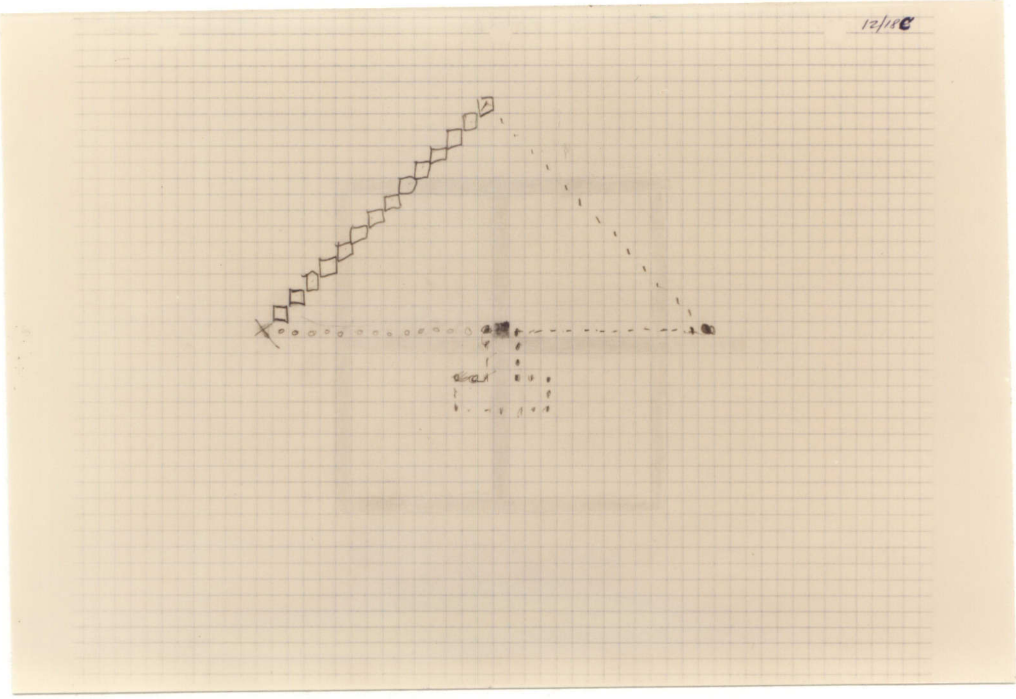


Figure 49. Assignment 9.1C. Knowledge used: concepts of procedural logic, point of origin, key points along a line, symmetry, left, forward, right, out of view, 90 and 135 degree angles; Linguistic tools: colored-in key shapes, points, circles, and "X", and square-to-diamond shapes; Logic: color-in shape, make small circles, an "X" then outline boxes, make points and dashes, then color-in dots, make more dashes and dots, scribbles, and a colored dot to indicate solution. (41% of original size)

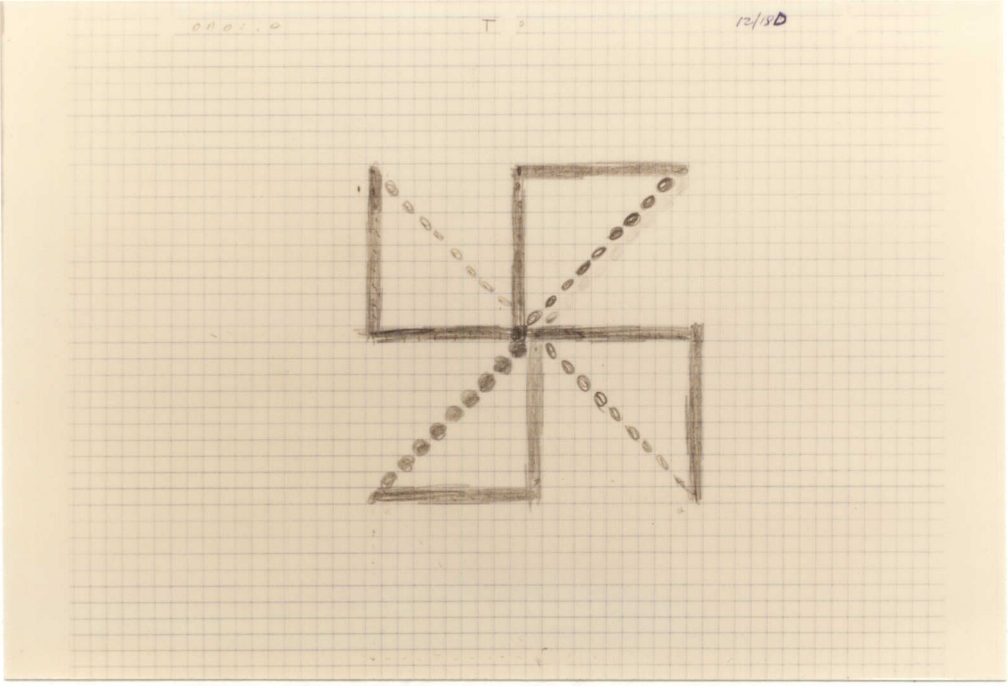


Figure 50. Assignment 9.1D. Knowledge used: concepts of procedural logic, point of origin, key points along a line, symmetry, forward, right, left, out of view, 90 and 135 degree angles; Linguistic tools: colored-in key shapes, points or dots, lines, and angles; Logic: color-in shapes over small dots/points, complete shape with broken lines (erase once to change placement). (41% of original size)

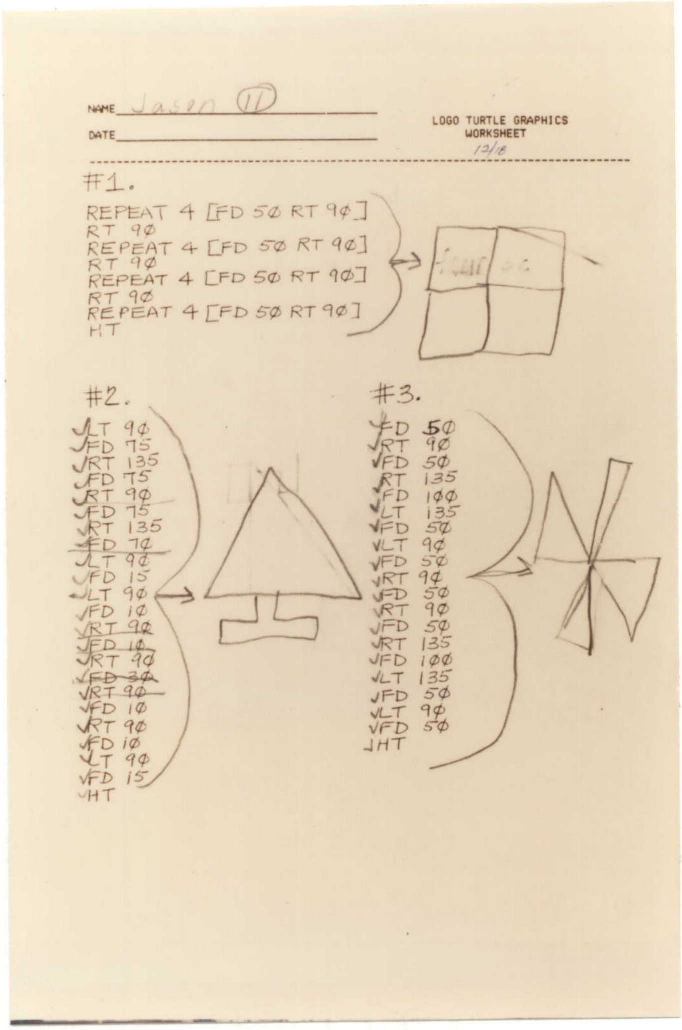


Figure 51. Assignment 9.1E. Knowledge used: concepts of procedural logic, equivalence (correspondence), cause and effect, repetition, forward, right, left, gone from view, 90 and 135 degree angles; Linguistic tools: brackets, outlined shapes, arrows, erased labels, checks, and lines through executed code; Logic: making checks, lines, shapes, arrows, and brackets. (41% of original size)

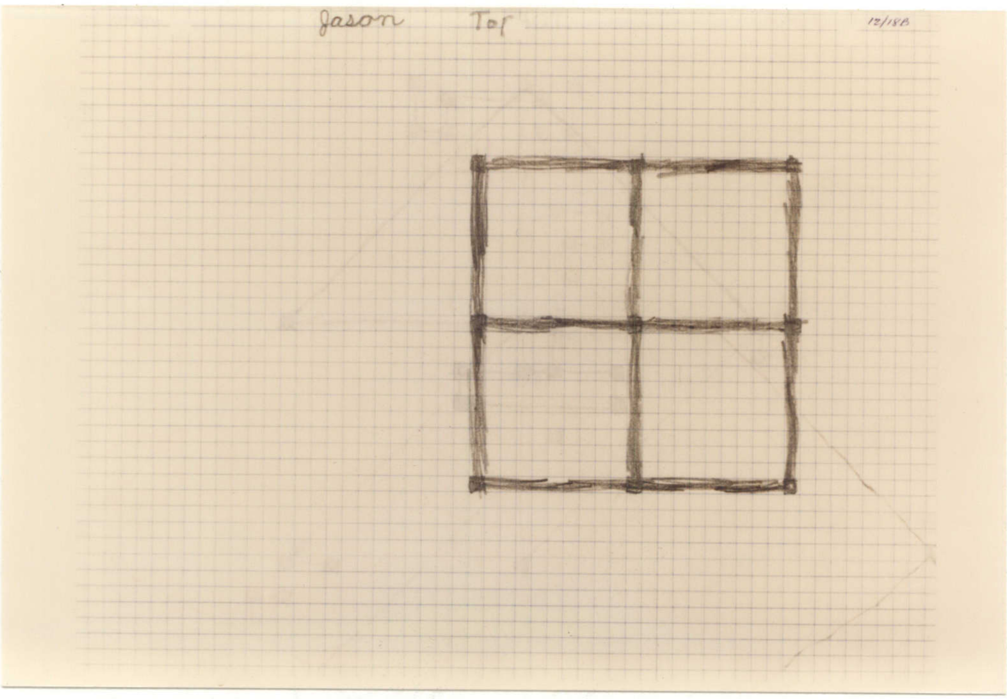


Figure 52. Assignment 9.1F. Knowledge used: concepts of procedural logic, point of origin, 90 degree right turn, forward, out of view, and symmetry; Linguistic tools: colored-in key points and colored-in connecting lines; Logic: read code, color-in key points, then color in connecting line (bracket the code and add drawing). (41% of original size)

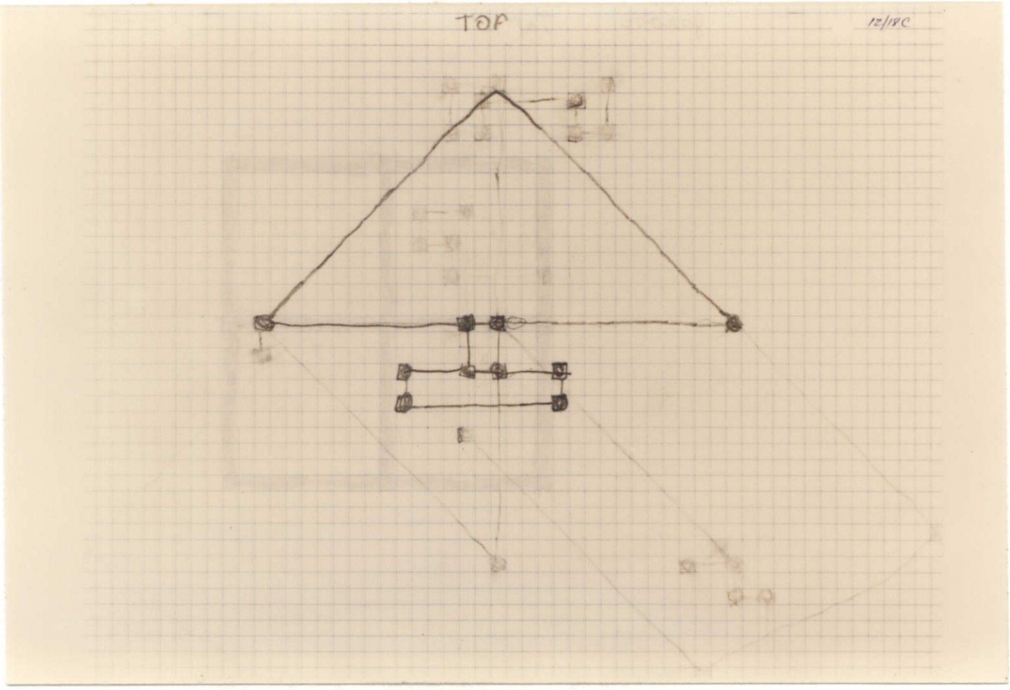


Figure 53. Assignment 9.1G. Knowledge used: concepts of procedural logic, point of origin, key points along a line, symmetry, left, right, forward, out of view, 90 and 135 degree angles; Linguistic tools: colored-in key shapes, connecting lines, and previously erased drawing; Logic: read code, color-in key shapes, draw connecting line, repeat then erase, change orientation, new drawing, same technique. (41% of original size)

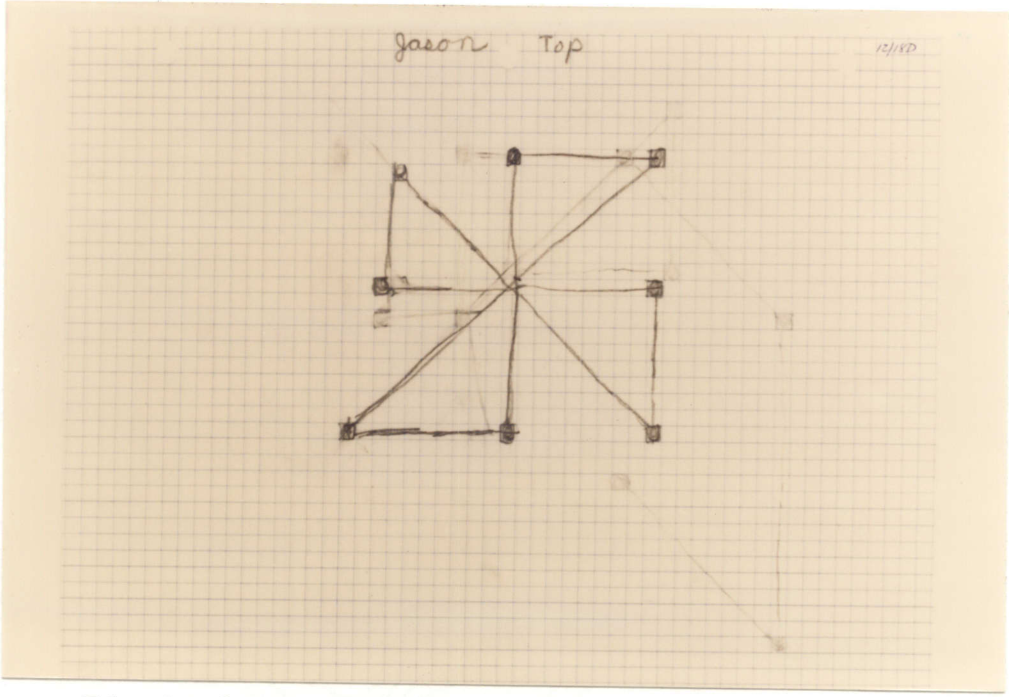
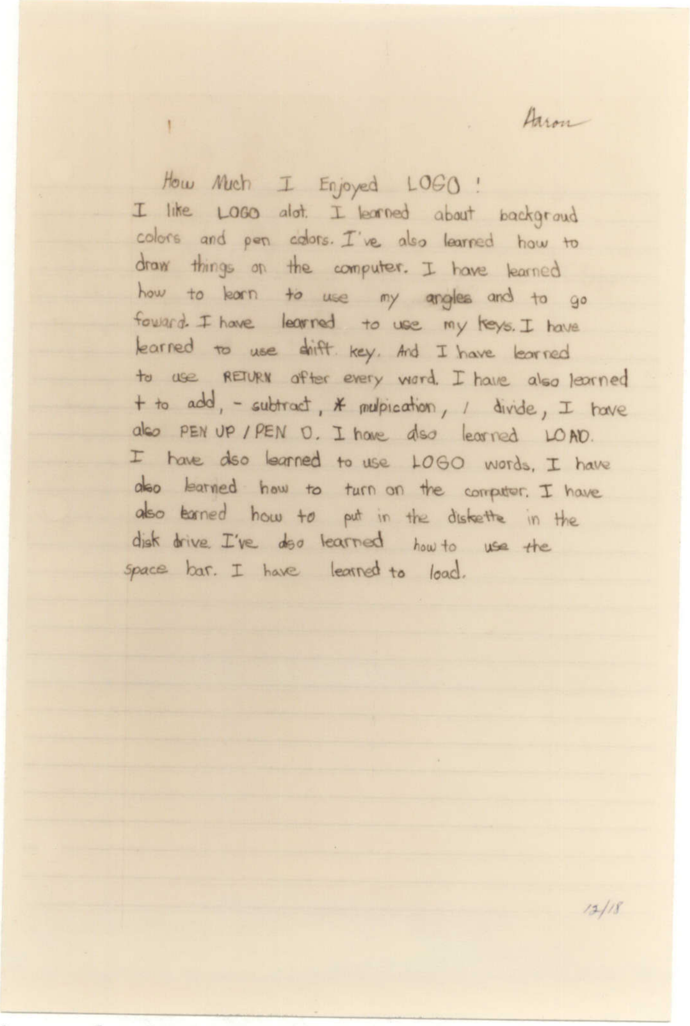


Figure 54. Assignment 9.1H. Knowledge used: concepts of procedural logic, point of origin, key points along a line, asymmetry, forward, right, left, out of view, 90 and 135 degree angles; Linguistic tools: colored-in key points, lines connecting dots, and erased points and lines; Logic: read code, color points, draw line, erase, repeat and keep a line or two then erase., modify, etc. (close approximation of desired shape is imposed over layers of erased lines). (41% of original size)

APPENDIX C

SUBJECTS' LETTERS



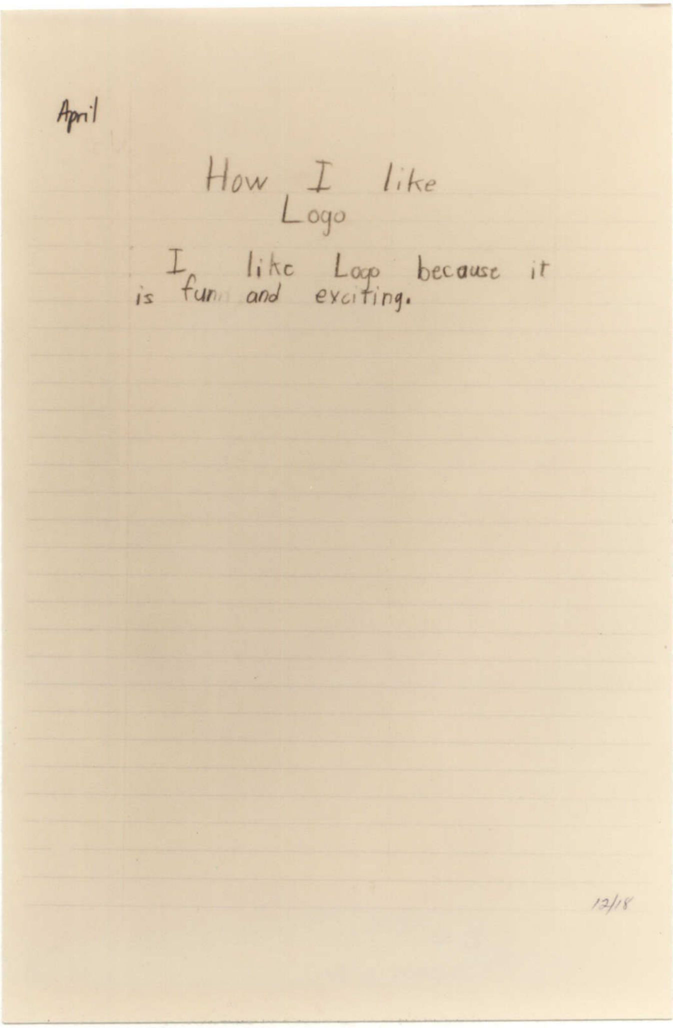
Aaron

How Much I Enjoyed LOGO !

I like LOGO alot. I learned about backgroud colors and pen colors. I've also learned how to draw things on the computer. I have learned how to learn to use my angles and to go foward. I have learned to use my keys. I have learned to use shift key. And I have learned to use RETURN after every word. I have also learned + to add, - subtract, * mulpication, / divide, I have also PEN UP / PEN D. I have also learned LOAD. I have also learned to use LOGO words. I have also learned how to turn on the computer. I have also learned how to put in the diskette in the disk drive. I've also learned how to use the space bar. I have learned to load.

12/18

Figure 55. Aaron's Letter.



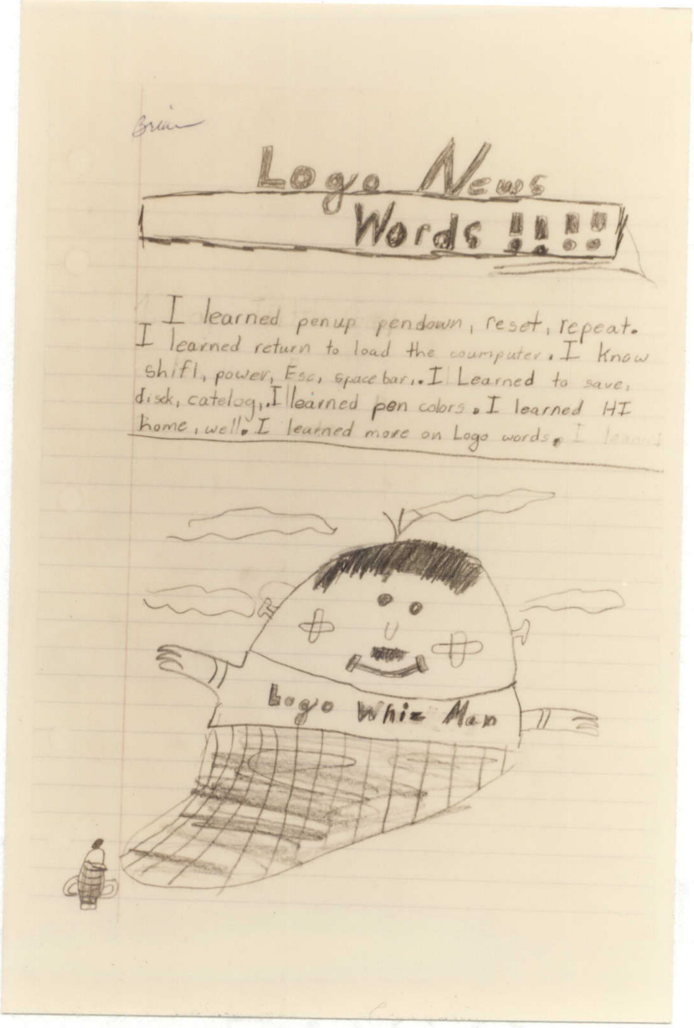
April

How I like Logo

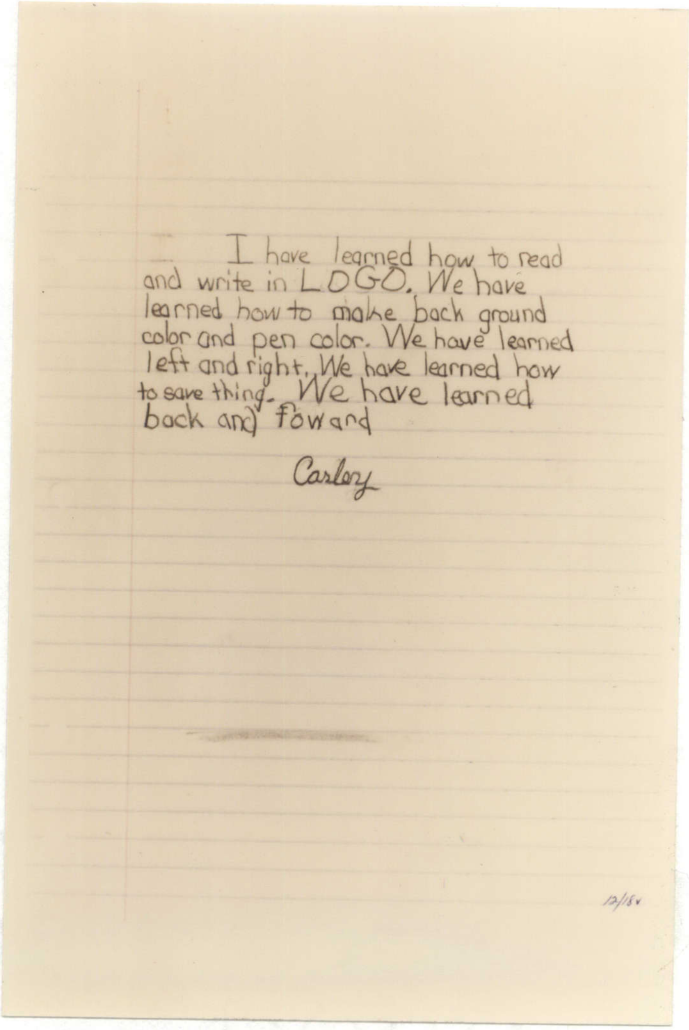
I like Logo because it is fun and exciting.

12/18

Figure 56. April's Letter.



<u>Figure 57.</u> Brian's Letter.

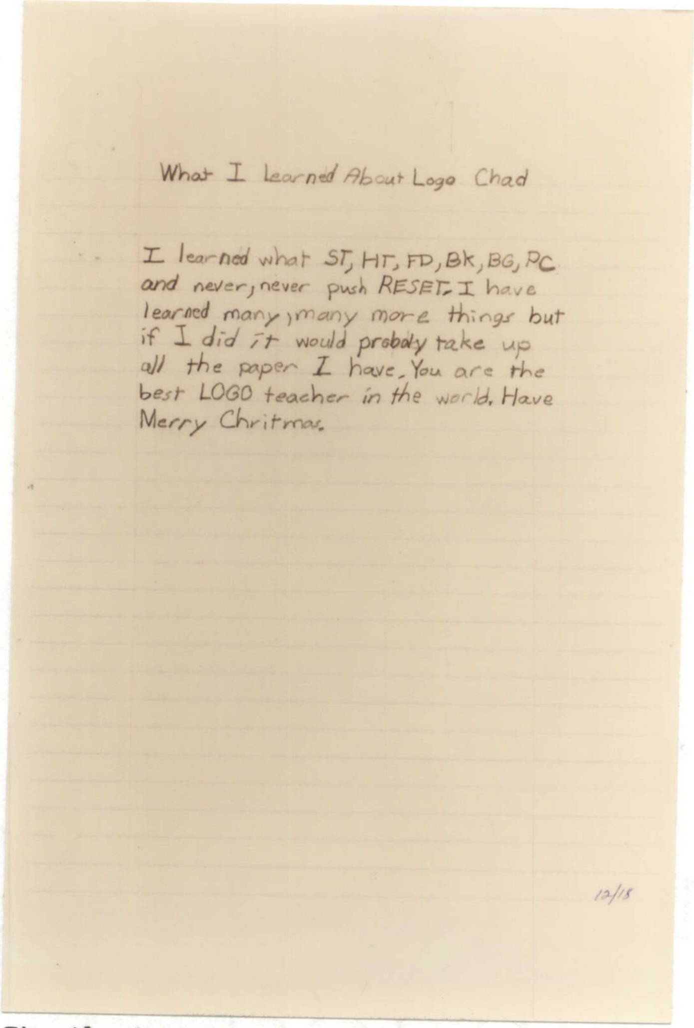


I have learned how to read and write in LOGO. We have learned how to make back ground color and pen color. We have learned left and right. We have learned how to save thing. We have learned back and foward

Carley

12/18✓

Figure 58. Carley's Letter.

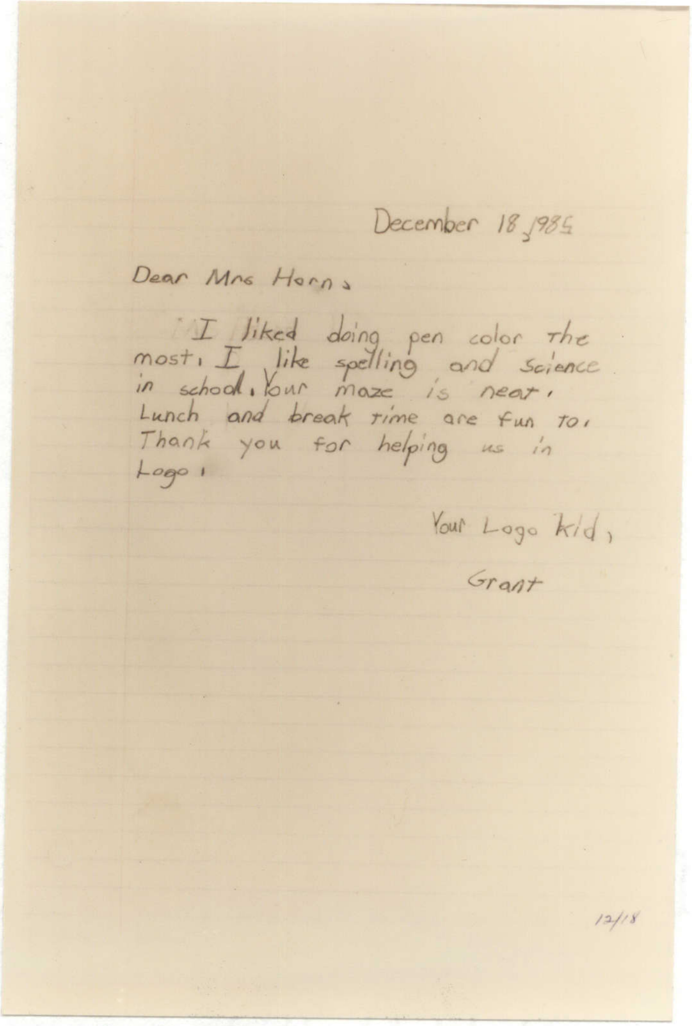


What I Learned About Logo Chad

I learned what ST, HT, FD, BK, BG, PC and never, never push RESET. I have learned many, many more things but if I did it would probaly take up all the paper I have. You are the best LOGO teacher in the world. Have Merry Chritmas.

12/18

Figure 59. Chad's Letter.



December 18, 1985

Dear Mrs Horn,

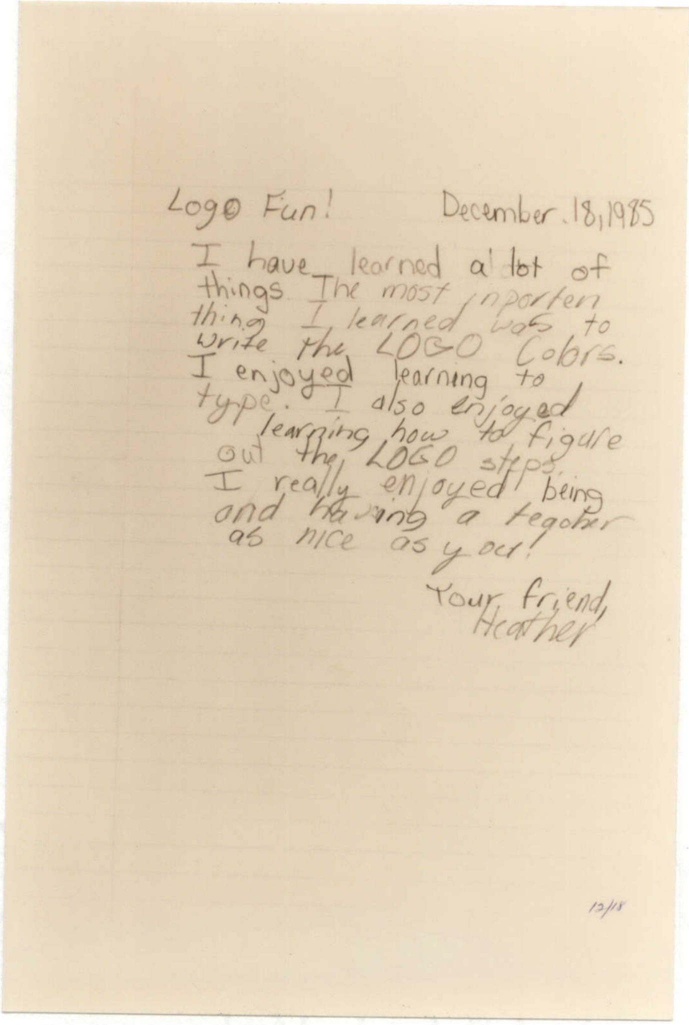
I liked doing pen color the most. I like spelling and science in school. Your maze is neat. Lunch and break time are fun to. Thank you for helping us in Logo.

Your Logo kid,

Grant

12/18

Figure 60. Grant's Letter.



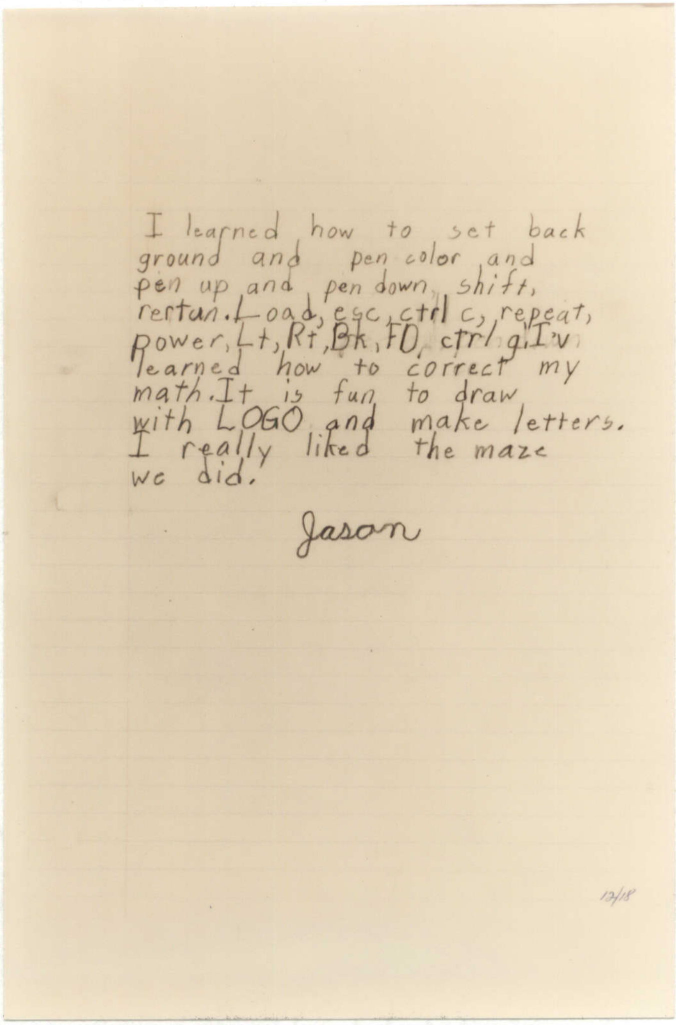
Logo Fun! December. 18, 1985

I have learned a lot of things. The most inporten thing I learned was to write the LOGO Colors. I enjoyed learning to type. I also enjoyed learning how to figure out the LOGO steps. I really enjoyed being and having a teacher as nice as you!

Your friend,
Heather

12/18

<u>Figure 61.</u> Heather's Letter.

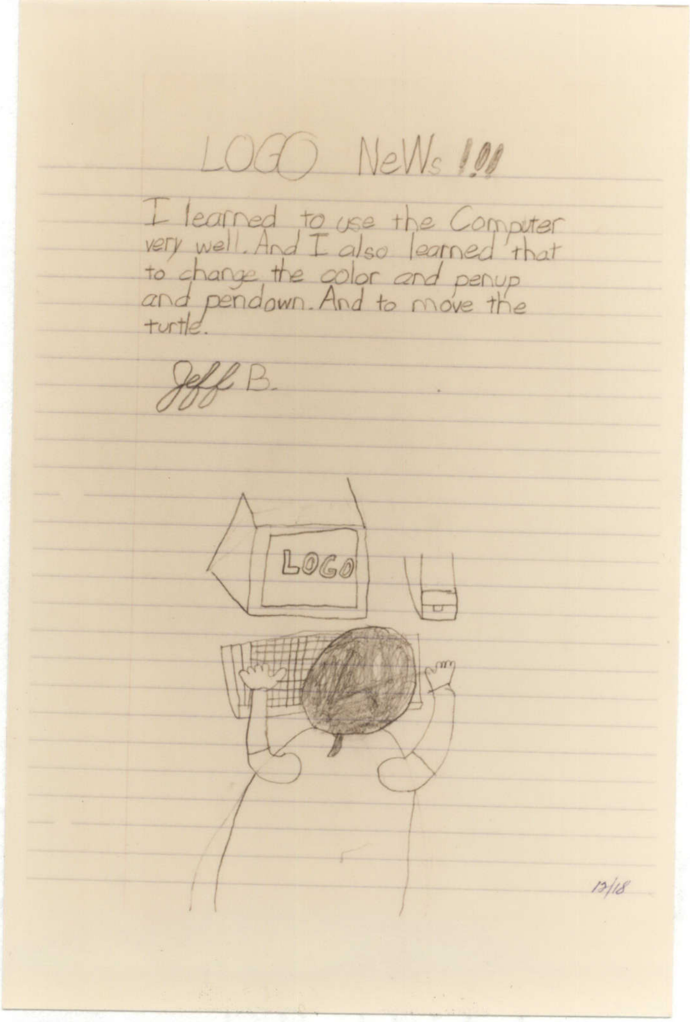


I learned how to set back
ground and pen color and
pen up and pen down, shift,
rectan. Load, esc, ctrl c, repeat,
power, Lt, Rt, Bk, FD, ctrl g. I'v
learned how to correct my
math. It is fun to draw
with LOGO and make letters.
I really liked the maze
we did.

Jason

12/18

Figure 62. Jason's Letter.

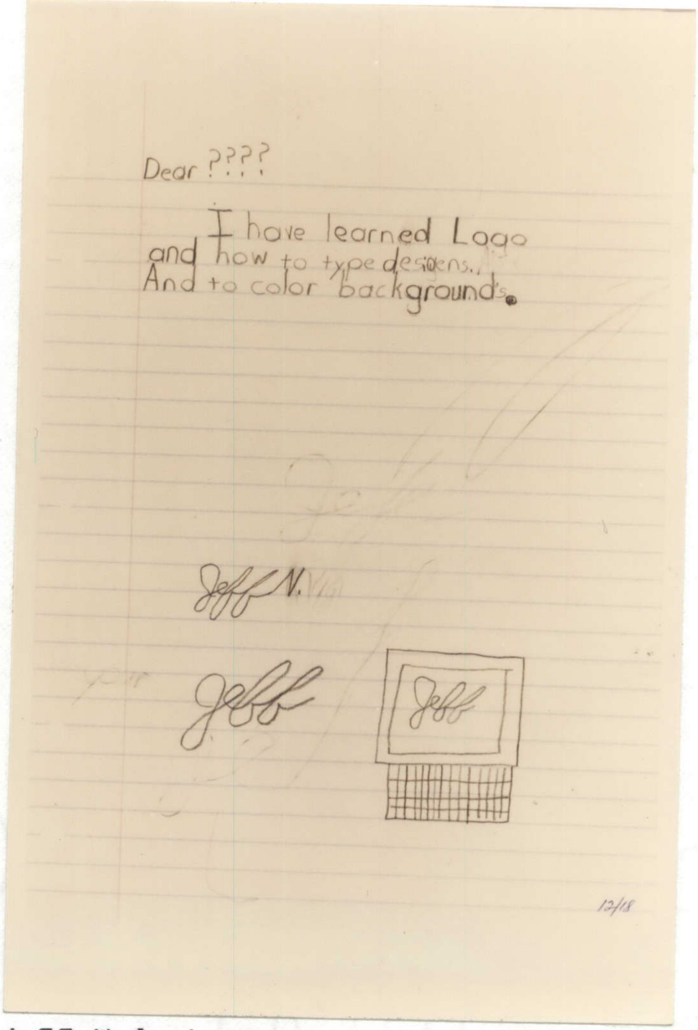


LOGO NeWs !!!

I learned to use the Computer very well. And I also learned that to change the color and penup and pendown. And to move the turtle.

Jeff B.

Figure 63. Jeff B.'s Letter.


Dear ????

I have learned Logo and how to type desigens.. And to color background's.

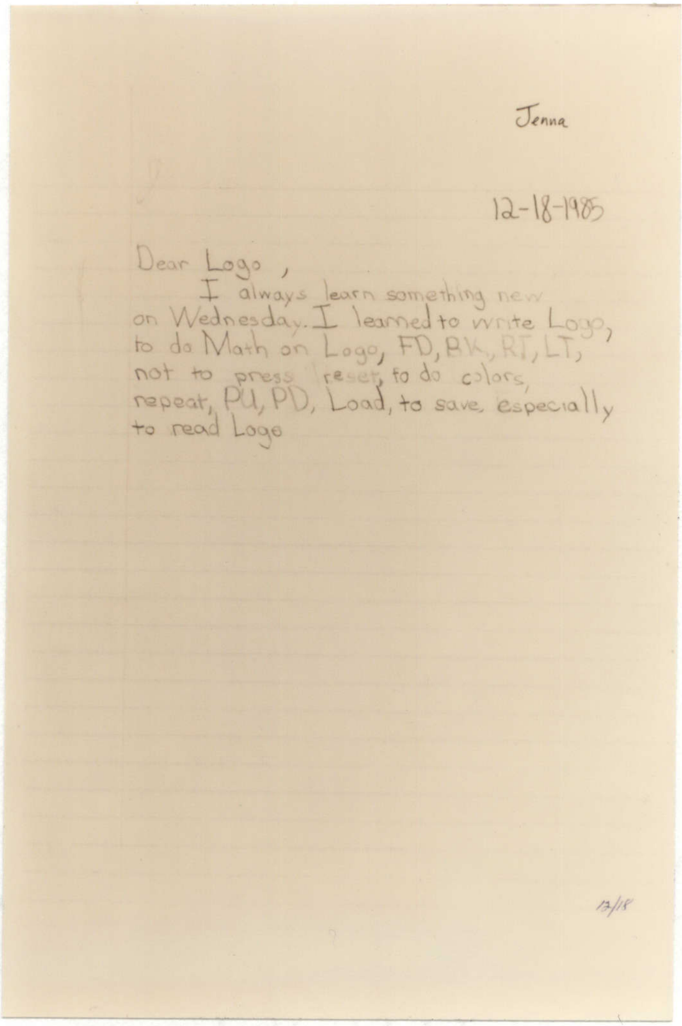
Jeff N.

Jeff

Jeff

12/18

Figure 64. Jeff N.'s Letter.



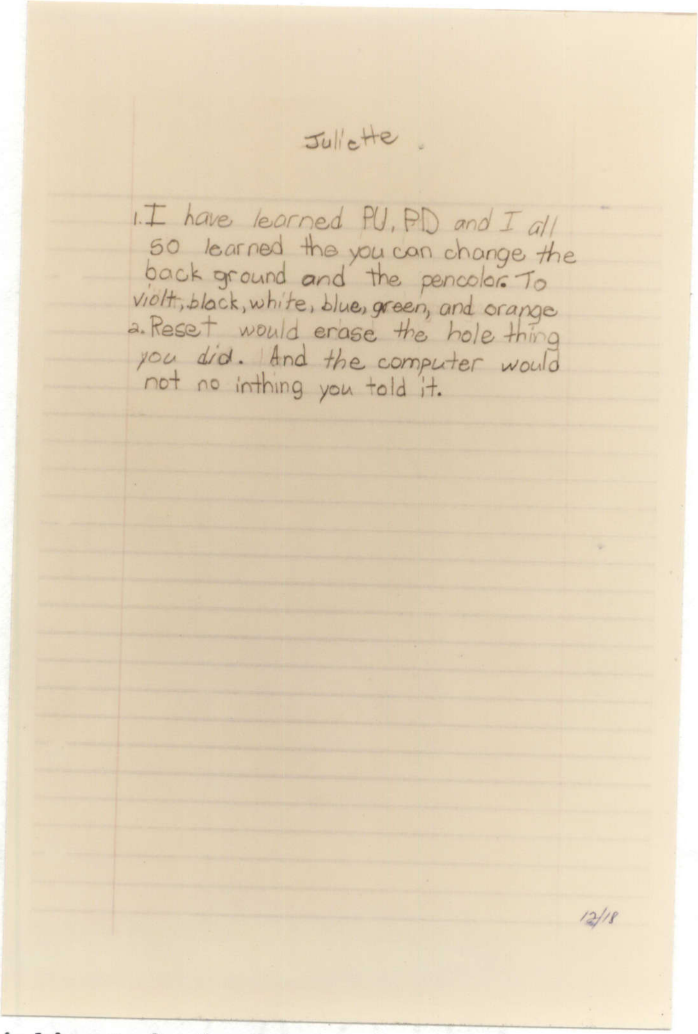
Jenna

12-18-1985

Dear Logo,
I always learn something new on Wednesday. I learned to write Logo, to do Math on Logo, FD, BK, RT, LT, not to press reset, to do colors, repeat, PU, PD, Load, to save especially to read Logo

12/18

Figure 65. Jenna's Letter.

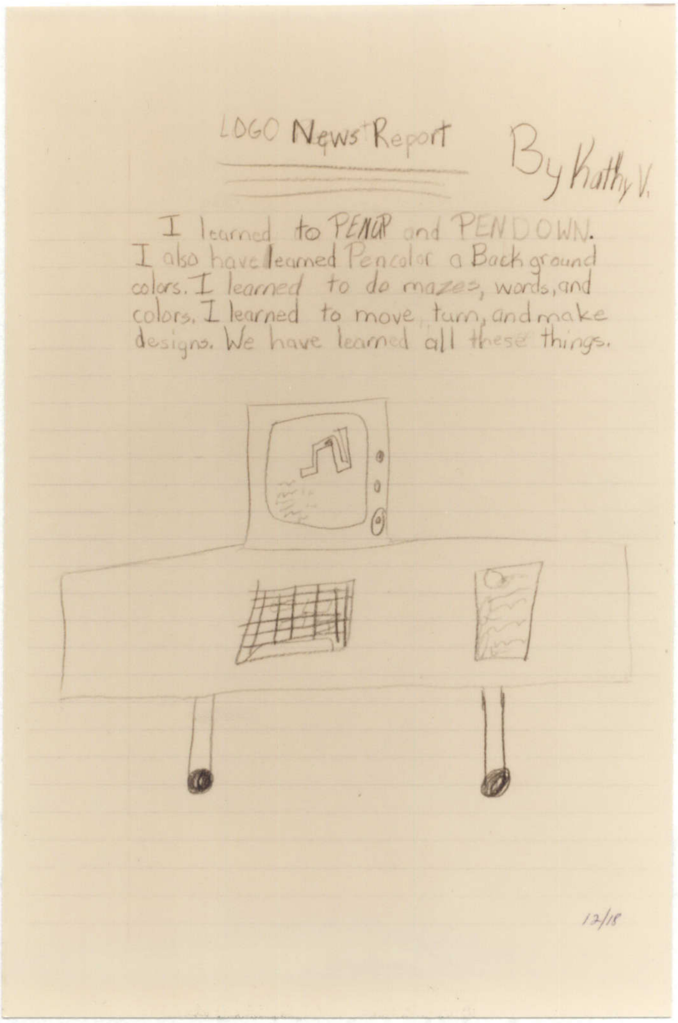


Juliette

1. I have learned PU, PD and I all
so learned the you can change the
back ground and the pencolor. To
violt, black, white, blue, green, and orange
2. Reset would erase the hole thing
you did. And the computer would
not no inthing you told it.

12/18

Figure 66. Juliette's Letter.

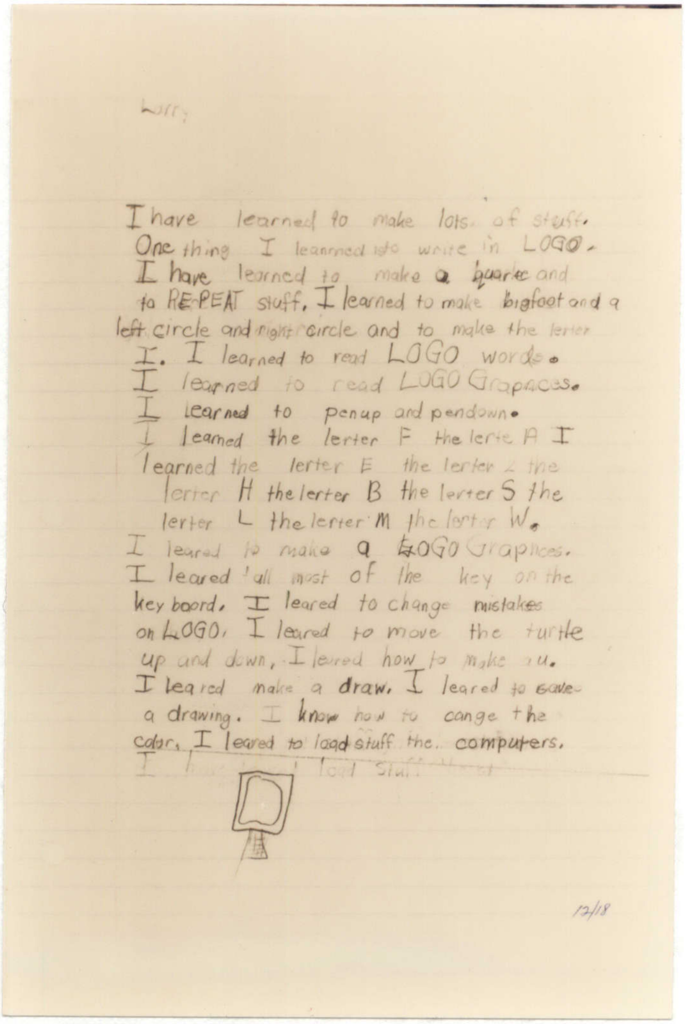

LOGO News+Report

By Kathy V.

I learned to PENUP and PENDOWN. I also have learned Pencolor & Back ground colors. I learned to do mazes, words, and colors. I learned to move, turn, and make designs. We have learned all these things.

12/18

<u>Figure 67.</u> Kathy's Letter.

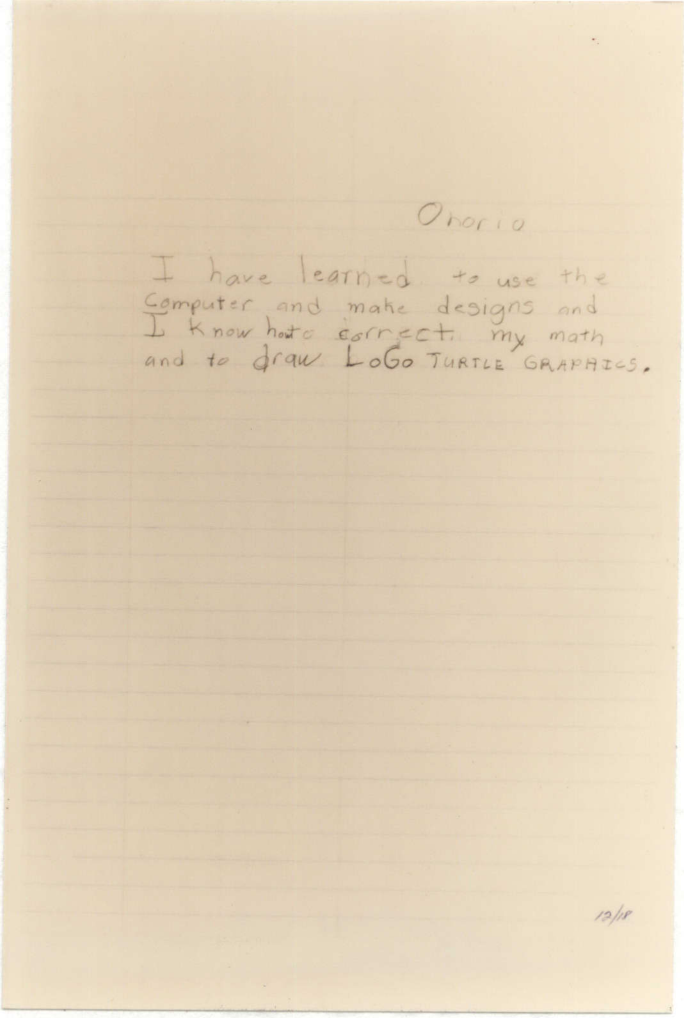


Larry

I have learned to make lots of stuff.
One thing I leanrned to write in LOGO.
I have learned to make a quarke and
to RE-PEAT stuff. I learned to make bigfoot and a
left circle and right circle and to make the lerter
I. I learned to read LOGO words.
I learned to read LOGO Grapaces.
I learned to penup and pendown.
I leamed the lerter F the lerte A I
learned the lerter E the lerter Z the
lerter H the lerter B the lerter S the
lerter L the lerter M the lerter W.
I leared to make a LOGO Grapices.
I leared all most of the key on the
key boord. I leared to change mistakes
on LOGO. I leared to move the turtle
up and down, I leared how to make a u.
I leared make a draw. I leared to save
a drawing. I know how to cange the
color. I leared to load stuff the computers.
I have [illegible] load stuff [illegible]

12/18

Figure 68. Larry's Letter.



Onorio

I have learned to use the
Computer and make designs and
I know how to correct my math
and to draw LoGo TURTLE GRAPHICS.

12/18

__Figure 69.__ Onorio's Letter.

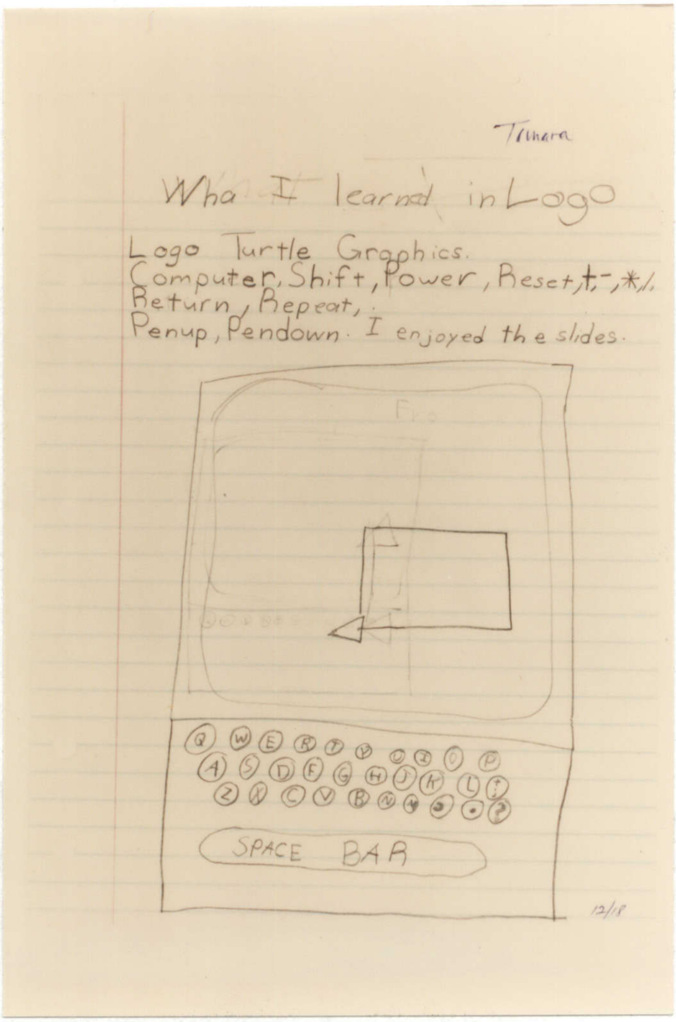
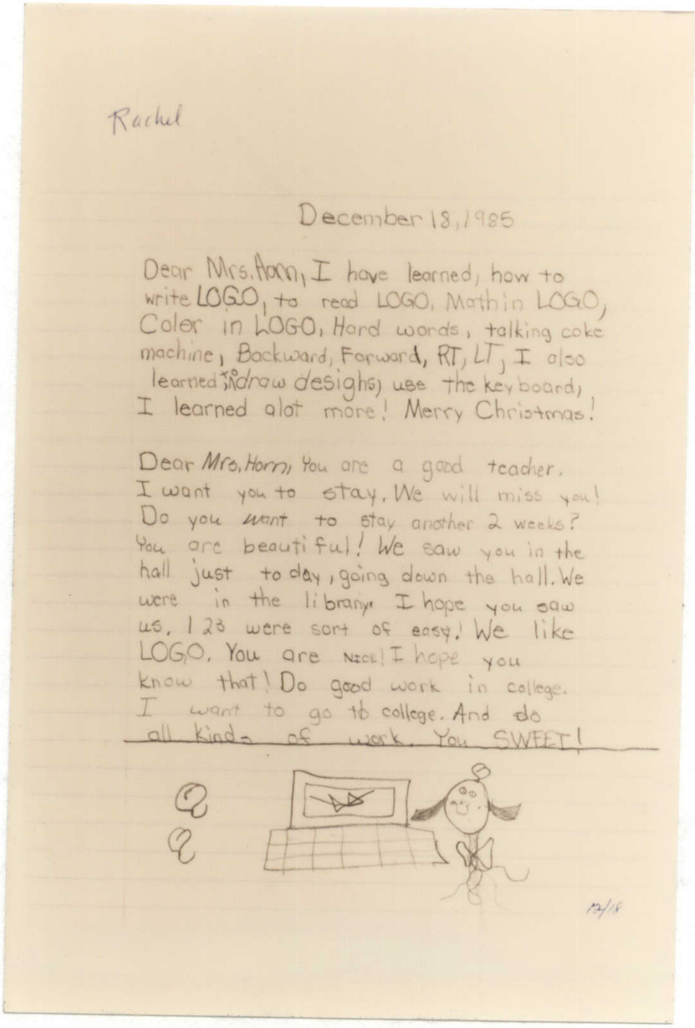


Figure 71. Tamera's Letter.



Rachel

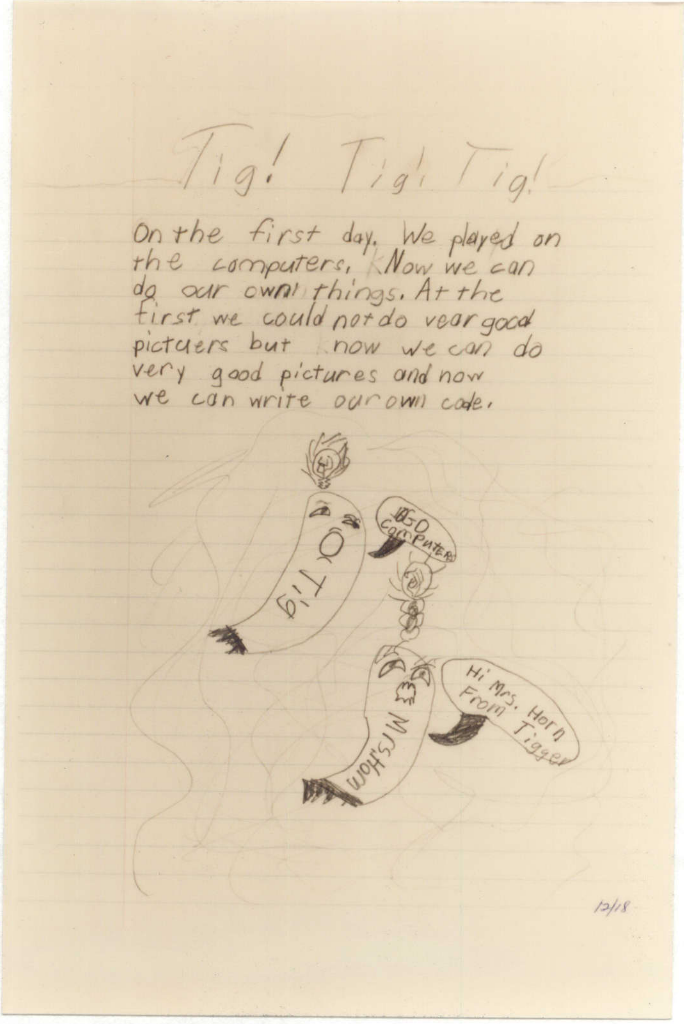
December 18, 1985

Dear Mrs. Horn, I have learned, how to write LOGO, to read LOGO, Math in LOGO, Coler in LOGO, Hard words, talking coke machine, Backward, Forward, RT, LT, I also learned to draw desighs, use the keyboard, I learned alot more! Merry Christmas!

Dear Mrs. Horn, You are a good teacher. I want you to stay. We will miss you! Do you want to stay another 2 weeks? You are beautiful! We saw you in the hall just to day, going down the hall. We were in the library. I hope you saw us. 1 2 3 were sort of easy! We like LOGO. You are Nice! I hope you know that! Do good work in college. I want to go to college. And do all kinds of work. You SWEET!

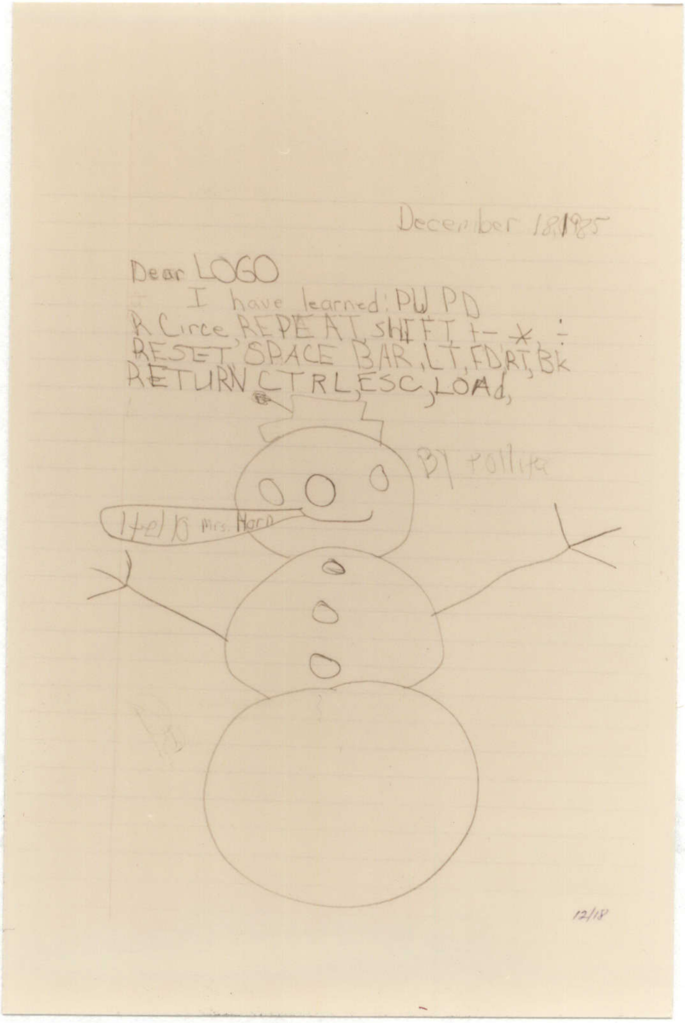
12/18

Figure 70. Rachel's Letter.


Tig! Tig! Tig!

On the first day. We played on the computers. Know we can do our own things. At the first we could not do vear good pictuers but now we can do very good pictures and now we can write our own code.

Figure 72. Tigger's Letter.


December 18,1985

Dear LOGO
I have learned: PW PD
R Circe, REPEAT, SHIFT, +- * ÷
RESET, SPACE BAR, LT, FD, RT, Bk
RETURN, CTRL, ESC, LOAd,

BY Tollita

Hel lo Mrs. Horn

Figure 73. Tollita's Letter.

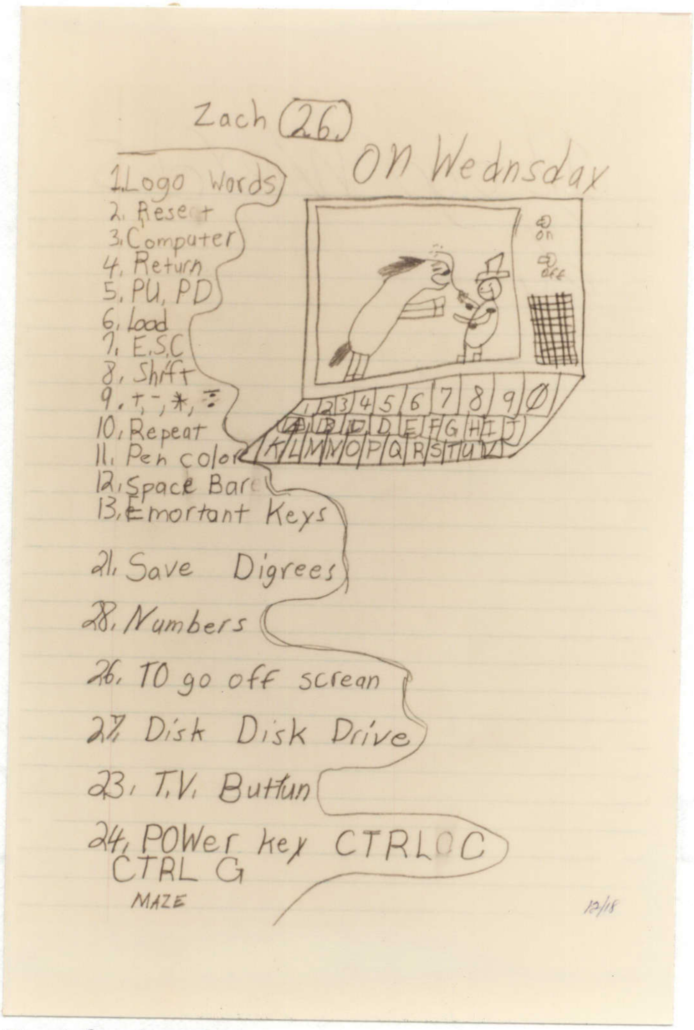


Figure 74. Zach's Letter.

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