GENDER AND STYLE DIFFERENCES IN A
LOGO-BASED ENVIRONMENT

by

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Gender and Style Differences in a LOGO-based Environment

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ABSTRACT

Previous gender studies on computer use have concerned themselves with attitudes and abilities but have neglected the deeper issues of how children appropriate and interact with computers. A field study of 10 children in a LOGO-based environment revealed that all of them appropriated the computer in meaningful ways; however, two distinct patterns of interaction emerged. Some children, many of whom are boys, tend to think about the computer in terms of what they can do with it to increase their expertise, power, and control over their physical and emotional environments. The focus on power and control issues may be due to difficulties they have with personal relationships. Other children, many of whom are girls, tend to think about the computer in terms of building personal relationships with it and others. Although they know the computer is not alive, they wish it were, and that it could communicate with them more easily. These children also want the computer to be their friend, to collaborate with them, to facilitate their thinking; they want to "trust" it. A model of interaction was developed from these differing patterns.

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In the fall of 1985 a research project called Project Headlight began at an inner city school in Jamaica Plain, Massachusetts. The project is a collaborative effort between funding sources, researchers from the Learning Research Group in the Media Lab at the Massachusetts Institute of Technology, and students, teachers, and administrators from the James W. Hennigan Elementary School. The purpose is to create a "school of the future" which provides 100 computers for 220 children. The intent is not to teach children computer literacy, but to help them learn to use the technology in ways that are meaningful to them.

During the first year of the project our group studied how a computer culture grows and the different styles children use to program computers. I was skeptical at first: I was not convinced that computers or we could make a difference in the way children learned or were taught. We followed Seymour Papert's philosophy of education: we did not teach programming, but instead allowed the children to explore the computer with the programming language LOGO. By the end of the first year exciting things were happening. Children were programming, sharing their ideas, and talking excitedly about their work. Our preliminary findings showed a wide range of programming styles that correlated with standard cognitive styles and projective psychological tests.

During the year many people visited the project and asked if we saw any gender differences. We had not seen any, but we had not studied the question systematically. In interviews with the children we had found that they said that they liked the computer, and that the computer was equally appropriate for girls and boys. We wondered whether a different kind of computer culture might eliminate the gender differences found by many researchers.

We felt a need to study gender and computers using a paradigm that focused on deep structures like personality and style rather than surface structures like attitudes and abilities. Fortunately, a new paradigm for studying gender has emerged which is structured around how developmental issues, identity, language, and style affect the way men and women think and know. My work has been greatly influenced by the work of three researchers: Carol Gilligan in her work on moral development; Sherry Turkle in her work on child programmers and the computer as an evocative object; and Evelyn Fox Keller in her work on gender and science. In their spirit I have developed my own study of gender and how children appropriate computers.
I have cast a wide net: the computer illuminates only one part of a larger picture of gender. Gender is not only about being male and female but includes issues of personality, personal relationships, style, identity, and language. Thus, when we speak of studying gender and computers, we include all these other issues. To create a profile of the "whole" child that encompasses each of these deep psychological structures is both complex and difficult. It demands a new methodology and a new way of thinking about the issue.

The way in which I collected my data and the way in which I present it here is not traditional research. I gathered much of the data through clinical interview and observations. The material is rich and different for each child so much of what has been seen and heard can only be captured as part of the whole picture. Therefore, you will not find a simple summary of the results, nor will you find a one-to-one correlation between the conclusions drawn and specific results. Instead you must read the results, conclusions, model, and case studies together to see how the pieces fit into the whole.

The first part of the thesis is an introductory piece on a new paradigm for studying gender. Next comes a discussion of personal appropriation. Third is a discussion of methodology with the last part of this section the specific methodology I use. After methodology is a description of the research site. Then comes a review of results and a longer theoretical discussion of the findings. The model of interaction I developed -- which actually represents many of the results -- follows this theoretical discussion. The reason it comes after the discussion is that there is an interaction between the results, discussion, and model sections. Each is part of the other; none can stand alone. Finally, the plausibility of my model and theoretical discussion is illustrated in the case studies.

To keep the flow of the narrative intact I have relegated many details to the appendices. Although they do not fall in the main body of the text, I hope you will take time to study these important details. I wanted to maintain a flow of narration that illustrates the interaction between theory, results, and my model of interaction.

In the text I have often made generalizations about the way boys and girls interact with and think about computers. I have done so to eliminate the awkwardness of constantly saying some children, many of whom are girls, tend to do one
thing, and some children, many of whom are boys, do another. I do not expect, nor do I want, the reader to believe that all boys do one thing and all girls another. You will see that I found general truths about girls and boys, and they do not necessarily apply to any particular girl or particular boy. The styles of interaction I have developed are extremes on a continuum; few children will fit at one extreme or the other. What is more likely is that most children will fit somewhere close to their preferred style of interaction.

Many readers will wonder why in this study of gender I have chosen to use the pronoun "he" instead of "he or she" or "he/she." I find these locutions awkward. The use of "she" is unfamiliar and no less biased than the use of "he." Therefore, I have chosen the conventional English usage.

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I. A NEW PARADIGM FOR STUDYING GENDER

In the educational literature on gender and computers psychological researchers have focused their studies on computer attitudes and abilities as they relate to gender. This thesis on gender differences in the use of computers in education goes beyond studying ability and attitudes and seeks ways of looking at how identity, language, and style enter into the fabric of what children think about and relate to computers. I see this thesis as contributing to an emerging paradigm for studying gender, one which I shall show to be particularly appropriate to the study of computer use. This paradigm is a structure which allows us to look at deep psychological and epistemological questions.

In my view gender research in the traditional paradigm verges on the behavioristic in several respects: Its methodology is one which focuses on correlations between observable attributes rather than on model building; it is biased toward quantitatively measurable attributes such as abilities and attitudes; when intellectual style is studied at all it seen through a prism of quantitative scores such as reflectivity versus impulsivity; and, the experimental design does not allow for recognition and interpretation of the complexities of the human personality. I do not reject any of these methods as such. They are appropriate to a different way of looking at issues related to gender and computer use, and I use them as ancillary devices for a
study that goes beyond "surface structures" to look for "deep structures" and goes beyond measuring attributes to attempt critical epistemological reexamination of their meaning. In my search for a different approach I have been particularly influenced by several researchers -- all women -- who have been developing a new paradigm for the study of gender.

In particular three researchers--Carol Gilligan, Evelyn Fox Keller, and Sherry Turkle--have independently begun to construct a new way of looking at and defining what it means to study gender. In different ways they are shifting the study of gender from its focus on specific abilities to a more epistemological approach--that is, to questions about the roots from which men and women construct knowledge, how differing work styles determine the way in which men and women appropriate knowledge, and how attributed meanings affect the models used to construct knowledge.

Carol Gilligan (1982) suggests that the gender issue is concerned more with questions of identity than with biological differences between boys and girls. Making use of Nancy Chodorow’s theories about gender differences, Gilligan poses her own model of development. Chodorow asserts that gender differences are due to the early social environment created by female caretakers. Girls identify with and remain close to the mother, and therefore tend to develop a personality that emphasizes connection. Boys, in
order to develop their masculinity and perhaps because of Oedipal issues, separate from the mother and identify with the father. This leads to greater individuation for boys, while girls feel more connected and less differentiated than boys. According to Chodorow, this primary definition of self does not mean that girls have "'weaker' ego boundaries," but instead means they have a built in mechanism for experiencing the needs and feelings of others as their own. From Chodorow's work Gilligan concludes,

...Relationships, and particularly issues of dependency, are experienced differently by women and men. For boys and men, separation and individuation are critically tied to gender identity since separation from the mother is essential for the development of masculinity. For girls and women, issues of femininity or feminine identity do not depend on the achievement of separation from the mother or on the progress of individuation. Since masculinity is defined through separation while femininity is defined through attachment, male gender identity is threatened by intimacy while female gender identity is threatened by separation. Thus males tend to have difficulty with relationships, while females tend to have problems with individuation.¹

Gilligan says this different way of thinking manifests itself in the moral development of men and women. Because of early development processes, men and women follow different patterns of moral development. Because women's identity is defined in a context of relationship they base moral decisions on a standard of responsibility and care.

On the other hand, men, whose identity is defined in a context of separation and achievement, make moral decisions based on principles of justice.

Gilligan’s position is in sharp conflict with the model posed by Lawrence Kohlberg (1984) who developed a stage theory for the development of morality based on a longitudinal study that included only males. Kohlberg asserts that there are six stages of moral development. They range from moral realism, the belief that the goodness or badness of an action is a real, inherent, and unchanging quality to stage six, the "morality of universalizable, reversible, and prescriptive general ethical principles."² Stage six includes the recognition that each person makes his or her moral judgements based on the equal consideration of the points of view of the persons involved as well as universal principles of justice.

Kohlberg’s model leads to the conclusion that women are less mature in their moral development than men. Ways of thinking that Gilligan admires in mature women are classified in Kohlberg’s third stage of development, a stage where "morality is conceived of in interpersonal terms and goodness is equated with helping and pleasing others."³ This statement carries an implicit judgement that certain types of thinking have greater value than others. According

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³ Gilligan, op. cit., p. 18.
to Kohlberg, making moral decisions based on principles is clearly a more mature form and better way of thinking than making moral decisions based in the context of relationships.

Gilligan (1982), in response to Kohlberg’s work, argued that in order to understand how women construct reality, one needs to study women as well as men; that a stage theory biased by a study of all men and based on male childhood development would not work as a model for female moral development. Gilligan found that a different outline of moral development emerged when she studied women. In her model, the moral problem arises "from conflicting responsibilities rather than from competing rights and requires for its resolution a mode of thinking that is contextual and narrative rather than formal and abstract."4

Implicit in this finding is the value placed on thinking in different contexts. For women, the resolution of a moral dilemma is dependent on maintaining a connectedness with others rather than a pure objectivity, on relationship rather than individuation. Women do not rely on principles of justice to determine solutions to moral dilemmas because they feel that the solution to moral dilemmas must be based on the context of the situation. For them, the solution comes from an ethic of care and relationship rather than an ethic of principles of justice.

Gilligan argues that this is an equally important and valid way of making moral judgements. She asserts that different modes of development may lead to different but equally valid ways of knowing which, in turn, lead to different ways of thinking about making moral decisions.

Although our culture recognizes the existence of different cognitive styles, it leads one consciously and unconsciously to assign greater value to certain approaches to thinking. One place where this has been clearly demonstrated is in the computer programming culture. Attitudes that recognize logical, analytical thinking as being a higher form of thinking have been built into structured computer programming languages. Most programming languages have been designed to favor a structured, top-down approach to programming. They emphasize logical, analytical, and modular thinking. They also involve issues of control. They allow programmers to build and control all the objects in a computer environment.

The traits needed for "good" programming in this style are those generally considered to be male attributes, not female ones. Computer programming emphasizes control, individuation, analytical thinking and objectivity, and de-emphasizes the "feminine" traits of subjectivity, contextual thinking, and connection. In order to be a programmer, one

must be able to talk and think in a logical, that is, masculine way. For women to do so is to deny the very attributes that give women their perspective and style. By implication, it means accepting the judgement that the male ways of thinking, talking, and doing are more important and valid than women's ways of thinking.

Evelyn Fox Keller (1985), in her work on gender and science, has proposed that society has generated a mythological dichotomy of male and female thinking: Objectivity and reason are considered male; subjectivity and feeling, female. This disjunction of male and female is sharpened when conceptual and social polarizations separate men and women in the practice of particular intellectual and emotional endeavors. This conceptual polarization defines men as being separated from emotional endeavors and women as being separated from intellectual endeavors. Keller believes this separation isolates the female or male perspective from the other, and by isolating one perspective, creates the illusion that only the other perspective is legitimate.

One way this polarization manifests itself is through the use of language. Keller claims that our interpretations of words associated with science are directly related to the construction of gender. For example, the word "objectivity" has been "genderized" to imply a definition that is related to the definition of masculinity, as in: "...the pursuit of
knowledge that begins with the severance of subject from object rather than aiming at the disentanglement of one from another."^6 Keller states that a predominantly masculine language creates the models by which scientists pursue their discipline.

This phenomenon occurs in other fields as well. For example, the language of the computer culture grew as a male language that women adapted to and assimilated. Words such as tweak, crash, delete, expunge, kill, and hack have a violent or sexually aggressive tone. Both the words hack and crash imply violence. To hack means to cut with irregular and heavy blows; to crash means to fall, break or collide noisily^7 as well as to fail suddenly. These words used to describe what one does on the computer, or what the computer may do, imply aggressive and controlling acts on the part of the programmer over the computer or the computer over the programmer. They suggest a continual power struggle between computer and programmer.

According to Keller, not only the vocabulary but also the pursuit of science, as we know it in the West, has violent overtones. Instead of being an endeavor of understanding, it has become an endeavor of conquering and dominating nature, partly because of the way in which doing

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science has been defined. Although many scientists today would say that what they do is to try to understand the physical world, much of what they do is try to control it. In fact, among the stated goals of science are prediction and, ultimately, control of the phenomenon studied. Understanding, as Keller defines it, is to appropriate, or to make one's own; it is also to accommodate, or make oneself that thing. It also means to have a deep personal connection and relationship with something; to find a symbiosis, a way of communicating, a way of "hearing" what nature has to tell us. It means unraveling the mystery for the sake of knowing, not for the sake of the control the knowledge gives us.

Keller asserts that the masculinization of words like "objective," and their association to the accepted way science is to be done has eliminated any other possible model. As during Kuhn's period of "normal science", this paradigm for accepted definitions and ways of doing science has been unalterable and immune from criticism. According to Keller, however, there are other possible and equally valid interpretations of the words associated with science. For example, the word "objective" can have a more feminine conceptualization:

"...a pursuit of knowledge that makes use of subjective experience in the interests of a more

8 Laudan, L. Progress and Its Problems. p. 73.
9 Emphasis added.
effective objectivity. Premised on continuity, it recognizes a difference between self and other as an opportunity for a deeper and more articulated kinship. The struggle to disentangle self from other is itself a source of insight—potentially into the nature of both self and other [object]....To this end the scientist employs a form of attention to the natural world that is like one's ideal attention to the human world: it is a form of love.\(^\text{10}\)

Keller calls this the concept of dynamic objectivity. Her interpretation of the meaning of objectivity not only redefines the term, but suggests a new way of thinking about science. Hers is a feminine perspective, one of being connected to as well as separate from what one studies. One example of this connection can be seen in the work of Barbara McClintock, the Nobel prize winning scientist. She said about her work,

"I found that the more I worked with [the chromosomes] the bigger and bigger [they] got, and when I was really working with them I wasn't outside, I was down there. I was part of the system. I was right down there with them, and everything got big. I even was able to see the internal parts of the chromosomes—actually everything was there. It surprised me because I actually felt as if I were right down there and these were my friends."\(^\text{11}\)

Her statement implies that she felt a part of the system and could imagine herself as a chromosome. Therefore, she could "see" and intuitively "feel" how they behave.

Keller suggests that maintaining this kind of connectedness allows us to learn not only about the physical

\(^{10}\) Keller, 1985, op. cit., p. 117.
world, but also about ourselves. By having the same kind of intimacy with the physical world that we would have with a lover we can only learn to know both the world and ourselves better. Relationships with others allow us to project our own emotions and personalities onto them, and in doing so, help us to know ourselves better. At the same time, intimacy with another allows us to know the other better too. Learning about the physical world through intimacy with it rather than through separation from it makes understanding a subjective as well as objective process. Having both a subjective and objective understanding allows us to ask questions not only about the physical world, but about ourselves as humans; how we work, and what we are made of.

In her work Keller has transformed the "gender issue" from being about males and females to being about two ways of understanding and knowing. Her paradigm proposes that we accept new definitions for the way in which we understand nature, shifting from a theme of disconnection and domination to a theme of connection and understanding by separating issues without destroying them, something Keller calls "disentanglement."

Another important aspect of this new paradigm for studying gender is the recognition of the existence of different styles of work and play. Sherry Turkle, in her work on computer cultures, found that computer programmers
have different styles of programming. For the sake of simplicity, she describes opposite extremes of a continuum to demonstrate two styles of programming, the hard masters and the soft masters. This is not to say that there are only two styles; there are many styles that can fall anywhere between the two ends of the continuum.

"Hards" are planners; they have rules for developing a plan and programming which they follow faithfully. If they find a bug they fix it and go back to their plan rather than incorporating its artifact into the program. They think analytically employing logical reasoning to solve programming problems. They program objectively; that is, they manipulate objects on the screen. When turning the turtle in Logo graphics they do not turn their bodies to see what direction to turn the turtle. They know without turning because they can objectively "see" which way it should be turned. The object is not an extension of hard mastery programmers; it is always something external to them that they control.

The "softs" are more impressionistic in their approach to programming. They negotiate with the material, building a piece here and a piece there and then putting the program together. If there is a bug in the program they are more likely to incorporate its effect rather than to delete the artifact. The object they are programming becomes an extension of the softs. One can often see a soft moving his
or her body as he or she tries to determine in which direction the "turtle" in LOGO must go. Like Levi-Strauss's bricoleur, softs "mess around" as they program. For soft masters, programming is more an exploration than a means to an end.

Using these models to study gender differences, Turkle found that girls tended more often to be soft programmers and boys were generally hard programmers. If girls identify with connection and relationship, and boys identify with objectivity and control, as suggested by Chodorow, then these profiles for hard and soft programmers are consistent with that model.

This theory of different styles of programming is also consistent with Gilligan’s models of moral development and Keller’s models for differing interpretations of language. As in their models, the issue of programming styles includes language, personality, and an acceptance of and the complementarity of varying styles. Different styles can be equally effective in solving problems, although with some problems one style might be better than another. For example, in some situations, such as studying motion in physics, it might be better to use the techniques of a soft mastery programmer. In figuring out the direction in which an object would move if it were hit by a second object, for

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example, it might help to be able to put oneself in the position of the first object. In other situations, such as preparing for a chemistry experiment where all the chemicals need to be measured precisely and in order, it may be better to use Turkle’s hard mastery style of working.

These three researchers have made an important contribution to the literature by questioning the assumptions of the existing paradigm for studying gender. First, they do not believe that the measured cognitive differences between boys and girls exhaust the important issues to address in the study of gender. They reject the implication of value in the concept of "ability" and they reject the narrowness of "cognition." Second, they believe that gender differences exist because of differing constructions of identity which are based on psychological experience. Third, they believe that language defines how we construct problems and knowledge. Varying interpretations of the meanings we give words associated with the pursuit of knowledge can lead to different and equally valid constructions of that knowledge. And fourth, they believe that different but equally valid styles of work may reflect both personality and gender.

This reframing has prompted a shift in the way we think about studying sex differences. We have moved away from studying specific abilities and biological differences and toward studying how the developmental process affects our
construction of meanings; that is, how differing developmental experiences affect men’s and women’s construction of knowledge, how men and women find different personal connections with the knowledge they have, what meanings they give to the language they use to talk about knowledge, and what makes certain constructions of knowledge important to them and why. Of equal importance is an emphasis on personal appropriation and subjective knowledge.

Issues of identity, language, and style have all become a part of the emerging paradigm for studying gender. In the study of computers and gender, however, the important issue of personal appropriation has been neglected.
II. THE NATURE OF PERSONAL APPROPRIATION

In the last section, we saw that Keller made two separate but interrelated arguments. One was that the way we define meanings in language changes the way we think and construct knowledge; the other was that the pursuit of knowledge is both an objective and subjective endeavor. For Keller, the traditional meaning of "objective" has meant the "pursuit of knowledge that results in the severance of subject from object." Keller's definition of dynamic objectivity changes the meaning to the "difference between self and other as an opportunity for a deeper and more articulated kinship." Keller follows psychoanalytic usage for the words subject, object, subjective, and objective; that is, a subject is the self whereas an object is another, whether a physical object or another person. To be subjective is to be connected to the other, to be objective is to separate oneself from the other.

Piaget defines objectivity differently. For him objectivity means, "the mental attitude of persons who are able to distinguish what comes from themselves and what forms part of external reality as it can be observed by everybody." Piaget too defines objective knowledge in relation to subjectivity; but he separates interpretation (subjectivity) from observed facts (objectivity) and ends up

close to the traditional value-laden or at least consensually-derived meaning of objective.

Piaget asserts that in early development children are unable to separate themselves from other things in the world. As the child develops he begins to be able to differentiate between two universes, the objective (external reality) and the subjective (internal reality). Yet, for Piaget, external reality is merely a world of objects and not of people. His interest as a scientist is to study how people (children) understand objects, particularly as separate from themselves. The child interacts with these objects to understand how the physical and metaphysical worlds work, and his interactions with people act as catalysts that help him to construct schemas of the physical world.

In contrast to Piaget’s model of the child seeing himself as part of the external world, the object-relations psychoanalysts such as Winnicott believe that the child first sees himself as part of the mother. For the child, both mother and child are one, a subject. Later as the child develops psychologically, he begins to see the mother as external to himself, and himself as separate from all others. Thus, the mother becomes an object and the child a subject. Although the goal of psychoanalysis is individuation which can be defined as identification of the

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14 Ibid, p. 131.
self as separate from others, its goal is for the self to be able to be intimate with and connected to others.

Winnicott (1971) emphasizes and carefully describes the psychological space between self and other (either a person or a thing). He analyzes how children use this "space" in order to separate the subjective and objective worlds. This space called play "...has a place and a time. It is not outside...nor is it inside...it is not part of the repudiated world, the not-me..."\textsuperscript{15}, nor is it part of the me. In the space between the me and the not-me, a relationship exists that stems from birth and represents the connection between mother and child.

In this thesis I define subject and object as the object-relations theorists do, with the subject being the self (whether separated from another or not), and the object being either a thing or another person.

One aspect of personal appropriation is subjective experience, where the object of inquiry becomes an extension of the self. The self does not become the object; instead the self becomes part of the system of inquiry. Thus, the example of Barbara McClintock being "right down there with the chromosomes" can be viewed as subjective experience because the chromosomes and she no longer are separated but have, instead, become one system. Although McClintock does

not herself become a chromosome, the line between what is subject and what is object has become blurred. Being so closely connected to the chromosomes allows her to subjectively know how they "think", "feel", and behave.

Treating objective and subjective as closely connected is difficult. Thinking of personal appropriation in terms of objective and subjective knowledge blurs the line between what is self and what is other. Personal appropriation can be defined as having ownership over one’s own learning. Personal appropriation is not something that can be taught; it comes from finding a deep personal meaning in and connection to the things one studies. In finding deep personal meaning in a discipline we find out about both the field of study and ourselves. We find out what is valuable to us and the models we use to relate to the world.

Seymour Papert in his book Mindstorms gives an illuminating description of how he found personal meaning in the "gears of his childhood." He writes,

"...I was particularly proud of knowing about the parts of the transmission system [of a car], the gearbox, and most especially the differential. It was, of course, many years later before I understood how gears work; but once I did, playing with gears became a favorite pastime. I loved rotating circular objects against one another in gearlike motions and, naturally, my first 'erector set' project was a crude gear system...I believe that working with differentials did more for my mathematical development than anything I was taught in elementary school. Gears, serving as
models, carried many otherwise abstract ideas into my head."\textsuperscript{16}

For Papert, the personal appropriation of the gears is a cognitive and affective experience. He writes, "\textit{I fell in love with the gears.}\textsuperscript{17}" Falling in love with the gears allowed him to forget himself, to become completely immersed in playing with them. This complete involvement allowed him to know the gears intimately, how they worked, the effects of changing the size of the gears, and from there, how to solve differential equations. His knowledge of the gears also led to subjective knowledge; that is, knowledge about himself. The more involved he got, the more he understood about himself, his passions, how his mind manipulated objects, how he could build systems, and what he found aesthetically pleasing.

For Papert, the gears were a physical "object-to-think-with" about the world of gear differentials, similar to Piaget's objects. However, there was also subjective knowledge involved. As he became more and more intimate with the gears, he became more immersed in them. As he immersed himself in them, they became an extension of him. As with McClintock's chromosomes, it may become difficult to determine what the relationship is between him and the gears. The entanglement, and then the disentanglement as he

\textsuperscript{17} Ibid, p. viii. Author's emphasis.
later separates himself from what he knows, can be seen as analogous to the child separating from the mother.

This is what Keller means when she claims that appropriation of knowledge includes both an objective and subjective component. She writes, "Scientists often pride themselves on their capacities to distance subject from object, but much of their richest lore comes from a joining of one to the other, from a turning of object into subject."

In other words, we are an extension of what we study. As we become more intimate and involved, it becomes harder to separate ourselves from the system. We recognize that our interactions with the system, including observation, affect both us and the system.

There are three senses of subjective knowledge. One sense of subjective is value laden. This is a popular and often derogatory sense which is criticized as a term because it implies a kind of "blindness" induced by personal views. The other two senses refer to qualities of subjective knowledge without any disparagement. Some "knowledge" is subjective because it involves our feelings. Discussion about our responses to a beautiful painting or an elegant mathematical idea is subjective insofar as it refers to our personal, therefore, "subjective" feelings. But it is also quite valid knowledge. The study of "subjective probability" by cognitive psychologists is subjective for

the same kind of reason: it refers to someone's personal sense of the likelihood of an event.

Finally, there is the knowledge that is subjective because it mirrors our thoughts, reflecting back the knowledge we have of objects (things and people) and allowing us to use that knowledge to know ourselves better. The knowledge we then have of ourselves is again reflected back to our knowledge of objects. Other cultures have often led us to question our concept of knowledge by using very different and equally valid ways of knowing about the physical world. Researchers travelling with the Pulawats of Micronesia found that the navigators can accurately gauge where they have been, the goal island to which they are going, and the location of the reference island (the island between the starting point and destination, usually off to one side and beyond the horizon) without instruments or charts. The Pulawat navigators can do this reliably even if they have been in open water, out of sight of land for days, in any kind of weather, or if they have to tack upwind to an unseen target.\footnote{Gentner, D., Ed. Mental Models. New Jersey: Lawrence Eribaum Asso., 1983, pp. 191-92.}

Western navigators found it difficult, due to language and cultural barriers, to understand the Pulawat's system of navigation. Using themselves as a reference point, the Pulawat navigators described their navigation in terms of
"islands rushing by" and by where the stars were located. The measured speed in units of inconsistent size (a system called ETAK), and expressed distance travelled in relation to the changing bearing of the reference island.

In contrast, the researchers described Western navigation to the Pulawats by drawing a bird’s eye view of the three islands, and with a compass, drawing intersecting lines of where the boat was based on degrees of longitude and latitude. Neither the Pulawats nor the Western researchers could understand the other’s system because each had a different concept of speed and distance. The Westerners measure speed and distance as though they and their boat are moving. The Pulawats measure speed by acting as if the islands are moving by them while they are standing still, and they use the movement of the reference island to measure the distance travelled.

These different ways of perceiving and measuring distance lead us to wonder how our constructions of knowledge are defined by the culture. The subtle interweaving of what is "subjective" and what is "objective" knowledge may be easier for us to accept in the context of primitive cultures. Although more difficult to accept as either scientific or valid in modern cultures, the merging of the subjective and objective knowledge has become impossible to ignore. In today’s modern culture it plays a particularly forceful role in knowledge about computers.
The computer’s ambiguous nature, "psychological, yet a thing" leads us to recognize its dual identity as an object: it is both a person and a thing. Because it sometimes resembles us, it seems easier to make it an extension of ourselves.

As an object in the Piagetian sense, computers are useful to think about the physical world. The computer is a modelling tool one can manipulate and use to explore intellectual ideas. One can create multiple worlds that embody these ideas: mathematical concepts such as recursion and randomness; design concepts such as space, form, and color; logic concepts such as sequential thinking; and debugging, an essential element in good problem solving.

As an object in the psychoanalytic sense (a person or a thing), the computer has a subjective quality too. This subjective quality of the computer includes the affective responses we have when working with the computer. It also includes how we use the computer to think about ourselves as human beings. As Turkle points out, the computer can act as an evocative object, similar to the story of the Wild Child of Aveyron.

The Wild Child, after surviving alone for thirteen years in a mountain climate, appeared near the village of Saint-Sernin in France. Researchers tried to teach him to

20 Turkle, op. cit., p. 31.
21 Ibid, pp. 11-12.
speak, read, and write with little success. It was hoped that if the child could be taught to speak he could talk about what it meant to be a "man of nature," without socialization and culture. Although the experiment failed, the Wild Child story continued to evoke questions about human nature, what is natural and what is not. 22 Thus the computer also may act as an evocative object.

Turkle's work has shown us that the computer can be a powerful object with which to understand ourselves and how we think, know, and feel. She writes, "The computer is... a 'psychological machine,' not just because it might be said to have a psychology, but because it influences how we think about our own." 23

"The computer, like a Rorschach, inkblot test, is a powerful projective medium....The Rorschach provides ambiguous images onto which different forms can be projected. The computer too takes on many shapes and meanings....What people make of the computer speaks of their larger concerns, speaks of who they are as personalities. The computer is powerful because it evokes questions about who we are, what we will become, and what we can create." 24

The computer has another subjective quality that leads me to call it a subject-to-think with. When I call it a subject-to-think-with I mean that the user, when deeply

23 Ibid, p. 16.
involved with the computer, does not distinguish between himself and the computer. Obviously the computer is not the self and the user knows it is not; however, it has qualities that allow us to think of it as a part of the self. It becomes an extension of the self and, as a black box, allows us to work directly with the material inside. As we become more intimate with the material, we become part of the system; thus, the line between self and other becomes blurred.

If it is true that the computer can act as an object and an extension of ourselves, I wondered, would there be gender differences in the way children appropriate it? Would both boys and girls see it as a subjective and objective phenomenon? Would they use it in ways that would tap into both attributes? Would they feel more comfortable with one or the other? How would their choices affect their attitudes toward the computer? And finally, how do other attributes of boys and girls related to their appropriation of the computer?

To find out whether there are sex differences in personal appropriation of computers requires that we recognize the dual nature of the computer may affect the way in which children relate to it. It also requires that we use a different paradigm from that used by researchers of traditional research on gender and computers (Clarke, 1984; Hawkins, 1985; Kiesler, 1983; Linn, 1985; Wilder et al). It
is no longer relevant to ask questions about whether children like computers or not. One must ask deeper questions about identity, language, and style. In the spirit of the research conducted by Gilligan, Keller, Papert, and Turkle, I developed a study that would look at gender issues in how children appropriate the computer.

The objective of this study was to create a model of interaction with the computer that would fit the profile of ten, eleven year old children. To build the model of interaction I looked at their gender, locus of control, work style, personal interviews, and appropriation of the computer. To gather the data I used the methods of testing, clinical interviews, and observation.
III. METHODOLOGY

Many of the studies concerning gender and computer attitudes and use have used survey instruments to gather data (Clarke, 1984; Hawkins, 1985; Moe, 1985; Wilder et al, 1985). The statistical evidence resulting from such inquiries give us a basis from which to begin analyses of greater depth. We want to know why the statistics show us what they do. Just knowing that boys enroll in computer classes more often and like computers better than girls, and that there may be developmental differences in these phenomena is not enough. We need to integrate issues of style, language, personality, and personal meaning into our studies of gender and computers in order to understand why these phenomena occur. A combination of the clinical method and observation will allow in-depth exploration of these issues.

Piaget (1929) asserts that the method of conventional tests has two important defects. One is that the child is tested out of the context in which the knowledge was meaningful to him. The second is that the experimenter does not ask questions that are relevant to the child’s reality nor does he design a task or universe that allows exploration of a concept. For example, when asking a child metaphysical questions about whether the moon is alive, the child must imagine a mental image of the way the moon moves in order to answer the question. He has no physical model
for thinking about the concept of the moon's motion. Having to create a mental image of the problem as well as answer the question complicates the question for the child, so he may give answers that are ambiguous or masked by his mental construction. Giving the child a physical model with which to manipulate and think about the question clarifies and focuses the question for the child.

Also, answers to questions often may be what the child thinks the interviewer wants or has prompted him to say instead of what the child really thinks. Only by making counter-suggestions can a researcher get accurate information. Piaget writes, "The real problem is to know how [the child] frames the question to himself or if he frames it at all."25

Although I used the "method of tests" as a preliminary measure of children's attitudes, the clinical method was more appropriate for studying how children interact with and find meaning in computers. Berg and Smith (1985) explain the clinical method as those aspects of research that have the following characteristics:

(1) direct involvement with and/or observation of human beings or social systems;

(2) commitment to a process of self-scrutiny by the researcher as he or she conducts the research;

(3) willingness to change theory or method in response to the research experience during the research itself;

(4) description of social systems that is dense or thick and favors depth over breadth in any single undertaking.²⁶

Each of the above facets of the clinical method will be discussed in relation to the present study.

A. Direct involvement and observation

The research design incorporated direct involvement and observation. Working with a child on specific tasks required direct involvement in the child’s learning process. I asked the children what they were doing, offered help and suggestions, and gave them feedback on their projects.

Direct involvement implies being part of the system of study. The "systems" approach involves "conceptualizing the phenomenon under investigation as a totality by defining its specific organizing principles, by showing that the events are the result of the interaction of these principles, and then by defining the part-whole relationships with the structures behind the event."²⁷ This definition implies that by breaking the whole into parts and studying only the parts one loses the qualities which are characteristic of the whole.

Susanne Langer (1957) describes this phenomenon with respect to paintings. For her, taking individual objects out of a painting and analyzing them changes their meaning. Individual objects, shapes, and colors have meanings separate from those of when they are put in the context of a whole. What gives meaning to a painting is its form and the relationship of colors, shapes, and textures to one another.²⁸

In the present study, the process of studying gender and computers is also seen as a whole system. The child’s learning cannot be detached from the context of his experience with computers, nor can the observer only watch without participating. I, as observer, am as much a part of the system as the child is. My interactions with the child provoke the child to think about things he might not spontaneously; his answers provoke me to ask questions I might not have thought of.

Piaget asserts the significance of the observation and direct involvement methods by stating, "...it is the observation of spontaneous questions of children which furnishes data of the highest importance."²⁹ In preliminary interviews children often ask questions or give answers that the interviewer has not thought of. This allows the researcher to incorporate these questions and answers in

²⁹ Ibid.
other interviews, and suggests directions for probing further. According to Piaget, this method should be used both in the beginning of all research on child thought and as a way of final control of the experiments which come from the initial interviews.

In a study on early childhood learning, Bussis et al (1985) developed a relevant methodology. They maintain that "systematic observation and documentation of behavior constitutes the first step toward understanding the meanings a child construes in his or her instructional environment." They organized the data collection for their study around the behavioral information readily accessible to teachers.

Pure observation, however, has two problems: the first is that it is impossible to observe a large number of children at the same time and a "child's egocentricity constitutes a serious obstacle to knowing him by pure observation unaided by questions." The lack of a large sample leads to a difficulty in generalizing the results. What Piaget calls the child's "egocentricity" makes it difficult to distinguish a child's play from his beliefs by observation alone.

For Piaget, a combination of observation and clinical interviews is the best method for getting complete and accurate information on the child’s thoughts and beliefs. Combining these methods and techniques allows the researcher to clarify the child’s answers by asking probing questions.

B. Commitment to a process of self-scrutiny

Clearly, in considering himself a part of the system, a researcher needs to commit to a process of self-scrutiny. This process includes recognizing that as part of the system, he has an impact on it. At the same time, the system has an impact on the researcher. Berg and Smith write, "When the influence of the researcher’s involvement goes unnoticed, a wealth of information about the social system is lost because the researcher is not attending to the characteristics of the social system that are influencing his or her feelings or reactions and may also be ignoring the hypothesis that the social system is responding, in part, to the researcher’s thoughts and actions."32 The researcher must recognize how he impacts the results of the study and how his feelings may interfere with the work.

C. Willingness to change or adapt theory while involved in the research experience

If necessary, the researcher must be willing to adapt the theory along the way, which may mean changing the data

32 Berg and Smith, op. cit., p. 27.
collection, type of involvement, or methods. New hypotheses may emerge from the information gathered and may suggest a need for a different method of inquiry, new questions or revised theories.

**D. Preference for depth over breadth**

The process of standardization and categorization means that information is lost. For example, if I had ten each of three shapes of blocks, circles, squares, and triangles, with three or four different colors of each, I could categorize them in several ways. One method would be to categorize them in terms of shape. I could put all the circles in one box, all the squares in another, and all the triangles in yet another. I would have some red, blue, and yellow squares in the squares box, and perhaps all green circles in the circle box. Since I have organized my blocks according to shape, however, I have lost information about what color the blocks are.

Since this was a preliminary study, I gathered as much information as possible on ten case study children. Thus, the information allowed me to make hypotheses that could later be tested on larger numbers of children.

Berg and Smith's four criteria and Piaget's methodology have strongly influenced the design and research methods of this study. In fact, I used the Piagetian method of

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33 Ibid, p. 28.
inquiry, but the characteristics of the clinical method as defined by Berg and Smith have influenced the process.

F. Experimental Technique

Utilizing the methodology of the traditional paradigm for studying gender and computers, I began my study by designing and administering a gender attitude survey. In order to insure that the survey results would be statistically valid, I administered it to 47 advanced work fifth graders, of which ten were the case study children. The survey included questions about the children's preferences in courses and computer work, whether they thought the computer was more like a machine or a person, and what fears they have about working with the computer.

Like most instruments used in the study of gender and computers, the results of gender attitude survey revealed children's attitudes but did not approach the deeper psychological and epistemological questions. The results (see Appendix A), however, supported the desirability of a preliminary in-depth interview to inquire why the children said or felt as they did.

The clinical methodology uses few subjects. I chose ten children by gender, grade, age, ethnicity, and the length of time they had worked on the computer. All were ten or eleven years old, in a fifth grade advanced work class, and had worked on computers every school day for a year. I chose five boys and five girls of whom four were
whites, two Asian, one Hispanic, and three Black (see Table 1).
Table 1. Subjects by race and gender.

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<td></td>
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<td>10</td>
</tr>
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</table>

* One white parent and one Black parent

In early November, after I completed the design of the in-depth interview, I interviewed each child for approximately one hour keeping audio-tape records. These interviews were directed by questions, but the subjects were allowed to range freely in their responses.

I then analyzed the interviews for issues that seemed important or interesting to the children. One preliminary finding was the different language boys and girls used to describe their interactions and feelings about the computer. From this material, I developed a second in-depth interview which included questions from the original interview as well as questions that would allow me to explore their feelings and thoughts further. I administered the second interview in mid-March. It took approximately one hour for each child depending on the length of their answers. In terms of administration, the second interview was like the first with one exception. I still allowed subjects to talk about matters apparently extraneous to the interview, but in order
to standardize the interview I made sure each child answered all the questions in the same order.

I administered two standardized tests: Rotter's Locus of Control Test (see Appendix B for results) and the Rey-Osterreith Test (see Appendix D for results) after the children had one year of computers. Again, to ensure statistical validity of the results of Rotter's locus of Control, I administered it to 44 children, of which 10 were the case study children. The individual results are reported as scores relative to others in the same age group. The Rey-Osterreith was administered only to the ten case study children. The results were used to measure the child's work style. It was then correlated with observations of the child's programming style.

Finally, I collected observations once a week on each of the ten case study children over a six month period of time. These observations came from either working with the child on a specific task, or by observing the child working alone or with another child. I spent ten hours a week observing and interviewing the children over six months. I observed the child's general behavior throughout the course of the year. Additional data was collected through writing samples and examples of computer programs.

G. Summary of Methodology

Ten case study children were chosen by gender, grade, age, and race. In the fall, I administered to them the Rey-
Osterreith, Rotter's Locus of Control, a gender attitude survey, and one clinical interview. In March I administered a second clinical interview. I collected other data by observation, through writing samples, and through computer programs.

Although other children were administered Rotter's Locus of Control (N=44 including the case study children) and the Gender Attitude Survey (N=36 including the case study children), the results were used only as a relative measure; that is, the case study children's scores were reported relative to the group as a whole.

III. RESEARCH SITE

A. The School

The research site was the James W. Hennigan Elementary School in Jamaica Plain, Massachusetts. Hennigan is a multi-cultural magnet school with grades kindergarten through fifth. The children participating in the study were also participants in Project Headlight, a high density computer project run by researchers from the Massachusetts Institute of Technology (MIT) Learning and Epistemology Group, a department of MIT's Media Lab. IBM donated about 100 IBM PC Jr. computers for the 210 children participating in the project.

Hennigan is a cinder block structure located in the heart of inner city Boston. Its exterior walls are covered with graffiti; the streets leading to it are full of
potholes. A security guard sits at the entrance to the building. The interior is also of cinder block with ceilings that leak from both the bathrooms and the roof. In 1987 a new roof was put on the building but the ceiling continues to leak. Water pipes in the ceiling are exposed and one can often see mice and rats running along them. It seems incongruous to see thousands of dollars of high-tech equipment in a building so badly in need of repair.

Hennigan was originally built in 1972 as an open classroom school with five circular pods. Two of five pods (B and C) are involved in Project Headlight. Each of these two pods have six classrooms off the perimeter of each circle and in the middle of the circle have two networks of 20 computers each (see Figure 1). Each classroom also has one or two computers at the back of the class which are used for demonstrations or by students during independent work periods.

B. General Environment

Each class is scheduled to use the networked computers in the pods for 45 minutes per day. This means that each child gets an average of 3.75 hours of computing time per week. On the network the children have access to Logo, LogoWriter, Bank St. Writer, a mail system, and the local area network which allows the children to change their passwords and send files to other kids. Some classes also use "Rocky’s Boots," a logic program, and allow the children
to bring in computer games to play during free time (i.e. recess or free work time). Most classes, including the one in the present study, use LogoWriter for both programming and word processing.

Computer classes are not systematically taught. Computers are integrated into the curriculum by assigning projects and work that can be completed on the computer. The children are also given "free time" when they can do whatever they want on the computer. Occasionally the children will be introduced to a new computer concept or command by a teacher, facilitator, or researcher. Facilitators are people who have programming expertise in Logo, and who help teachers develop curriculum and help children with their programming projects. Researchers not only observe and test the children, but ask students what they are doing and offer suggestions. Generally, ideas are shared and spread among the children through conversations and observation. Children sometimes work together, although most prefer to work alone.

For four weeks during the year each class in Project Headlight works with Lego-Logo.\textsuperscript{34} Lego is a plastic construction kit that allows children to build various devices. It includes bricks, gears, motors and sensors. Lego-Logo is a Logo computer program that allows children to attach their devices to the computer and run them. For

\textsuperscript{34} Registered trademark of Lego Systems, Inc.
example, a child might build a car with Lego. He can then
hook up his car to the computer and make it run backwards,
forwards, turn and stop depending on his design and the
program he writes.

C. Class Environment

The teacher of the advanced fifth grade class involved
in the present study will be called Mrs. Bocello. There
are two advanced work classes each for fourth and fifth
grades. Each class is taught by one teacher for two years,
so the children in this study had already been with Mrs.
Bocello for one year. Her ethnically diverse class has 20
students: seven white, eight Black, three Asian and two
Hispanic. Mrs. Bocello, a warm, loving teacher around 50
years old, has been teaching in the school system for 24
years. Mrs. Bocello has been working with advanced work
class children for 13 years.

Mrs. Bocello’s educational philosophy is a mixture of
pragmatism and idealism. She understands the problems inner
city children have, and she tries to provide a supportive
environment while also trying to make learning fun and
relevant. For example, each year Mrs. Bocello, who teaches
the most advanced math class, teaches her students how to
fill out tax forms. It is not unusual to see several of the
children’s parents sitting in the class learning with their

35 All subjects’ and teachers’ names in this paper have been
changed to protect their anonymity.
children. Students whose parents cannot participate in the classroom will often be asked to help their parents at home. Classes such as these make learning fun and relevant to the real world and are empowering for the children.

Mrs. Bocello's philosophy of teaching is to give the children as much freedom as possible while still maintaining some structure. She follows the Boston city school system guidelines for curriculum, but tries to give the children some flexibility in how they learn the material. The atmosphere is relaxed and inviting. Children are often seen lying on the floor reading, or sitting with their feet propped up on their desks discussing a problem with another child.

Mrs. Bocello often says that she has only one rule, which is strictly enforced: "Never laugh at another person." She feels that this is an important rule because it allows the children to answer questions and give opinions without feeling embarrassed or intimidated. I have seen how this rule effectively advances children's ability to speak in public. At first some were so shy they could barely speak in front of the others, but by the end of the first year, almost all children would not only openly speak their ideas, but also would volunteer to read in front of the class.

Mrs. Bocello does not like using computers although she has spent two, two week summer workshops at MIT learning Logo and how to use the computer. She knows a lot less
about them than many of her students, and does not feel the
necessity to learn any more. She often jokes about the
amount of dust accumulating on her home computer. Because
of her own aversion to the computer, Mrs. Bocello has not
forced any of the children to work on the computer any more
than is necessary to complete their assignments. Because
she does not teach the children new computer concepts, they
usually learn such ideas from children in another room, the
facilitators, or through self-discovery. Perhaps because of
Mrs. Bocello’s freer attitude, two of her children were
semi-finalists in the city wide computer contest and one won
third prize.

Mrs. Bocello’s children were not taught computer
programming. They were given a few Logo commands and were
allowed to "mess around" with them. Their programming
styles seem to reflect their personal styles: like the
children studied by Turkle, some children used an analytical
approach where others negotiated with the material.

Much of the work done on the computer in Mrs. Bocello’s
class is voluntary. Often the children may choose to read,
play games, watch a videotape or work on the computer. At
least half the class usually chooses to work on the
computer. Most of the children work alone unless they are
required by Mrs. Bocello to work with another person. They
often ask each other and the facilitators for help and there
is much discussion and social conversation. If someone has
written a particularly interesting program, the children will gather around to watch. Exchanging programming ideas and commands is usually done among friends, but often a child from another group will see a program and ask how it was done. There are some rivalries within the class and sometimes a group of children will keep a program secret. When there is rivalry between a group of boys and a group of girls there is often teasing and offers of exchange. I never observed any fighting over the computers.

The classroom environment and the children who participated in the study were exceptional. Mrs. Bocello’s philosophy of education gave the children a chance to find meaning in their work by allowing them to explore their ideas freely. Mrs. Bocello’s students took advantage of the freedom by asking many questions, thinking about many possible solutions to problems, giving opposing opinions, and above all by supporting each other. They also took advantage of the expertise and talent of the MIT researchers. A child was just as likely to speak with an MIT researcher about a problem (computer or otherwise) as he would be read a book. None of this might have happened without the support and freedom Mrs. Bocello offered.
IV. RESULTS AND DISCUSSION

A. Summary of Results

The results of the gender attitude survey come from data on 36 children. I found that girls tended to like animation best whereas boys liked games best. Although both boys and girls thought that writing was least fun to do on the computer, 73.5% agreed that it is easier to write on the computer than with a pencil or pen.

Seventy-five percent of boys thought the computer was more like a machine and 60% of the girls said it was more like a person. Both tended to give cognitive reasons for the computer being more like a machine or more like a person (e.g. smart, understands, does what they say).

Over 90% of all the children felt the computer was interesting; however, only 40% of the girls are using computers because they want to, while 76% of the boys are.

I administered the Rotter’s Locus of Control to 44 children. All are included in this summary. I found that there was no significant difference between the boys’ and girls’ locus of control tests (M=4.95; girls; M=5.857, boys; M=5.43, both; SD= 2.95). Of the ten case study children, three boys and three girls had an internal locus of control while two boys and two girls had an external locus of control.

The Rey-Osterreith test was administered to the ten case study children. Three girls and two boys drew it
holistically, one girl and two boys drew it analytically, and one girl and one boy used both styles to draw it.

The clinical interviews are difficult to summarize because the material is rich and different for each child. A child’s style of interaction with the computer is based on his perceptions of the computer, his identity, style, and functioning in the world. Each individual child functions uniquely. Because of the uniqueness of each child and the generalities of my conclusions, it is impossible to draw a one-to-one correlation between the results and the conclusions. Therefore, I have relegated many of the specific results to the case studies and Appendix C.

Two general patterns of interaction related to gender emerged from the interviews and observations. Girls tended to think about the computer in terms of human relationships; they wanted to communicate, collaborate, and be friends with it. They also wanted to trust it. Boys tended to think of the computer in terms of power and control of the computer environment which is sometimes related to their difficulties with human relationships. From these patterns I developed a model of interaction described below in the section on Two Styles of Interaction. I believe that the case studies support the model.

The results from the ten children are summarized in Table 2.
Table 2. Relationship Between Children and Their Locus of Control, Rey-Osterreith, Style of Interaction, and Gender.

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<td>STEWART</td>
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**KEY:**

- **LOCUS OF CONTROL (LOC):** I = INTERNAL  E = EXTERNAL
- **REY-OSTERREITH (R-O):** H = HOLISTIC  A = ANALYTIC
- **INTERACTION (STYLE OF):** R = RELATIONAL  E = ENVIRONMENTAL
- **GENDER:** F = FEMALE  M = MALE

**FOR ALL:** B = BOTH
B. The Child's Conception of the Computer

The results of my study indicate that computer has an ambiguous status with children. Its complex nature, both like a person and a thing, makes it difficult to know whether it should be related to as an animate or inanimate object. These findings are consistent with findings by Turkle. She found that children talk about physical criteria when describing noncomputational toys. However, when children discuss the nature of computational toys, psychological criteria "dominate the discussion...even after the child consistently uses biological language to talk about the aliveness of traditional objects."\(^{36}\)

My findings show that by the age of ten most children understand the computer is not alive, but their ways of relating to it do not reflect the simplicity of their stated opinions. Few of them explicitly state that the computer is more like a person than a machine, but many talk about it much as they would about another person. In my sample, girls were more likely to talk about and interact with computers in terms of relationships whereas boys were more likely to talk about and interact with the computer as a thing.

The difference does not reflect what the children know; it is a psychological issue. Most of the children in this study said that the computer is a machine and not a person,

\(^{36}\) Turkle, S. op. cit., p. 328.
yet when working with it some children revert to a model of interaction that resembles the way they interact with humans. Other children interact with it as they would with inanimate objects.

The computer is a complicated and powerful device to the child. It sometimes resembles a person and other times resembles an object. If the computer is a machine, then by its very nature, it should be consistent. Since it is not it seems more like a person. Because they are uncertain which it is at any one time, children do not know how to interact with it. To complicate matters the computer’s human-like qualities are not consistent. A computer cannot feel or imagine, yet sometimes it seems smart. Other times it does not. Sometimes the computer seems friendly, but other times it is threatening.

The computer is powerful, too, because it can be difficult to use and understand. In order to make the computer "understand," a child needs to speak precisely in the computer’s language. When the child first works with the computer he is illiterate. He does not know the language of the computer, nor does he understand the logic of how procedures fit together. Although the child knows the computer cannot do anything without his input, he also knows he cannot do anything to the computer without using its language. This creates a constant power struggle between computer and programmer.
In order to work with the computer, children want and need to make sense of it. One approach is to personally appropriate it in some meaningful way. Some children use the computer as a way of exploring powerful intellectual ideas and others use it as an "evocative" object, a way of exploring themselves. One child who was very shy used the computer to explore his sense of humor (see Case Study of Stewart). The computer became an animation kit with which he made very funny animated illustrations of everyday situations. Another child, for whom dance is an important aspect of her life, choreographed dance animations. Finding meaningful ways of using the computer, however, does not eliminate the feeling that the computer is powerful and difficult to control.

To feel in control, children want to understand it and they want it to understand them. To understand it, many boys interact with the computer the same way they learned about the construction kits and mechanical (or electronic) toys of their childhood. As small children they learned how to put together Tinker Toys, Lego, and Lincoln Logs. They built model cars with motors that they later raced. They used blocks, and constructed forts and houses with tools such as hammers and saws. They also took apart their toys, clocks, and radios to see how they went together. After months and years of playing with toy construction kits, they began to understand the language of the materials in their
environment. The language of the materials allowed them to be creative, but also gave them instrumental control over their environment. As they gained control over the environment and were able to manipulate the materials, they felt more powerful.

For many girls learning about computers is similar to learning about relationships. When they were little they played with dolls, acting out relationships with them which reflected conflicts in their relationships with their family and friends. They learned that there are ways of relating which include communication and negotiation, particularly when what is being said or done is not understood. Through their play with dolls, girls, who want to maintain connectedness, learn to negotiate for that closeness.

Keller and Gilligan might claim that this socialized dichotomy stems from early childhood development. Girls, who remain close to and identify with the mother, develop a way of being that emphasizes connection and intimacy, thus they want--and learn to work with--materials that reinforce those aspects of relationships. Boys, who are separated from the mother and who identify with the father, develop a personality that emphasizes individuation. They want and learn to work with materials that emphasize analytical, objective (i.e. disconnected) thinking.

For both, the process of play (whether with the computer, in relationships, or with other objects) is one
that includes manipulation of objects (things and people) in the environment. Through this process children are able to act out their feelings about their relationships with others safely. Thus, play permits them to grow emotionally.

Winnicott states that through the manipulation of these objects playing develops, "from playing to shared playing, and from this to cultural experiences." Playing facilitates growth, leads to group relationships, and is a form of communication; thus, the manipulation of objects is essential for the intellectual and emotional development of the child.

In order to create a safe place in which to explore the computer (i.e. play), children defend themselves against the computer's power and complexity by interacting with it in ways that are familiar to them in the outside world. Boys tend to interact with it the way they would a thing, an object they can take apart and put back together again. In doing so they then begin to understand the logic of how the computer works. Girls tend to interact with it the way they would a person, negotiating with it, expecting it to be changeable (as it appears to them it vacillates between being a thing and a person, and between various human-like qualities). These familiar styles of interaction, which I call the interlocutor, when transferred to the computer, act

37 Winnicott, op. cit., p. 51.
as a defense mechanism\textsuperscript{38} against the computer's power. The child makes the computer safer by giving himself a familiar place to play in. As a defense mechanism, the interlocutor mediates the child's interactions with the computer by defining a relationship with that will increase instrumental and psychological control over it. The increase in control comes from the computer responding in familiar and predictable ways: the computer must respond to their boys' rules of logic and to girls' rules of relationship.

\textbf{C. The Interlocutor as a Model of Interaction}

To understand how children defend against the computer's power, I have found it useful to posit the \textit{interlocutor} as a psychological construct through which children interpret the computer's actions. The interlocutor resides in the child's unconscious as a defense mechanism. It can be defined as a style or model of interaction that the child has used successfully in the past to cope with some unknown situation. In other words, the interlocutor is a model of interaction the child has successfully used in the past to manipulate objects (things and people) that initially were unfamiliar to them.

\textsuperscript{38} Defense mechanisms, as defined by Anna Freud, are the "ways and means by which the ego wards off unpleasure and anxiety, and exercises control over impulsive behavior, affects, and instinctive urges." (My emphasis added to indicate the most important aspect of her definition).
I see the child's interactions with the computer as being mediated by the interlocutor. The interlocutor symbolizes the child's representation of the "other" and as such defines the nature of the relationship with the other. If the child sees the other (in this case, the computer) as a person, he will unconsciously choose an interlocutor that will allow him to relate to it as a person. If he sees the other as an object (thing) then he will unconsciously choose an interlocutor that will allow him to relate to the computer as an object. The model of interaction the child knows from past experiences is brought forth from the unconscious to help him find a safe way of interacting with the computer. Thus, the interlocutor, or model of interaction, helps the child to find meaning in his interactions by representing a relationship with the other that the child is already familiar with.

I assert that children, in unconsciously defining their interlocutor, build models of interaction that are consistent with the way they interact in the world in general. The model the child uses to relate to the world is then transferred to the computer. Some children prefer to use a model of human relationships while others prefer an environmental model; that is, a model of interaction by which they would interact with things. A child whose predominant world experience has been with personal relationships will generally choose to define the computer
in terms of personal relationships. A child whose predominant world experience has been in interacting with things will more likely choose to define the computer as a thing.

The computer’s ambiguous nature--human-like yet a thing--makes it confusing for both boys and girls. Because the computer-object is unpredictable, both boys and girls unconsciously use the model of interaction with which they are most familiar and comfortable. Children define the computer as either a thing or a person to provide some consistent way of thinking about it. For boys, this means defining it as a thing; for girls it means defining it as a person. Thus, boys and girls each have rules by which they interact with it which come from early childhood experience.

Although girls know the computer is a thing, it has enough human qualities to make it sometimes seem human. It collaborates with them, helps them do their work, and also hurts them by sabotaging their work. When the computer is not human because it does not feel, talk, or understand, girls often want it to be more like a person; that is, they want it to be more relational, to understand them, to communicate more readily with them, to be their friend. They personalize it; they talk about it specifically in relation to themselves. The computer "doesn’t talk to me," or "...it doesn’t have feelings. It can’t communicate with you. Well, in a way it can, but not the same way as a
person would." Girls want to communicate with the computer the way they would another person for that would make it feel more familiar and them feel more connected to it.

Boys give cognitive reasons for the computer being more like a machine than a person. Although it has some human-like qualities such as being smart, these qualities are given to it by a person. They are not inherent in the machine itself. One boy discussing the intelligence of the computer said,

...[it is] not smart like we think about it, but it knows things we don't. It knows things I don't. But the people who made it probably know more [than it].

For boys, computers are machines; they do not think or have feelings, nor are they expected to. They are things that are to be manipulated just as their toys were when they were younger. In order to manipulate and understand the computer, boys revert to the model of interaction that was familiar to them when they played with and took apart their toys. Understanding the computer becomes a way of gaining power over it. They want to know what they can make the computer do, whether they can beat it, and if they are as smart as it is. Just as toys worked for boys as they became more fluent in their uses, they expect the computer to work for them. They want it to do what they tell it. The have a relationship with the computer because they want to control it, not because they want to feel connected to it.
D. Two Models of Interaction

The children in this study used two styles of interaction with the computer. The first style describes the interaction with the computer in terms of a relationship with another person. I call this the relational model. The second style describes the interaction with the computer in terms of a relationship with a thing. I call this the environmental model. The models represent extremes on a continuum of styles of interaction. Few children will fit at either one extreme or the other. What is more likely is that a child will fit somewhere on the continuum closer to one style or another and will generally use his preferred style of interaction with the computer. I found that girls tend to prefer the relational model of interaction whereas boys tend to prefer the environmental model of interaction.

In the following, I build a model of interaction which includes both styles giving examples from the protocols to support my assertions.

Knowledge

At the top of my model (see Figure 2) is the knowledge that all children have about computers, such as the knowledge that the computer is not really alive and cannot think. Most children see the computer as an object (thing), but many interact with it as though it were a person. In order to find a way of interacting with it that is familiar to them, the children unconsciously construct an
Figure 2. Model of Interaction.

MODEL OF INTERACTION

KNOWLEDGE

WHAT CHILD KNOWS
ABOUT THE COMPUTER

MODEL OF
INTERLOCUTOR

RELATIONAL

HUMAN
QUALITIES

CHILD'S
EXPECTATION
OF THE COMPUTER

DESires
CONNECTION WITH
THE COMPUTER

INTERLOCUTOR
AS INSTRUMENT

ENVIRONMENTAL

NO HUMAN
QUALITIES

DESires TO
CONQUER, DOMINATE
THE COMPUTER

ANIMATION
TOOL USER

GAMES
TOOL BUILDER

CHILD'S RESPONSE TO COMPUTER
NOT PERFORMING AS DESIRED

GETs ANGRy AT
THE COMPUTER

LOCUS OF CONTROL

GETs ANGRy AT
HIMSELF

THREATENED BY POWER

VALUES CONNECTEDNESS

ADmits POTENTIAL
POWER OF
THE COMPUTER

VALUES AUTONOMY

CHALLENGED BY POWER
interlocutor as a mediating device. The interlocutor is a model of interaction that they have used successfully in the past with others (either things or people), thus, they unconsciously bring it forth from interactions they have had in the past. They prefer to use this familiar model to interact with the computer.

Expectations

Children using the relational model have different expectations of how they will interact with the computer from those using the environmental model. First I will define these models in terms of general attributes, then in terms of their responses to the computer not doing what they want, and finally, in terms of control.

1. General attributes of each model

Relational Model--The relational children (those who use the relational model of interaction) construct their interlocutor as "human-like." They know it does not have feelings, but they relate to it as though it had a will. For example some children will say, "It did that to me," or "It makes mistakes. It erases the words. They don’t come out."

They define it with respect to relationships they have with other people. They expect it, as human-like, to give them the advantages of a relationship with another person. One child said of the computer:
It doesn't seem nice. I mean it doesn't help you in anyway really with your programs. It isn't nice.

Relational children expect the computer to understand and communicate with them; to be reliable, helpful, and not to do anything to hurt them. If they feel the computer has hurt them, they may redefine their relationship and no longer work with it. One child, who lost all her programs when the computer crashed, stopped writing her own programs and instead helped other children write theirs (see Case Study of Florence). This way her need for connectedness and relationship was satisfied without the threat of the computer sabotaging her work. Such children will also build relationships with other children by sharing programs and ideas.

Although a computer looks like a machine, its inconsistency is more like a human; nevertheless, it is unable to negotiate the way a human would. The relational children would like it to be more human. They talk about how it doesn’t have feelings, it doesn’t listen, it doesn’t communicate. However, the human qualities they would like it to have are relational.

The relational children want to elicit the computer’s friendship and reliability. To breathe life into the computer, they are apt to prefer programming animated
drawings. Often their animations are simulations of real life situations or people. These children like watching moving objects on the screen because it is familiar and the way the computer "should" be. For these children, the computer has intention, so they interpret failure of an animation project as sabotage on the part of the machine.

**Environmental Model**—The environmental children construct their interlocutor as a way of interacting with a Piagetian object (i.e., a thing rather than a person). Objects are things to be manipulated, controlled, and mastered. Although their interactions with people may be reflected in the way they interact with objects, human relationships are external to the interlocutor-determined connection between the child and computer. However, the child may use the computer to work through conflicts in his relationships with others.

The environmental children expect the computer environment to be challenging and fair. The computer, as an object, does not have feelings and is not expected to have any. Nor does it have intention, for the computer is a machine. In describing it as a machine, they talk about its lack of cognitive qualities. They say that it does not understand or that it cannot talk. One child stated:

> [It is] like a machine because sometimes it doesn't really know what you mean. If you turn it

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39 To animate means to make alive, or fill with breath, according to Webster's Dictionary.
on and leave it there, it doesn’t do anything. It doesn’t know what to do. It doesn’t act human.

Another said:

I don’t know how [anyone] could think it sounds like a person. ’Cause it’s not like you can say, "Will you please give me a glass of water," and it says, "No, sorry I can’t. I don’t know how to get a glass of water."

For them, the important difference is that the computer does not know, cannot think. They do not talk about its relational qualities, only its cognitive ones.

For the environmental children, the computer’s limitation is in its hardware. The computer is smart, but not as smart as the people who built it. It is faster than the children using it are, but could be faster still. It could have more colors on the screen and it could do more interesting things. These children want to obtain the best possible performance from the computer and themselves.

They expect the computer to work for them, not to help them by working with them. They expect to conquer and control the computer and thereby their environment (both physical and emotional). Because they often have difficulty with human relationships, they want something they can control. They like the computer because it does what they tell it, unlike the people in their environment. When they play videogames, they play to win, not for the sake of playing itself. Some play with other children, others play against the computer depending on the relationship the child
has with others. One child said that what made him feel powerful was, "Winning on videogames. Breaking a record on my world games." If they cannot show their prowess or win, they probably will not want to play.

These children are less likely to share programs with others partly because of their difficulty with personal relationships. If they do share their programs, they generally do so with only one or two close friends. They want to keep their procedures a secret, to maintain the mysteriousness of the computer. They have fused the concept of their power with that of the computer's; therefore, they must maintain the mysteriousness of the computer to keep it and themselves powerful. If others understand how computers or the child's programs, the child's power is diminished. If the child maintains the mystery, he will have power not only over the environment, but over other people as well.

2. **Response to the computer not doing what the child wants it to**

Relational Model—The relational children are more likely to start a program and not finish it than the environmental children are. If there is a bug in their program or they cannot figure out how to do something on the computer, they are more likely to delete the project they are working on or start a new one. If a difficulty arose in a friendship, these children would negotiate with the friend rather than
abandon the relationship. Since the computer is unable to negotiate with them, they eliminate the problem by deleting it. This does not mean that they never finish a program or do not write interesting programs on the computer. They do, but they are more likely to write programs that produce interesting artifacts or that explore complex intellectual ideas (such as recursion) than they are to try to comprehend the computer’s error messages. They also are more likely to get angry at the computer rather than at themselves. A typical example is:

A person does everything you tell him. A computer doesn’t. Like you tell it something and it’ll mess it up for you....see that’s what a computer does to you. It messes you up.

When something goes wrong, they give the computer relational qualities; they feel that it has abandoned them, been mean, or unhelpful.

Relational children are more likely to have an internal locus of control (see Table 2), which means that they believe that they have control over what happens to them. Since relational children have an internal locus of control we would expect them to take responsibility for their mistakes on the computer, however, this is not the case. Although they know the computer is an object, they interact with it as a human, thus they respond to it as they would a person. If the computer does not do something for them, it is because it "did not listen" to them or "did not
understand". Thus, they get frustrated and angry at the computer for not being easy to communicate with.

Environmental Model-- The environmental children are more likely to fix a program they have written than to start over. They see finding bugs and fixing them as a game or competition against the computer. Also, debugging is a more analytical task, which is consistent with the way an environmental child is likely to think. Environmental children are more likely to say they like to start and finish programs. These children are interested in their own power, one proof of which is that their program works.

Although their locus of control is more external than that of the relational children, these children are more likely to get angry at themselves when the computer does not do what they ask because they feel less powerful and out of control. They want to conquer the computer and make it obey them so they can reassert their power.

3. Issues of Power and Control

Both the relational and environmental children admit the power of the computer. Both are interested in control issues concerning the computer, but they respond differently to these issues. The models developed here are consistent with Gilligan's models of moral development and Keller's model of Western science, however, both groups have the same goal in mind: To manipulate the computer in order to know and understand it. No matter what model of interaction they
choose, children find aspects of the relationship that are meaningful to them which then help them to grow intellectually and emotionally.

The issue of control for some children may be complicated if they act out, with the computer, conflicts they are having in personal relationships. Since much of emotional growth comes from interactions with other objects (things and people), if a child is having a conflict he may transfer it to the computer, thus, his interactions with the computer can be interpreted in terms of working through these conflicts (for a complete discussion see section on The Child's Relationship to the Computer).

**Relational Model**-- The relational children value connectedness as a model of human relationships. They want to develop collaborative relationships with the computer that will facilitate their thinking. They are interested in maintaining connection, and feel upset at the computer if it treats them "badly." They also feel connected to it when they have done good work. One girl describes her feelings about completing work with the computer:

> When I'm working on a procedure and I'm almost done and I know I'm going to be right and I know everybody's going to like it and it's big and it has all these different things and I worked real hard on it, then I like it. I like that feeling that I did it. No mess ups, no nothing 'cause you know a lot of times you can't do what you planned on doing because of the computer.
The relational children recognize that the power of the computer can facilitate their thinking. They want to harness the computer's power, not for the sake of domination, but so that they have some connection to it and can use it to help with their work. In talking about being allowed into the system controller to help the teacher make new accounts for her classmates a child said:

Mrs. Bocello asked me to [give the students accounts] when the thing broke down. We logged everyone back in. So everyone said, "Oh, she got Syscon's (system controller) password, that's so unfair," but I'd say, "Guys, it's not big deal. I'm not going to steal anyone's program or take a look at anybody's password or anything so I don't care about it."

This child saw her work for the teacher as collaborative and helpful. She was not interested in breaking into Syscon the way the environmental children were, and once in had no interest in looking at passwords or programs that were other children's private property.

**Environmental Model**— Because the environmental children often have difficulty with personal relationships, they seek expertise and control over the computer environment. They are interested in speed, power, and winning. Winning, beating the computer, and being an expert in programming makes them feel powerful.

The environmental children are challenged by power. They are excited by competition and feel really good when they win. They want to know what they can make the computer
do. They manipulate their environment and learn how the building (i.e. programming) materials work. One way to do this is to break into the system controller. Many environmental children spent the year trying to figure out the password to Syscon. They even made a game of it and challenged one facilitator to keep them out. These children want autonomy which means being able to manipulate the materials in such a way that they have ultimate power over it. As one child said,

You don't have to go out and buy all the separate pieces. If you need something you don't have to go out and buy that piece. It's just right in there.

Instead he can build his own environment over which he will have ultimate control. Knowing how each piece works because he built it allows him to manipulate and control each aspect of his programming environment.

In the next section we see that personal appropriation of the computer is deeply connected to how the child interacts with the computer.
V. THE CHILD'S RELATIONSHIP WITH THE COMPUTER

The children in this study found many different kinds of personal meanings in their uses of the computer; some used the computer to think about "neat ideas" while others used it as an artistic or expressive medium. Still others used it as a way of gaining control over their physical and emotional environments. The personal meanings given to the computer are consistent with the value these children give to other aspects of their lives.

The personal meanings given to the computer often reflect the nature of their relationship with other people; thus, the relationships children have with the computer are complex and can be very intimate. The complex nature of the child's relationship with the computer stems from their relationships with other people. Children who are able to interact with people well prefer the computer to be more like a person. If it is a thing, they feel less secure because they feel less of a connection with things than they do with people. For them, what is scary about interacting with things is the possibility that "It doesn't understand," or "It doesn't help me," thus, they will lose their connectedness to it.

Other children have a complicated relationship with the computer partly due to the complex nature of their feelings about relationships with people in general. Many of these children desperately want to have more friends or closer
relationships, but they do not know how to so they displace their feelings by projecting them onto the computer. Both human relationships and their relationship with the computer are full of ambivalence. Their feelings toward the computer include both positive (e.g. love) and negative (e.g. anger) feelings. Some children, for example, say very negative things about the computer, and then say, "But I love it."

The child who has a difficult time with personal relationships, in order to develop emotionally, needs to find something he can relate to. If his relationships with others become too difficult (i.e. unsafe), he may relate only to objects or seemingly to nothing at all.\(^{40}\) Bettelheim (1967), in speaking of infantile autism, asserts that a relationship with an object "constitutes a self-chosen positive attachment and this...soon permit[s] the child to escape his exclusive relatedness to the one set of negative experiences."\(^{41}\) In other words, when a child has had terrible experiences in relating to other people, he chooses to relate to a physical object which then acts as a conduit for expressing his extreme negative feelings.

The child's relationships with people are full of ambivalence: He feels love and hate, attachment and

\(^{40}\) Bruno Bettelheim (1967) claims that this inactiveness is not lack of relating, but is instead negative relating to other people. See, for example, The Empty Fortress. New York: The Free Press, 1967, page 91.

avoidance, joy and anger, fulfillment and frustration. The objects that he employs help him to work through and cope with the continuum of feelings that he has about his relationships with others.

For Bettelheim, the important factor is that the autistic child, although mute, has an intense desire to relate. Yet, he is terrified of the intensity of his feelings of hate. He is also afraid of feeling any more pain for more pain will surely cause him to die. When a child feels threatened by his feelings, he will repress them perhaps to the point of not expressing anything at all because, "...repression of the longing for relatedness [with other people] is more total than in any more open or active show of hate. It is repression of such depth that it has to be kept from ever coming to awareness by a total avoidance of all relatedness..."\(^{42}\)

Children who have difficulty relating to others often respond to computers in ways that remind us of Bettelheim's children. Although by no means autistic, they share with autistic children the desire to relate, to be understood, to be loved. They discuss their deep feelings for the computer, and interact with it with the same intensity they might a person. They are devoted to it, and act toward it in ways they wish they could another person.

\(^{42}\) Ibid, p. 90.
The complexity of the children’s relationships with the computer manifested themselves in my relationship with them as well. By the end of the study, I found I had gathered more information on and was closer to children who were able to interact easily with people rather than things. I wondered if I had caused this by being more relational myself, or if this was an effect of their individual styles, or both. I knew that since their styles of interaction are very much a part of their personalities, I had not just by working with them influenced some children to be environmental and others to be relational. However, the relationship I had with the children was closely connected to the model of interaction they used with the computer.

Because connectedness and interaction with others are important to them, the relational children developed a close relationship with me. When I asked questions they responded willingly and revealed intimate details about themselves and their lives. The environmental children, although they revealed some of their feelings, were less willing to share their ideas or feelings with me. Perhaps because of their limited experience with personal relationships, they felt less comfortable sharing their personal experiences.

Often the environmental children used the computer to distance themselves from me. They wanted a relationship with me, but did not know how to ask for it. They would ask me to come see their work, but when I did or if I showed too
much interest, they became guarded. They would invite me over to see a program, but when I asked about how they programmed it, they would keep the code a secret. One group of environmental boys worked with their monitors off so it was difficult seeing their work in progress. Instead, at the end of the day, they gave me permission to collect samples of their programs. This allowed me in, but also kept me at a distance from them. They felt ambivalent: They wanted the closeness they saw I had with the other children, yet, when I tried to work closely with them they felt vulnerable and shut me out.

One boy, a bully who had extreme difficulties with other children, distorted my name to see what I would say. When I told him I preferred to be called by my real name, he immediately complied. Since our relationship was less formal than his relationship with his teacher, he needed to find the boundaries by testing them. The way he knew how to do this was to test the limits of his power by finding out if I would object. This same child would ask me for help, and when I gave it to him, would pretend he did not care about or need my help. Clearly, our relationship (and his relationships with others) was quite complex.

Had I been more environmental myself, I might have been able to relate more like the environmental children. We might have developed a different language for talking about
what they were doing or how they were feeling. Instead, I gave them the room they asked for which led me to know less about them, but which helped them to feel safer with me.

VI. CASE STUDIES

In the case studies I illustrate how the model of interaction is related to what the children think about, feel, and do on the computer. They have been written from the interviews, tests, and observations of the ten case study children. I have chosen to illustrate five children in the case studies section. Two boys will illustrate the environmental style, two girls the relational style, and finally, another boy will illustrate someone who straddles both styles.
A. FLORENCE

1. Background

Florence is an eleven year old fifth grader. She is very bright and friendly; her peers consider her one of the best programmers in the class. She lives with her mother, father, and two brothers, one older and one younger. Her father is a house painter, but has a graduate degree in religion from an Ivy League School and is presently working toward a Ph.D. in religion from a local university. Recently Florence was accepted at two private schools with scholarships at each, but turned down both so that she could stay with her friends at the neighborhood public school. She does not own a home computer.

2. Appropriation

Florence appropriates the computer by using it as a tool to think about powerful ideas. For example, Florence solved the problem of the Towers of Hanoi (see Appendix E) in a month. She was able to break the problem down into small pieces, using only one disk, then two, and then three to figure out the pattern. Later when solving the problem with many disks she saw that solving the problem with any odd number of disks was similar to solving it with one, and solving it with any even number of disks was similar to solving it with two disks. The computer allowed her to work scientifically by making hypotheses and immediately testing them.
Florence also found the computer to be a powerful tool when working with an MIT researcher on the concept of parallel processing. Mitch discussed with Florence how a primitive in LOGO called **TONE** works. In LOGO the command **TONE** takes two inputs (two numbers). The first number is pitch and the second is duration. For example **TONE** 100 30 would play at a pitch of 100 for a time of 30 (which is equivalent to a low note for 10 seconds). **TONE** has a feature that makes it different from other LOGO primitives. In most cases the whole observable effect of one command is completed before the next is begun, but the effect of **TONE** is only to initiate the sound. Thus, if **TONE** is typed in first and then a procedure named **CIRCLE**, the sound will continue through the drawing of the circle. If the procedure **CIRCLE** comes first, the computer will draw the circle and then play **TONE** following the more common pattern. In the following interview, Mitch and Florence have already tried various cases of **CIRCLE** **TONE** 400 20 and **TONE** 400 20 **CIRCLE** and are beginning to discuss why **TONE** works the way it does.

**M:** If you say **FD** 5000 **TONE** 400 20, what do you think will happen?

**F:** While it’s moving it’ll play the **TONE**.

**M:** [tries it]. So it drew first, then played the **TONE**. How about the other way? **TONE** 400 20 **FD** 5000. **TONE** then forward.

**F:** It’ll play the **TONE**, then go **FD** 5000. [tries it]. It played while it was moving, didn’t it?
M: Yeah. Let’s go back to TONE and CIRCLE. Do you remember which way was which?

F: CIRCLE TONE drew the CIRCLE then played the TONE. TONE CIRCLE played the TONE while it was going around.

M: How about with FD and TONE?

F: Forward, it always did the TONE... OK, when you did FD 5000 TONE, it went 5000 then did it. [tests it again] Right. But with TONE FD, it did it [played the TONE] while it was moving. [tests it]

M: So is that like the CIRCLE case?

F: Yeah, it is. I know, because the TONE takes more time to run. It does it, but it does the other thing while it’s running. It reads the whole line, not just half the line at a time. So when it does TONE 400 20, it starts it, then doesn’t have to look at the procedure anymore because it knows how long it’s going to run it. Instead of... I don’t know if I’m making any sense. But it knows how long it’s going to run it so that’s in its conscience [sic] but it’s not thinking about it. Then it does FD 5000. But if it’s FD 5000 TONE 400.... That would still work though, the other way around would still work since 5000 would know how many and would just keep going... although it needs... here’s another thing. When you’re forwarding 5000 you can’t use the turtle, but when you TONE 400 20 you can use the turtle. Maybe that has something to do with it. Because they’re procedures. Do you get any of what I’m saying?

M: When you say because they’re procedures, what do you mean?

F: It would work the other way FD 5000 TONE 400 20, but in a way it wouldn’t because FD 5000 would make it go 5000, but something would still be going on that you could see and still had to think about. Something had to move.

M: The computer has to pay attention to the turtle, but when it’s playing a TONE it doesn’t have to pay attention to it?

F: TONE stays exactly the same for 20 whatever. But FD 5000 is moving, and going on different parts of the screen, and those little dots [pixels] have to come alive, light up.

M: I see what you are saying, you have to keep changing something.
F: Yeah. I play the piano, and if I play a chord, I wouldn’t have to think about it. I’d only have to keep my fingers down. But if I’m playing a scale, I know what to do, but I have to watch it because it’s going to change. Each little thing, something else is going to happen. Like something else is happening cause it’s on a different part of the screen. Know what I’m saying?

M: Yeah, I know what you’re saying.

F: It’s probably not right, but that’s what I’m thinking now.

Being able to test her hypotheses and see the results immediately showed Florence the potential power of the computer in an exciting but safe manner. It also helped her become a scientist by allowing her to test her hypotheses. The computer’s behavior evokes questions about how things work. In this case, the computer, now transformed into an object-to-think-with in the Piagetian sense, helped Florence think about abstract, yet powerful ideas. She formed several hypotheses about how TONE works and was able to test them. Whether Florence was right or wrong about her hypotheses does not matter. If they were wrong, she formed new ones.

3. Model of Interaction

Florence’s model of interaction with the computer is relational and reflects her interactions with other people. She relates to others by communication and exchange. She judges relationships by the actions and intentions of others. If others are both giving and accepting, then she considers them worthwhile friends. Although she knows the
computer is not alive or human, she uses the same rules for her relationship with it.

Florence says the computer does not have any feelings and cannot communicate with people. Then she modifies her statement by saying:

Well in a way it can. It's not like a person, because most people aren't easy...well, they are easy to communicate with, but they have a say in what goes on and the computer doesn't. You type in and it does it. I mean, unless something is wrong with it. But a person has a say in what [he] can do, what [he] wants to do most of the time.

In other words, although Florence knows on an intellectual level that the computer does not have intention, it still feels like "it wants to mess you up." The computer’s status is ambiguous and confusing.

She also believes the computer thinks differently from her and she does not know how to gain control over the way it thinks. She says:

"You have a problem and you know this is going to work and [so you] put it on the computer and it doesn’t work, [but] not because the computer’s not right. You have to figure out the problem. And it’s weird because you think...I figured it out in my mind and it works and it doesn’t work on the computer so I think the computer is weird."

Florence considers this lack of communication mysterious and describes it in terms of human relationships. She says about a problem,

"Because I already have figured it out in my head and I’ve got it perfectly. This goes there and that goes there and it fits altogether and makes a big happy home or family. Then you put it into
the computer and all of a sudden it says, 'Sorry, this isn’t going to work.' That can’t be, because I already figured it out."

If her thinking works for solving problems, then it should still work on the computer. Since it does not, she feels confused and baffled.

She cannot reconcile the computer’s apparent intelligence with its inability to solve problems the way she does. There is no question in Florence’s mind that her way of solving the problem is correct. She does, however, realize that she has trouble communicating with the computer. Although she believes that the computer is smart, she does not believe that it thinks. She says, "It doesn’t think, because people think and they put their thinking into the computer....It doesn’t have to think because people put their ideas into it. It doesn’t need ideas for itself because it has so many ideas already." Yet, if other people’s thinking is in the computer, and it does not understand Florence’s way of thinking, then something must be wrong with it.

This confusion about whether she should interact with the computer as a person or a thing is reflected in one particular interaction. Early in the year Florence had spent many weeks programming an animation of a hot air balloon flying across the sky. When the program is run, the balloon during flight gets popped by a bird flying by and falls to the ground making a noise.
Soon after completing her program, the hard disk on the network failed, so all the children’s programs, including Florence’s balloon program, were lost. After that happened Florence often worked on the computer, but never finished any of her programs. She had good ideas, and understood new concepts well, but she did not finish what she started. She reacted as though the computer had hurt her, and she had responded by not "trusting" it anymore. Instead, she would write very short programs that would do "neat" things, or would help others with their programs.

During this period she wrote a program that would make a mirror image of a drawing. Both writing procedures that would do intriguing things and helping others allowed her to show her prowess at programming, but protected her from the computer hurting her. She now had a defense against the computer sabotaging her work.

Florence knows that working with others eliminates her from any programming competition. Florence is competitive but does not have to win. She talks about loving to play soccer and says, "We always lose, but I don’t care. I’d rather lose every time and get to play than not play." Her attitude toward the computer is similar: She sees it as a challenging puzzle rather than an environment she must control.

Collaboration with others gives Florence the feeling of connectedness she sees as a crucial aspect of relationships.
When working with others she sees cooperation as the key to getting things accomplished. She realizes that in larger projects it makes sense to divide the work into equal shares and then put the pieces together to create a final product. She states, "[In Lego] I liked working in a group because there were so many different things to do that each person could work on a separate thing. When you put it all together it would be like one," just as working together allows a group to become one.

4. Tool User

Florence sees the computer as a tool for thinking about problems, but does not always use computer programming to solve them. It is the problems that she finds compelling, not the computer. She says that her favorite thing about computers is that it "gives me problems to figure out and keeps me interested." In other words, it encourages her to think about powerful ideas.

5. Style of Work

As a pianist, Florence is fond of music. One day she decided to turn the computer into a keyboard. She wrote a procedure that she called MOVE which allowed her to move the turtle a certain amount and in a specific direction by pushing one key on the keyboard. When she talked about writing a program that would allow her to make a singing Christmas card, I suggested to her that she use the same principle in her MOVE program for building her piano.
Florence began exploring the **TONE** command by bringing an electronic keyboard to school so she could match the notes to the computer. This task is technically difficult on the IBM PC Jr. she was using. With the LOGO manual in hand she then turned her computer keyboard into a music keyboard by assigning key A to note A, key B to note B, etc. When she got to flats and sharps, however, she realized that it would be too hard to play if one had to hold down the control key and the note at the same time. At a classmate’s suggestion she changed the keys to resemble the keyboard pattern on a piano.

Florence’s use of the computer demonstrates an analytical style of working. She uses a systematic method for programming and always has a plan. She also works on a problem with a top-down approach, breaking it into smaller pieces. Florence’s Rey-Osterreith Test\(^{43}\) supports this view. Although she drew the outline of the figure first (which is typical of a holistic style), she then divided the figure into sections. She drew the contours of a segment and then filled in the details. Then she went to the next segment. Although she drew somewhat holistically, her overall style is more representative of an analytical style. Florence saw the relationship among the sections and how they fit together to make the whole. Her programming style

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\(^{43}\) See Appendix D for a discussion of the Rey-Osterreith test.
is similar. She analyzes the problem and then works on it serially. She does not go onto another section until the first one is completed.

Although Florence usually does not like changing her plan, she will occasionally accept a suggestion. When her classmate suggested that she make her keyboard match the finger pattern on the piano, Florence immediately saw it as a good solution to her problem so she accepted it. However, most times she will not change her plan. She explains that changing her plan makes her lose her original ideas, "I have a picture of what I want in my head and if somebody changes this picture any bit I’m going to lose it all and get all messed up."

Florence goes on to explain that when she is drawing or working at home, her brothers will often add something. This infuriates her and she says to them, "That wasn’t supposed to be that way. Why did you change it without asking me?" Florence feels that her brothers have overstepped the boundaries of their relationship and have damaged her work. Her feelings resemble her feelings about the computer sabotaging her work. Because that is an inappropriate way for a person or a computer to act, Florence does not want to tolerate such behavior, either as a partner or a friend.
6. Power and Control Issues

Although Florence understands the potential power of the computer, she does not want to relinquish what control she has over it. Instead she needs to find a way to negotiate with it so that it works with her. At one point Florence had drawn a city for her Christmas card and she wanted it to be snowing. Since she was going to use the turtles to make the musicians play, she wanted to stamp the snow. I pointed out that snow is a random event and does not fall in a regular pattern. Since Florence had decided to use a shape as snow and stamp it on the screen, it would form a regular pattern.

I showed her how we could make the snow fall randomly by using the REPEAT and FD RANDOM primitives. At first we just tried repeating 1000 times a dot of snow. Florence suggested that she make a shape of snow and randomly stamp it so it would "snow" more quickly. Making snow like this produced random clumping of the snow which Florence did not like. Instead she controlled the snow by stamping it one inch at a time manually, not even using REPEAT in a symmetrical pattern. In doing so she wanted to control the computer, and make the snow fall in a more even pattern. This story is consistent with the results of her locus of

44 STAMP is a primitive in LOGO that works like a rubber stamp. When told to STAMP, the computer prints on the screen a graphic of the turtle shape.
control test on which she shows an internalized locus of control.

Florence’s music program also exemplifies how she maintained control over the computer. Her tone program would let her "play" her computer keyboard only in "real" time, the way she would a piano. I showed her how to write a program where it would play the notes as programmed. She understood, but preferred to control the keyboard herself rather than have the computer play the song for her. In this case the control issue is complicated by aesthetics: Florence also got pleasure from playing the keyboard.

Florence chooses not to use the computational power of the computer, but instead is exploring her own powers. She reduces the computer’s power by taking away what it does so well. However, her intention is not to conquer the computer; it is to find a way of working with it that will facilitate her thinking in a non-threatening manner.

7. Conclusion

Florence’s response to and style of interaction with the computer are consistent with the relational model of interaction. She discusses the computer in terms of human qualities, and interacts with it as though it were a human. She desires a relationship with it that emphasizes connection and communication and feels disappointed when it does something "to hurt" her. When the computer sabotaged
her work, she found new ways to interact with it that would be more acceptable to her.

Florence was a tool user. She used the computer as a laboratory for testing her ideas and theories. In her work with the MIT researcher she made hypotheses and then used the computer to test them. It became an object-to-think-with in the Piagetian sense; a way to explore visual conceptions of programming ideas. She also used it to think about interesting mathematical concepts as in her discussion of the RANDOM command.

Florence was somewhat threatened by the power of the computer, so she found a way of using it that reduced its power and made her more powerful. She turned it into a familiar object (a keyboard) and transferred knowledge she has about the physical world to it. However, when the computer acted in ways that hurt or confused her, she abandoned working on her own computer programs and worked with others. This gave her the distance from the computer she needed while still maintaining connection with others.
B. BETTY

1. Background

Betty is an eleven year old fifth grader. She is an only child who lives with her mother and stepfather, and who visits her father and stepmother weekly. Recently she was accepted at a private school which she plans to attend beginning next year. Betty would like to be an actress when she gets older. She does not own a home computer.

2. Appropriation

Betty has appropriated the computer by using it to make animated and written stories. The first animation she made was of a man rowing while a radio in the boat played music. Betty was more concerned with what the finished product looked like than the programming code itself. She spent quite a long time making sure that the notes were played at the right moment. Like other relational children, Betty would like the computer to be more like a person. She says she likes animation because:

...You can make someone do something and it looks like...they are really there 'cause when you work on a computer it’s like weird. You can tell it to do stuff and it’ll do it but it’s not like another person because you have to type in a certain thing....And that’s why I like animation because you can make it like a real person, make it move and stuff.

Because Betty is interested in theater and dance, many of her programs were animations of people dancing. She would write one program and then instead of altering it she
would copy it to another page where she could add new elements to it without changing the original program. One program she wrote was of a woman dancing. Later she copied it to another page so that she could add several other dancers without changing her first program.

Betty particularly likes writing. If she does not become an actress she would like to be a newspaper reporter. She says she has bad handwriting so the computer frees her from worrying about whether her stories will be messy or not. She says, "...if I were writing [the answer on a test] on the computer that had the questions, I would write down like pages full of answers and stuff."

3. Model of interaction

Betty knows the computer is not human, and is frustrated by it. She wishes it would communicate with her as readily as a person would. She says:

What I don’t like is when the computer doesn’t understand something you say in regular...in English and it’s not...[it’s] in commands. It doesn’t understand what you say, "Well, go back a little farther but keep on the line." It won’t understand. They should make something like that where it understands English.

Although Betty says the computer is more like a machine than a person because "It doesn’t have feelings, it can’t do anything by itself, stuff like that," she wishes it had more relational qualities.

...It isn’t nice....If you could ask it something like, "If I wanted to do this, how could I get the
turtle to do this?" It would answer...instead of not helping, it would tell you how to move.

For Betty, collaboration is an important aspect of human relationships. When she discusses working alone as opposed to working with people, she says she likes to work with people when, "They aren’t stubborn, and when you don’t know how to do something. You can then go ask someone else."

Betty finds LOGO particularly difficult because she has difficulty with spatial relations. If the computer (i.e. LOGO) could understand her English, then she would not have to figure out the angles of the shapes she draws. Betty said on the gender attitude survey that she hates to draw. When I asked her why she answered it is hard because,

You have to have just the right command. It has to be going just the right way. It’s not like a pencil in your hand, you know how you want it to look. Sometimes you can’t get it to look that way, but [writing with a pencil] is easier and it looks something like you want to than it [does] with the turtle.

One day Betty tried to draw a Christmas tree but did not know how to make the angles of the triangle a size which would make the top come out right. I explained that there were 180 degrees in a triangle, so if she made the bottom two angles the same and subtracted them from 180, she would find the third angle. She did not use my method and was unable to find the right angle. Instead she tried different angles until she found one that was not quite correct, but was close enough for her.
4. Style of work

Betty is a classic soft mastery programmer. She does not plan her programs, but instead adds to them as she goes along. When I asked her if she had a plan before she began writing or programming she said,

No, [in writing] I just get my idea. Well, you could start it out by doing this, or you could do something like what this is about. Sometimes I just get a good idea for the ending and I have to make up the other parts....[in programming]...I figure out, well, I want it to do this so I have to put in this and this and this. [On one program] I thought all I’m going to do is make a guy walk and now I have this whole other thing added and it’s altogether different.

If she has a bug in her program, she incorporates the artifact from it into her original program. She thinks about programming globally; she creates an image in her head of what she wants to do and changes it as she goes along.

Her Rey-Osterreith test supports this view. She drew the outline of the figure first, then drew the major supporting lines, and finally added the details.

5. Power and Control Issues

Betty’s issues of control with the computer are somewhat different than those of the other children. She feels she has difficulty using the computer, and is not as good a programmer as others which leads her to feel inadequate and helpless.

Some kids like Sam easily adapt to using a computer [and] are quick to learn how but...for me it takes...a while to learn how just right....It takes me so long to learn and I don’t like
learning things unless it's really important and I really want to do it. I mean I want to work on computers but it just takes me so long to remember all the commands and learn all the things and how you do them...

Although she feels as though she is not good at programming, Betty was a runner-up in the school's computer contest. She made an animation of Paul Revere's ride through a town, and showed the Redcoats marching across a field. Even so, Betty measures success by how easily she can do something. I suggested to her that good programming has two aspects to it: one is writing the code, the other is creating interesting ideas. Later, when I asked her who the best programmers in the class were, she did not mention Sam. I asked her why. She acknowledged her agreement with my earlier comment by saying, "He's alright [as a programmer but] his ideas aren't always that interesting."

Although she feels insecure about how good she is at programming, Betty finds computers most exciting when "I've done a new program and it's real good." Her comment is consistent with the results of her locus of control test which (six questions answered with an external locus of control) shows she has a borderline internal locus of control. Her score reflects her ambivalence about her abilities. According to Betty, a good program is one that, "...[does] better things, they look better like Stewart's."
They are just so much more complicated." Still she ends with, "I can’t do real complicated programs."

Like the environmental boys, Betty, too, would like to get into Syscon, but for reasons unrelated to power. Instead they have to do with how people act towards each other. She says about wanting to get into Syscon:

Sometimes [I want to get in]. When people go into my thing [account] without telling me and Mrs. Bocello won’t let me have a password. And I don’t like knowing that people could just go into my programs and stuff. Some people just try to login on other people’s names and stuff. It’s alright if you give someone permission to, but if they do that without your permission it’s kind of annoying...if they mess up your program.

The rule of relationships she is alluding to is about privacy. For Betty a computer account is private just as a diary would be. Unless she gives someone permission to "read" what is in her account, she does not want them looking at her work. It is not a matter of keeping her programs a secret; she is more concerned about other students tampering with her programs. She also insists that they respect her as a human being: friends do not look at one another’s work without permission.

6. Conclusions

Betty’s model of interaction with the computer is relational. Although she believes the computer is more like a machine, she would rather it be more like a person. She wishes it were more communicative and collaborative, and
that it would have more human qualities such as being nice and helpful.

Betty has appropriated the computer by programming animations that are directly related to activities that she likes such as dancing. By her own report, she likes animation particularly because it makes the computer seem more human and alive.

Her control issues with the computer concern fluency more than power. Betty would rather have a collaborative, friendly relationship with the computer than a competitive, controlling one.

Betty does not feel that programming is easy, and since she believes that what is easy is what one is good at, she feels incompetent at the computer. Even so, she recognizes that good programming ability includes creativity, not just good programming skills.
C. SAM AND ROGER

Sam and Roger interact with the computer in similar ways, but appropriate it differently. In the following case studies, I discuss their similarities first, and then talk about each separately.

1. Background

Sam is the youngest boy in the class. He is an only child, very smart, and is overweight, which bothers him tremendously. Last year when Mrs. Bocello asked the children what they would change about themselves, Sam wrote that he would like to be thinner. Sam does not have many friends and came to be considered a "computer nerd." During the last year, his parents had marital problems and the family has been in therapy. His mother has a graduate degree in child psychology.

Roger is the biggest child in the class. He is the second of three boys. Roger is a "tough" kid: He does not show his emotions, and rarely responds to negative or positive feedback. He is not always liked because his peers consider him a bully. Roger’s father is a truck driver, so Roger has grown up with very traditional values about what it means to be a boy and masculine. As Mrs. Bocello has said, "Roger would rather die than go to a ballet." He is very smart, but is also a wise guy. The family lives in a poor neighborhood which reinforces Roger’s concept of what it means to be tough.
Neither Roger nor Sam is well liked by his peers. Roger is considered to be too tough and unapproachable and Sam is unathletic and considered to be a nerd. Both like computers, and are considered to be hackers, or "a person who enjoys learning the details of computer systems and how to stretch their capabilities." Both have their own computers at home which they use to play games and do homework. Both are proficient at programming so are considered to be two of the best programmers in the class by their classmates and teacher.

Roger and Sam say they like playing videogames on the computer best, however, both spend much of their time with the computer programming. Neither says he particularly likes to write, but they each agree that it is easier to write with the computer than with a pencil. The major issue for both is control over the environment: Sam because he wants to belong, be understood, and be loved; Roger because being tough and in control is what he identifies as being masculine. Both manifest these control issues by trying to obtain power over the computer environment. Also both have an external locus of control (see Appendix B for a discussion of the Locus of Control test).

D. SAM

1. Appropriation

Sam has appropriated the computer by becoming an expert on it so that he can control his external environment. Partly because of the present problems in his home environment he has continued to gain weight over the last year. The more he loses control over his body and the situation at home, the more time he spends trying to control the computer environment. Thus, he has become an expert programmer. He resembles the "hacker" who spends all his spare time with the computer with little regard for anything else including his appearance.

He hopes that by becoming an expert on the computer he will make friends, be well liked, and be respected by his peers. Although friends are important to Sam, he is unable to communicate well with his peers, and does not understand how to interact with them.

The computer has become Sam's refuge, a safe place in which he can explore his relationships with and feelings toward others. He knows he is good at the computer and this helps him feel secure. However, his refuge becomes threatening when others are around: For example, often visitors come to Project Headlight to see what projects the children are working on. Sam was asked if he liked having people watch him program.
S: Well, I can't breathe when everyone crowds around. Like before when some people came to our room and we showed our Legos, I mean, there was a big darkness. I couldn't see anything. Then suddenly when they all left a big bright light came and I breathed much easier. I don't know why.

I: It must be nerve-wracking to have people around while you are trying to work.

S: Yeah. And mostly when people are around me and everything worked the day before. Something goes haywire and nothing works.

I: How does that make you feel?

S: Angry. Disturbing. Embarrassed. "Oh, no. This doesn't work."

Sam is anxious when he feels he is being judged because the people evaluating him may find fault with him and decide that he is not good enough to be loved or understood. His deep relationship with the computer already suggests that he finds having a relationship with an object safer than with a person.

Although he feels that expertise on the computer may gain him the respect and friendship of his peers, he does not know what the rules of relationships are. For example, Sam believes that people demonstrate their love for and friendship towards him by doing what he says. One day, Sam's mother accompanied the children on a field trip as a chaperone. Sam spent most of the day whining to her about how hungry and hot he was, and trying to get her to pay attention to him. He also convinced another child to carry his gear for him including a large cooler for his lunch.
He has transferred this model of relationships to the computer. When asked, "If a computer had a personality, what traits would you give it?" Sam answered,

"It would obey stuff like if it says debug, all you would have to do is type in 'If I have a problem, fix it.' And it'll be happy, it'll say, 'Good morning, Sam. How are you doing today?'"

When Sam was asked whether he wanted to have a job where he could use computers, he said yes, that he wanted to invent a robot. When asked what he would want the robot to be able to do, he answered,

"I want it to walk and to talk and you can program it to do everything. And at your voice, you can tell it what to do. You can say, 'Omnibot, go over there and rob a bank,' and it'll answer, 'Yes, Master.' 'Get me all your money.' Shh, shh, shh. Aa, Aa."

Sam wishes he could manipulate people as easily as he can manipulate objects on the computer screen. He cannot communicate with them nor can he make them love him. The more difficult it is for him to communicate with others, the more he becomes involved with computers. He knows better than any other child in the class how the computer works. When asked he says, "...I know there’s a motherboard, input box, a RAM card, and there’s expansion slots. That’s about it." He also understands programming concepts well. If he knows the rules by which it works, then he can at least communicate with it. Perhaps then it will understand him.

However, the more Sam becomes involved with his computer, the more he alienates himself from the very people
he would like to have as friends. His peers can not communicate with or understand him because Sam often talks in computer jargon. One child said of Sam, "He’s kind of strange, he brags about how well he does on the computer." When asked, "What makes him seem too involved?", she answered, "The way he is always working on the computer and stuff. The way he knows how to do everything and he always tries to do more than he can. He thinks he can do more than he can."

Sam struggles to use the language of computers in his conversations about them while also making noises like a machine. When talking about liking "computers with different styles" I asked what he meant. He said,

Like the monitors all having modern electronics...about 15 inches, all kinds of diagonals, directional angles and stuff. And the keyboard, much interesting, space age design.

He struggles to find meaning in the language and to make it his own. He wants to be understood and knows that the only way the computer will understand him is by speaking in its language. However, he really does not know the details of how the computer works. Sounding like he knows about computers will protect him from the scrutiny of others by keeping them at a distance.

He does not necessarily think of himself as a machine (he says people do not think like machines), but sometimes it is more expressive for him to make noises than to
converse. His behavior is an attenuated version of Bettelheim's mechanical boy, Joey\textsuperscript{46}. Joey, who was diagnosed as autistic, would not interact with people because his relationships with them in the past had been so painful. Through what Bettelheim calls negative relating, Joey expressed his intense pain and rage by turning his body into a machine. Thus, Joey's one relationship was with a machine, himself.

Joey believed he would die if he was not "plugged into" the wall. He saw his body as a machine and made elaborate mechanisms that included tubes, wires, and a propeller that would make him function as a machine. He made whirring noises that would indicate when he, as a machine, was running.

Sam is by no means autistic, but his relationship with the computer reminds us of Joey's relationship to his body as a machine. Sam uses the computer's language and noises as a way to communicate in a world where he is neither listened to or understood. At one point he says, "I wish I had said everything...I wish I had one of those voice activators that says, 'Do your stuff.' It says, 'O.K. son.' Ai, ai, ai. Like IBM. They invented this new program. If you say stuff, it'll type it out. 'I am cute.' It'll go shh, shh, shh. Yeum." Although Sam knows he is not a machine, he sometimes sounds and acts like one. The

\textsuperscript{46} Bettelheim, B. 1967, op. cit. pp. 233-339.
computer is an object that he can relate to safely. It will not hurt him the way people have, therefore, the more he works with it, the more like it he becomes. He hopes that if he is "good enough", both as a person and as a programmer, he will gain friends. Instead, his language is incomprehensible to the other children so they think he was weird and "too into computers." He does not know how to talk to them about computers in a language they can understand, nor does he know how to interact with them as friends. In order to defend himself against the pain of more rejection, the computer becomes his life blood, his way of relating and defending against rejection and pain.

Sam's feelings of helplessness in personal relationships are revealed by his locus of control test. It indicates that he has a more external locus of control than most of the children; he answered over half of the questions with an external locus of control. The questions he answered with an external locus of control were those that indicated feelings of helplessness in the home situation (e.g. "Do you feel that it's nearly impossible to change your parent's mind about anything?") or in relationships with others (e.g. "Do you feel that when somebody your age

47 "Good enough" is a term that has been used by psychoanalysts to designate the "good enough" mother, a primary caretaker who creates a safe place for and lets the young child know he is loved. In this case I mean it two ways; Sam as a good enough person and as a good enough programmer.
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wants to be your enemy there's little you can do to change matters?"). Sam hates this feeling of helplessness. To gain more power he controls his computer environment. There he can create a safe place for himself.

Even though Sam has difficulties with relationships, he prefers working with others because it gives him contact with other people. He wants that contact, and needs the positive feedback that others can give him. In talking about Lego he says, "I like working with partners the best because it's more fun. You can say, 'Hey, why don't we do this?' and he'll say, 'Alright, alright.'"

Because Sam is overweight he is not active and does not participate in sports. However, his favorite games on the computer are "World Games" (Olympics) and "Hard Ball", a baseball game. These games allow him to fantasize what it would be like to play sports with the other children, and to be one of the gang. Playing games gives him vicarious connection to others. When playing videogames he would rather play against someone else than the computer, because it gives him contact with others.

Sam has become deeply attached to his computer. When asked if he was afraid that he would become too involved with the computer he exclaimed, "I'm already too involved!" But he did not consider this bad; rather he thought it was good that he knew so much. Becoming too involved means being too close. Sam is aware of his deep feelings for the
computer, and how those same feelings have scared him in the past. His rejected love for others have caused him great pain; he hopes the computer does not do the same to him.

2. Model of Interaction

Sam's interaction with the computer reflects his need to be in control. He believes the computer is a machine with no relational qualities; it does what he tells, however, people do not do what he tells them. And for those things he would really like people to do, understand him, accept him, love him, Sam cannot possibly tell them for he will lay himself open once again to possible rejection and pain. Sam's relationship with the computer is terribly complex: He wants and needs from it the very things a computer cannot give to him. It will, however, give him time and a place where he can safely work though his relationships with others.

At home Sam feels he is not heard and cannot have his way. At school the children do not like him and he has few friends. He hopes to control his school environment by being one of the smartest kids in the class. In this way, perhaps he can get people to respect him even if they don't like him.

When Sam was asked if a computer could think, he said, "It can think with its machine, I mean, with its, like, memory banks, but it's not as good as a person."

I: Why not?
S: No, it can never replace a brain.

I: Why?

S: Because brains...we’re talking right now and doing all this stuff and all the computer can do is what you tell it to.

I: Do you think it can learn from itself?

S: No, definitely not.

Later in the year I again asked him if the computer could think. He said, "Not unless someone tells it to think. A computer doesn’t really think. It only does what it’s programmed to do. I can’t believe I’m saying all these things bad about computers. I love them so much."

I: Why do you love them so much?

S: ’Cause they’re fun to work with. And the games and stuff.

I: What’s fun about them?

S: That’s hard to say. Just it’s fun working with them. Like all the games you can play on the computer and the writing is much easier and what you can do with your own imagination.

Sam’s relationship with the computer is complicated by the fact that he relates to it the way he wishes he could a person. He has ambivalent feelings toward it; yet, there is a large difference between Sam’s relationship with the computer and his relationship with people: He trusts the computer. It is safe to project his rage onto the computer because it will not reject him. He is unable to articulate his feelings without intellectualizing them, but he says that he loves the computer in a way that suggests he loves
it as an object (person). It is not just something he loves to do; he literally loves the computer itself. He is able to love the computer because it does not threaten his very being the way people do.

Sam uses the computer in two ways: as a tool with which to do his homework, and as an evocative object with which to explore his feelings. He is unable to articulate how the computer makes him feel, but he uses it to explore his feelings about others. We see this in the content of his programs. All year Sam’s programs were about war. He programmed helicopters, spaceships exploding, tanks shooting at helicopters, and buildings burned or knocked down. The content of Sam’s programming can be interpreted as his way of working through his problems as in play therapy. It is an environment he can control without any repercussions from the people around him. He can act out his fantasies without hurting anyone or feeling guilty. Thus, he can kill those he hates or is angry at without feeling guilty. He can then bring them back to life again. This ability to destroy and bring back objects (people and things) is crucial for his emotional well-being and intellectual growth.


49 Piaget believes that the permanence of objects comes from the child’s ability to organize the spatial field, an ability that develops during the sensorimotor stage. Winnicott states that the child’s individuation from the mother (i.e. subject from object) is crucial to the healthy
Sam says he likes playing computer games best. Games are a place where Sam can fantasize that he is the best, both as a person and a programmer. Although he is not able to explain it, subconsciously he is aware that the games make him feel happy and in control. He says, "the games make me relax". Games have limits, rules, and boundaries. With them Sam does not need to guess what the rules are, he knows. That makes him feel secure enough to relax. Games also allow him to be who he is. They will accept him, and because he is particularly adept at them, will praise him by telling he is good or giving him a gold medal.

3. Power and Control Issues

The computer environment offers Sam a chance to control the environment by manipulating objects on the screen, and a place to gain intimate knowledge of how a system works. For Sam learning about the inner workings of a mechanical or electronic system is easier and safer than trying to understand the rules of personal relationships.

Sam said breaking into Syscon, the system network, was like breaking into the Pentagon. He also said,

"It felt like I accomplished something....But I don’t want to do it anymore. I know I got into big trouble. It’s not O.K., but it’s O.K."

When I asked if he felt excited by breaking into Syscon he said, "It was exciting when nobody could do it. Nobody development of the personality. For further discussion see Piaget (1977), p.457, and Winnicott (1967), Chapter 6."
knew how. We just actually tried to login and it didn’t ask for a password, it just logged us in." Like the other boys, Sam finds breaking in to be exciting, not only because he is in forbidden territory, but because "no one else could do it." This sense of being able to do something no one else can do makes Sam feel powerful. He does not like to get in trouble, yet he is challenged to gain power by doing things no one else can do.

4. Style of Work

Sam is analytical and mathematical. At graduation this year he won a prize for achievement in math. In his programming he is interested in the code more than in what the program looks like on the screen. His end products are sparse and violent. He does not use superprocedures, but instead writes a few very long procedures.

Sam added Florence’s TONE procedure to his program although he did not know how it worked. He did not ask anyone, nor did he "mess around" with it. When he added TONE to his program I went over and asked him if he knew how it worked. Sam said that he did not, so I showed him. After that he used it in all his programs. Still he did not explore the command, but instead learned the rule for using it. Like Turkle’s hard mastery style programmers, Sam used a top-down approach to programming following rules that he had set as guidelines.
His Rey-Osterreith test confirms this impression that Sam uses an analytical style of working. He began at one end and drew the figure detail by detail, debugging the drawing as he went along and adjusting misplaced lines. He does the same when programming.

5. Conclusions

Sam uses the environmental style of interaction with the computer; instead of thinking of the computer in terms of personal relationships the way the relational children do, Sam instead uses the computer to gain some control over his physical and psychological environment. Like other environmental children, Sam has difficulty with personal relationships. He hopes that, through his expertise, others will recognize his goodness which will in turn make them understand him, love him, be his friend.

Because Sam is acting out his feelings on the computer, he has developed a complex relationship with it. Sam desperately wants to be heard, to be understood, and most importantly, to be loved; however, any additional rejection from people would be too painful, so he instead relates to the computer.

Sam knows the computer is not a person which is exactly why he is able to have an intimate relationship with it. He knows it will not reject him or respond the way others have. It is a safe place where he can explore his feelings, and as such, he has come to trust it. He feels he has become too
involved with the computer, that is, too attached to it. He would like this kind of attachment with others, but that is too scary for him, thus, his need for attachment is different than the relational children’s. His attachment to the computer is a way of protecting himself from others, not a way of staying connected to others.

His external locus of control, too, indicates that he is environmental and reveals to us the source of his feelings of helplessness. He does not take responsibility for the effect of his actions, nor does he feel he can control others feelings toward him. Unlike the computer, he cannot manipulate the way others act towards him.

Sam is challenged by power, especially when doing things with the computer that no one else can do. He does not ask for help, and maintains distance from others by talking in a language no one can understand. He desperately wants friends, but cannot bear the pain that comes from rejection, thus, he distances others by maintaining a close relationship with the computer.

It is possible that Sam, by using the computer, will slowly build up his confidence. His expert programming abilities may gain him the acceptance he needs and wants, particularly from other computer enthusiasts. If so, he will belong to a community of people with whom he can communicate and be friends.
However, Sam is at risk for becoming a "hacker". Both his personality and work style are already reminiscent of MIT's hackers. Turkle writes, "The hacker, however, is lost in the jargon of his machine and its programs." Sam, too, has begun to lose himself in the computer environment, where he has found something he can gain control over. Projecting his feelings onto the computer is safe for now, but as he matures, may render him less and less able to relate to people. Thus, he may end up terribly lonely, with fewer relationships than he has now.

50 Turkle, S., op. cit., Chapter 6.
E. ROGER

1. Appropriation

Like Sam, Roger is interested in power over the computer. He sees the computer as a self-contained but open system. In computer programming, LOGO is a construction kit for him. He can create any procedure he needs, which makes him feel independent. He says, "If you need something you don’t have to go out and buy that piece." The computer allows him to create the environment over which he then has control because he made it and knows how it works.

Although Roger has some difficulties with other children, unlike Sam, he does have friends. He does not use the computer as a replacement for friends; he makes a sharp separation between what he would want a computer to do and what he does with his friends. We discussed building robots, and when I asked what he would want the robot to do, he said:

   R: Clean my room. That’d be good.

   I: There are lots of things a computer could do. What else would you like it to do?

   R: Get me breakfast, lunch, everything. Clean my room.

   I: What about play with you? Sports?

   R: I play sports all the time with my friends.

And when he plays computer games, although he generally plays against the computer, he plays with a group of friends around him. The point is to get the best score, or best
time, but it is also to be social. And for Roger, it is psychologically easier to accept being beaten by the computer than it is being beaten by one’s friends.

2. Model of Interaction

Roger is very sure that a computer can not think because it is a machine that has been programmed by a person. He said, "No, because all the stuff is already programmed into it. The one who made it put all this stuff into it or the disk has the stuff." For Roger, the computer is not at all like a person.

I: Does it think the way we do?
R: No.
I: Is it smarter than you?
R: In math probably, but not anything else.
I: What can you do that it can’t?
R: I can run around, play, just sit in a room and sweat all day.

Roger never talks about the computer having relational qualities. He does not talk about creativity, feelings or imagination. Nor does he make the fact that the computer has no feelings explicit. Of course it has no feelings. It is not expected to have any. The computer is a machine.

Roger’s says his favorite use of computers is for videogames. Being best is a big theme for Roger, yet his definition of best is confused with that of being first. Although he wants to get good scores and grades, the way he
measures his success is in terms of finishing first. In class he always tries to finish his exams and assignments first. Being first means being best even if he gets answers wrong. Mrs. Bocello tried to slow Roger down by telling him if a story was not coherent or there was a problem wrong on an exam he’d get an F. It slowed him down some, but he still always tried to finish first.

His feelings about being best can be seen clearly in the following example:

I: What do you like about Logo?

R: Making animation. Because I might win the computer contest some year. Not this year, but some year. Not this year because Stewart beat me.

I: How did that feel?

R: Don’t ask.

I: You felt bad? Do you think you should have won?

R: Yes.

Winning is very important to Roger. He associates winning with masculinity and power. For this reason, he often turns aspects of using the computer into a game. He broke into Syscon, the system network, several times and wrote a letter to a facilitator challenging him to keep Roger out. I asked him about it:

R: I kept breaking Harry’s password. This one I can’t get through.

I: Did that feel good?
R: Oh yeah. I wish Mrs. Bocello didn’t tell us to stay out. Then I’d keep breaking in.

I: You didn’t do anything when you got in?

R: Just looked in everyone’s files.

I: Is there anything that makes you feel like that?

R: Winning on videogames. Breaking a record on my World Games.

Roger needs to be the best at everything so that he can feel strong, masculine and number one. Computers give him a place where he can try to be best. When asked who were the best programmers in the class, Roger said, "On the top of the list, me." Then he proceeded to name some of the other kids.

3. Power and Control Issues

Roger’s locus of control test, like Sam’s, is more external than the class average. He answered eight of 19 questions with an external locus of control. Again, all the questions answered this way had to do with powerlessness at home or relationships with other people. Roger does not feel he has control over other people or his external environment. He often tries to control both, with much resistance from other people, but little from the computer. If he learns how the computer works well enough, it will do as he tells it.

Roger is also very competitive. During the year Roger participated in a chess club that was started. His best
friend, John, won the trophy for being the best player in the school, but Roger had worked hard to win it. He was disappointed when he did not.

He and John often worked on the same programs at different computers. They sat next to each other and borrowed each other’s ideas, but they rarely worked at one terminal together. They would sit at the computer reading the LogoWriter manual and trying all the examples. They would find a command no one else knew, try it out in a program and then show the program to others. They kept their programming code a secret, even turning off the monitor while typing.

One day Roger and John were working on programming an adventure game. In each segment of the game the player was offered two choices for the next move. Roger and John wrote the program with the monitor off so that no one would know the right choice. A visitor came and tried the game. She suggested that they use "psychology" and make the most obvious choice the wrong one. Roger loved the idea and proceeded to program it. He loved having the secret of how to program and win the game. Making it difficult to win gave him control over other people.

During the year, Florence, another student in the class, was taught how to use READCHAR as a way of getting the computer to do something with a letter or number input. She showed her program to Roger and John, and Roger said in
a condescending tone, "Oh, I can do that." He went back to his computer to write a program that would do the same thing. When he found out he could not program it, he went back to Florence to find out how to do it. Florence was hurt by his earlier comment, so she decided not to give it to him. Although she did not give the program to Roger, Florence gave it to several other children. A friendly rivalry between Florence and Roger began which continued throughout the year.

During the year, Roger was asked to solve the Towers of Hanoi problem. He reached a level where he knew the odd-even rule (see Appendix E), and had recognized and learned the pattern for solving the problem. In order to solve the problem on the computer, one has to input the number of the pole the disk is on and the number of the pole the disk is to be moved to. Since he had memorized the pattern, he was very fast at inputting the numbers of each tower. Usually he knew the next 10 or 12 moves so he very quickly put the numbers into the computer. The computer was not as fast at making the moves as he was at entering them, so he would sit back in his chair and watch it. Solving the problem was not of great interest to him; instead he liked competing with the computer by solving the problem faster than the computer did (one can only "beat" the computer this way because it always solves the problem in the least number of moves). Unexpectedly, since he has an external locus of control, he
was not bothered by his mistakes and would "undo" them using the undo command.

This was also true of his programming. Roger was very good at debugging his programs. Only occasionally would he have to ask someone for help, which he did reluctantly. It was important for Roger to not need anyone’s help. He needed to function independently even when he was working with John. Roger and John sat next to each other, and sometimes copied each other’s programs, but they never worked on a program using the same computer.

Roger says he does not learn anything from the computer, that it is just fun, but throughout the year his programming skills progressed. Even more important is that Roger’s sense of power was increased by his work on the computer. Since he was really good at programming, he was able to manipulate the objects on the screen. He says what is fun is that the computer does what he tells it to. Like Sam, because he does not know how to have relationships, he is unable to manipulate the people in his life as easily as the computer although he wishes he could.

He does not find it mysterious (although he likes to make it mysterious for others) and thinks programming is easy to both do and understand. Like most of the boys, he cares about knowing how the computer works. He’d like to know "how it does the command," yet, he understands on some level how it works. Roger feels in control, powerful, and
interested when he knows how the computer works and is able to create or work in an exciting computer environment.

4. Conclusion

Roger’s model of interaction with the computer is environmental. He believes that the computer is a machine that has no relational qualities. He is interested in controlling it, particularly by scoring high on computer games. He also likes maintaining the mystery surrounding computers by shutting off his monitor, and making games that are difficult to win.

Roger is challenged by the power of the computer. He finds activities like breaking into Syscon exciting, and even challenges others to keep him out. He is able to exert his own power over the computer by scoring highly on computer games, and by controlling it with his programming expertise.

Like other environmental children, Roger has difficulty with personal relationships. He defines masculinity in terms of power, which results in his bullying his friends, thus, he is not well liked by his peers. His difficulty with relationships has led him to use the computer to both explore his powers and his masculinity by challenging it to be stronger, faster, and more powerful than he is. He does this by playing videogames or by programming games that no one can win.
Because of the conflict caused by Roger’s inability to maintain relationships, Roger prefers working independently of other people. The computer provides him with an environment in which he can do this by allowing him to create new elements to his programs and games. Thus, for him, the computer is a self-contained construction kit.
F. STEWART

1. Background

Stewart is very quiet and reserved. Although at the beginning of the year he did not talk much, he was always extremely polite. All three of the other case study children are in advanced math, but Stewart is in a regular math class. He has difficulty with math and logic problems (such as the Towers of Hanoi), and does not play computer games very well. He does not have a home computer.

2. Appropriation

Stewart appropriated the computer by turning it first into an artist’s tool kit, then into an animation kit. The first program he drew was a tree with green leaves on it. As the leaves fell off the tree, they slowly turned different colors. His drawing was beautiful when he was finished with it, although the programming code was spaghetti (code that is written in one long, unstructured procedure).

Shortly thereafter, the class was introduced to animation (Stewart had made the leaves fall by making the turtle, which was now a leaf, move forward toward the ground). I explained to Stewart that he could animate his leaves so that they would fall. He did so, adding a drawing of wind which also blew the leaves around.

Instead of programming the backgrounds to his drawings, Stewart drew them and then animated several aspects of the
drawing. When the hard disk was full, it would not allow anyone to save a program on it. I suggested to Stewart that he write procedures for the drawings as well as the animation to save space on the hard disk and so that he could save his programs on a floppy disk. He began programming the drawings although he still had problems with the hard disk being full. One day he logged in more than ten times during the hour so that he could save a program he had written. The disk still would not let him save his procedures so he lost what he was working on. Stewart showed good spirited frustration and a lot of perseverance, but never complained and never talked about how the computer had "done something" to him.

3. Style of Work

Stewart drew a new picture or programmed an animated scene every four days or so. His imagination seemed endless. He was a classic bricoleur; he used the same primitives and commands in every program, but he reworked them many different ways until he got to know them.

52 The term bricoleur, or tool user, originally comes from The Savage Mind by Claude Levi-Strauss. He writes, "His universe of instruments is closed and the rules of his game are always to make do with 'whatever is at hand', that is to say with a set of tools and materials which is finite and is also heterogeneous because what it contains bears no relation to the current project, or indeed to any project, but is the contingent result of all the occasions there have been to renew or enrich the stock or to maintain it with the remains of previous constructions or destructions" (p. 17). Sherry Turkle uses it to describe a programmer that uses a closed set of programming tools. He reworks them to create many different programs from the same components.
intimely. Occasionally, he would learn a new primitive and incorporate it into his animation "world". Stewart had created an artist's toolbox and animation kit that allowed him to not only gain control over the computer's power, but that also to gain a sense of confidence and a great deal of respect from the other children. Not only was he creative and talented, but he was also incredibly fluent with his programming. The other children talked of him with great admiration. One child said, "Not everyone can do what Stewart can do."

While Stewart experimented with his programming, he learned about himself. Through a series of animations, he began exploring his sense of humor. First he drew a man driving a car who stops, gets out, and paints a house either red or blue. Next he programmed a gym where some people do sit-ups, others do bench presses, and a very fat woman does jumping jacks. She gets very red from exerting herself, then she passes out. When she wakes up, she continues her exercises, and eventually becomes very thin. She then goes into the locker room, changes her clothes and dives off a diving board into a swimming pool. This extremely funny program really shows off Stewart's sense of humor.

The computer allows Stewart to express himself safely. During one interview we asked Stewart why he didn't like writing. He said, "Because it's kind of embarrassing. You try to make a story and um... you um... are trying to express
yourself and you can get embarrassed...." His computer programs showed how he felt, but was a much safer medium of expression for him.

At first Stewart had a hard time debugging his programs. He wrote such long procedures, it was difficult to find errors. It was suggested to him that he write shorter procedures and then put them into a superprocedure. Stewart began to do this very slowly. He wrote slightly shorter procedures, then slowly shortened them further as he became more familiar with individual commands, primitives, and how to program.

He had a negotiating style of interacting with the computer, learning the system intimately, "messing around", and exploring the possibilities. When he became more sure of it and his own power over it, he would try a new command or primitive. Stewart also developed an intimate relationship with his computer. He worked on it during every free period and sometimes stayed on it through math class.

4. Model of Interaction

When asked about whether the computer was more like a person or a machine, Stewart was very clear that the computer was a machine. He said that the computer was, "[Like a] machine. It’s not living. It doesn’t have feelings. It can’t talk. It can’t be like a person." Stewart said that he was much more creative than the
computer. He does not give the computer intention, nor does it "do" anything to him. The computer breaks down because it is a machine; it does not do it to him personally.

Although Stewart believed that the computer was more like a machine, he developed a very personal relationship with it. He spent all his spare time programming it, making one animation after another. He found it compelling saying that one idea merged into the next, that he never had any trouble with finding new things to make. At the end of the year, he was sad because he did not have a home computer, and at his new school there was little opportunity for using computers.

Like the relational children, Stewart sees the computer as something that can help him think about himself and powerful ideas. He also feels that it has somewhat human qualities. When asked what personality traits he would give the computer he answered, "Be nice to me. Always help me with my work. Don’t take my job over." Stewart is aware that the computer’s power can either help him or hurt him.

He does not take a clear stance on how smart a computer is. Like the relational children, he feels it is smart "In a way. Not smart like we think about smart, but it knows things we don’t know...", and it acts in ways he doesn’t understand. For example, one day a program he wrote wouldn’t work. The computer gave him an error message saying it "didn’t want to, it didn’t know how to." Stewart
could not figure out why it could not do what he had programmed. But he knew that it was he who had made the error, not the computer.

5. Power and Control Issues

Stewart has an internal locus of control. He answered only three questions out of 19 with an external locus of control. As with other relational children, all three had to do with questions about relationships with other people. Although shy, Stewart likes other children and is well liked by them so when he has concerns about control, they have to do with personal relationships. His internal locus of control results in Stewart taking responsibility both for when he does poorly and when he does well. I asked what his favorite thing was about the computer. He answered, "Writing procedures and seeing that it works."

Working on the computer gives Stewart a sense of accomplishment and a feeling of fulfillment. He knows something is good when, "I just say, Stewart, it's good." Although a positive response from other children feels good, Stewart knows intuitively when something is good. He does not need the outside feedback, he gets it from within himself.

I asked Stewart when he found computers most exciting. He said, "When I'm learning about them. How they work, different things. Like if I'm learning about how something works, it's kind of exciting." In contrast to the
environmental children, Stewart is not interested in videogames or winning. Fluency with the computer is important, but Stewart does not need to conquer it. Nor does he need to compete with others to show how powerful he is.

During a conversation with John and Stewart, Stewart asked how the screen of the computer works.

S: The pictures. Are they little lights?
I: The pictures on the screen?
S: Yeah.
I: [explains briefly how it works]
S: After a couple of years wouldn’t it slowly fade?
I: It wouldn’t fade as long as the electricity was on. It’s made of some filament that stays lit for a while and slowly fades. By the time the beam has come down here, the first one is faded.
J: Oh, it always goes back and forth?
I: Yeah. [explains about red, green and blue]
J: How does it get color?
I: All the colors are a mixture of some combination or red, green and blue. Hue is the color and intensity is how bright it is.
J: How do you get white?
I: When you add all the colors together you get white light.
J: What?
I: Red, green and blue all together give you white light
S: Yeah, when you look at it you can see a little bit of blue.

I: If you take a prism and hold it up to the light, you will get a rainbow of colors.

S: What's a prism?

I: A prism is a piece of cut glass. If you hold it up to the light, it will...you know those crystals that they sell in stores? If you hang that in front of a window so that the light coming through it reflects on a wall, you will see a rainbow. The prism breaks the light into separate bands and each band is a separate color.

Again, as with Florence, the computer has evoked questions about how the physical world works. Stewart was interested in the inner workings of the computer, and its relation to how other things work in the physical world. For him, the computer became a powerful tool for thinking about light.

Stewart prefers to work alone. He says, "I like to make stuff on my own. I don't mind a group, but I can make stuff on my own and really get it how I want it." Because he does not have difficulty with other children, Stewart does not need to work with them the way Sam does. He likes to work alone because, "It comes from you and you can make it all yourself. It's like your creation."

Having a place where he can be creative is very important to Stewart. He needs a way to express his innermost feelings and ideas. His feeling about working alone was not uncommon. There are enough computers for each child to work alone and many children choose to do so.
Stewart chooses to do so because he likes having ownership over his ideas. He can explore them and work on any project he wants without having to make compromises. Also, if he has a theory, he can go try it out on the computer. Stewart was not anti-social, he just preferred working alone. Occasionally, if he needed to, he would ask another child or a facilitator for help.

When I asked him if the computer is challenging, Stewart said, "Yeah. Making all the procedures. Like every time I go out there, right when I'm in the middle of a procedure, I think of another procedure that I want to do so I just start and make the new procedure." For Stewart, one idea leads to another. The computer environment is a place where he can let his imagination flow.

After the first few programs Stewart made, his classmates became interested in his work. Whenever he finished a program, the children would gather around to watch what he had made. The programs were not interactive, they were self-contained stories. For example, one program he wrote was of a woman who gets hit by a car. An ambulance comes, misses her, backs up and picks her up. It then takes her to the hospital. When the woman is seen leaving the hospital, she is walking with a cane.

His classmates found his programs to be entertaining and creative. He won many friends through the respect he gained for his ability on the computer. He was well liked
although he was shy. Throughout the year, with his increased self-esteem and new found respect, he became more open with his feelings. He would laugh out loud, and often called over facilitators or researchers to show them what he was working on.

6. Conclusions

Stewart is an example of a child who has integrated both the relational and environmental styles of interaction with the computer. Although he has a deep personal relationship with the computer, he does not relate to it as a person. He is very sure of the boundaries between the computer being a thing and his being a person. Stewart was both a tool maker and a tool user. He turned the computer into an animation kit which would allow him to express his creativity. Like the environmental children, he wanted to be able to control different aspects of his environment, but not for the sake of power. He did not want to conquer or compete with the computer, but rather wanted an outlet for his creativity. This is consistent with other relational children who use the computer as a tool to facilitate their thinking.

His locus of control, like other relational children, was internal. Consistent with an internal locus of control, he knew when he had written a good program when he "felt" it from within. Because he did not have control issues he did not have to act them out on the computer.
Stewart’s expertise at the computer also gave him a greater sense of self and freed him to be more open about his feelings. Through this expertise and freedom he gained respect and friendship. At the same time, he preferred, as environmental children often do, to work alone while being creative and maintaining ownership of his ideas.
VI. CONCLUSIONS

The results of my study support Gilligan's findings of a "different voice" in moral development, Turkle's finding of different styles in child programmers, and Keller's work on how language affects what we know and subjective versus objective knowledge. All the children appropriated the computer in ways that were meaningful to them; however, they exhibited significant gender differences in what they did with the computer and the language they used to describe their interactions with and feelings about it.

Girls tended to interact with the computer the way they would a human; they wanted to communicate and find an emotional connection with it. Although they know the computer is not alive, they talked about it in terms of personal relationships. The model they used for interacting with the computer is consistent with their model of human relationships in the world.

Boys, on the other hand, generally related to the computer as an object (thing) and focused on issues of control, power, and their own expertise. They did not care that the computer is not more relational; in fact, the question was irrelevant to them. The model they use for interacting with the computer is consistent with how they manipulate and control inanimate objects in the environment.

If the disparities in the way in which children interact with computers are due to differences in early
personality development as Gilligan claims is the case in moral development, we must rethink the issues surrounding gender differences. We should acknowledge that there are different and equally valid ways of thinking and knowing. The high value placed on objective and analytical style of thinking may be a disservice to the scientific endeavor, because both a relational and analytic style of work can be used in creative and worthwhile endeavors. Women, using their own style of thinking and knowing, often advance knowledge by making what they study an extension of themselves. By relating to and maintaining a deep connection with the material they can "see" things men using an analytical and objective style of thinking might miss.

For example, in this study one relational child had extreme difficulties with understanding spatial relationships. When trying to draw a triangle, she found it almost impossible to figure out the angles. However, when working on her own projects she came up with wonderfully creative animations and dances. She made an animation of Paul Revere’s ride for which she later won an honorable mention.

Different ways of interacting with the material may result in a change in the way we model problems. For example, in fields such as computer science and artificial intelligence a woman’s perspective, experience, and way of
knowing may lead to an entirely different paradigm for solving the problem of how to model intelligence.

This is not to say that a women's way of thinking is better. The different ways of thinking and knowing complement each other. Gilligan acknowledges this when she discusses the changing conception of moral choice men and women have in the years after college. During this time, men and women begin to merge their conceptions of moral choice. She writes,

"Though both sexes move away from absolutes in this time, the absolutes themselves differ for each. In women's development, the absolute of care, defined initially as not hurting others become complicated through a recognition of the need for personal integrity. This recognition gives rise to the claim for equality embodied in the concept of rights, which changes the understanding of relationships and transforms the definition of care. For men, the absolutes of truth and fairness, defined by the concepts of equality and reciprocity, are called into question by experiences that demonstrate the existence of differences between other and self. Then the awareness of multiple truths leads to a relativizing of equality in the direction of equity and gives rise to an ethic of generosity and care. For both sexes the existence of two contests for moral decision makes judgement by definition contextually relative and leads to a new understanding of responsibility and choice." 53

In other words, during this time the boundaries between care and principles of justice become blurred because both men and women begin to redefine the way they think about the self in terms of the other. For each, the new definition of self brings individuation and connection closer together.

53 Gilligan, op. cit., p. 166.
Although men and women think differently, their styles of thinking are now closer together.

The "different voice" Gilligan speaks of is consistent with Keller's argument that the way we define language determines how we know. Keller asserts that the masculinization of language has determined how and what we know. For Keller, however, there is another way of knowing which I believe can be applied to children using computers. She defines a concept called dynamic autonomy that "reflects a sense of self as both differentiated from and related to others, and a sense of others as subjects with whom one shares enough to allow for a recognition of their independent interest and feelings-- in short for a recognition of them as other subjects."\(^{54}\)

I have claimed that computers, too, can act as subjects; that the more connected to and involved with them we are, the more they become an extension of us. This deep involvement results in the computer being transparent to the user. Thus, what is interacted with is not the computer, but the material inside. In directly interacting with the material, we recognize ourselves as part of the system, part of the world, part of the computer and the computer as an extension of us, our minds, our psychological and physical worlds.

\(^{54}\) Keller, op. cit., p. 99.
This is what makes the computer powerful as an evocative object. Its ambiguous nature as both a thing and like a human evokes thoughts about who we are and what we are made of. As an extension of us, our minds, our thoughts, and our feelings, the computer also reflects our personalities and the issues that are important to us. Thus, as a powerful projective medium, it could, perhaps, be a diagnostic tool in therapeutic settings. If computer programming reflects the personality of the user, and acts as a projective medium for children to express their fantasies and feelings with, it could be used to understand their personalities and styles of interactions with others.\textsuperscript{55} It can act as a mirror reflecting the child’s thoughts and feelings to the therapist in a safe environment for the child. The computer provides children with a place where they can explore their feelings while allowing them to become deeply involved.

The focus here is on style of interaction, not content. The computer, like a pencil and paper, could easily be used to evaluate the content of the child’s work. More importantly, however, is the use of the computer as a

\textsuperscript{55}Joseph Weizenbaum wrote a computer program called "Eliza" which emulates a Rogerian therapist. His intent in writing the program was to demonstrate one could communicate with computers in natural language. After using "Eliza", many mental health professionals suggested that the computer can act as a therapist. I do not believe that the computer can or should be used as a therapist. I am claiming that it could possibly be used as a projective medium, a tool for understanding personality.
diagnostic tool for understanding a child’s interactions with it. The models the child uses for interacting with it can tell us a great deal about his personality, the model of relationship he uses in the world, and his style of being.

Finally, if early psychological development affects how we construct knowledge, then changes in how children are raised might affect psychological growth. If men were the primary caretakers for children we might see entirely different models of development for boys and girls. Oedipal issues (Electra complex) might result in girls being separated from their fathers sooner than boys which could, in turn, result in more individuated girls and more relational boys. Or, because they are individuated themselves, male child caretakers might promote greater individuation in both boys and girls. Obviously this theoretical speculation is simplified for illustrative purposes, but the issues it raises will become increasingly salient as men share more equally in the responsibility for early child care, particularly in the first few months of a child’s life. Surely we can expect to see some developmental changes in both girls and boys. Children may be exposed to both an ethic of care and subjectivity and an ethic of individuation and objectivity. Later, the psychological growth that occurs may result in a hybrid of male and female thinking styles. We cannot expect this change in developmental growth to happen quickly; it
necessarily would evolve over a long period of time and result in changes in longstanding character traits.

This raises another question: Should we try to teach children different styles of thinking? If our personalities and our ways of knowing are deeply connected to early childhood development, then any attempt to "teach" children different styles of working could be futile; however, it is crucial to expose children to many different styles of working and perspectives. We have seen that no one style is more appropriate than others, and that different styles complement each other. Styles of working give us a powerful window onto children's personalities and the meanings they find in their experiences and knowledge. Our access to the understanding of how individuals know is dependent on reading the meaning they attribute to both language and experience. Thus, we can and should promote individualized styles of thinking by allowing children to appropriate knowledge and ways of knowing and being that are meaningful to them.

The gender issue is not only about being male or female, but is also about the complexity of the human personality. Early childhood experience, issues of identity, and personal style all play an important part in defining how we know; thus, specific attention should be paid to understanding these aspects of male and female experience.
Also, we should accept that gender differences exist in how we think and know, and that these different ways of knowing are complementary and equally valid. Neither male nor female ways of knowing are better; each leads to meaningful and worthwhile intellectual and emotional experiences for children.

The gender issue is deeply connected to how we know, not what we know. In the present study, children had the same knowledge; they knew that the computer is not a person, and that it is powerful. However, the models they used to interact with it reflected different ways of knowing and relating to it. Although gender differences do exist in how children relate to and interact with the computer, the issue is not one of gender, but of how we know.

The relationship with the computer the child has is exceedingly complex and is exemplary of the complexity of the human mind and personality. What we know about computers is affected by who we are, our early experiences, how we interact with the materials, and our relationships with others, thus, the study of computers must include a deeper understanding of these issues.
APPENDIX A: Gender Attitude Survey

The gender attitude survey was given to two advanced fifth grade classes (N=36) to test for general attitudes toward the computer. It was analyzed for frequencies, statistics, and attitudes by gender (crosstabs).

Results: Almost 40% of the children had access to home computers, but as in previous studies (Hawkins, 1984) boys were found to be two and a half times more likely to have a computer at home. Although these children had computers at home, their parents often did not know how to use them. The children, in general, were glad their parents didn’t know how to use them because they liked knowing something that their parents did not.

Of the girls, 40% liked doing animation best when working on the computer. Of the boys, 38.5% liked playing games on the computer best. Only 10% of the girls liked computer games best.

Since it is unusual to find girls more likely to like programming than boys, it suggests that either the learning environment or the kind of programming they are doing is more pleasing to the girls in this study. There may be something inherently engaging about animation for the girls to choose it as the kind of programming they most enjoy. It also suggests that girls may not like the competitive nature of most computer games as do the boys.

Of their least favorite thing to do on the computer, 45.8% of the boys and 22.2% of the girls said writing. Generally the reason was either that it was boring or that the child could not type which made it slower than writing with a pencil or pen. However, when asked whether they preferred writing with a pencil or a computer, 73.5% of all the children said a computer because it was easier or faster. If the children who said they prefer using a pencil learned to type, they might prefer writing with a computer.

When asked if a computer is more like a machine or more like a person, 75% of the boys said machine and 60% of the girls said person. One hundred percent of the girls who thought it was like a person said that either because the computer understands or that it is smart. Those girls who felt it was not like a person mostly said so because it does not have feelings. The boys gave many answers for why they thought it was like a machine. The largest percentage (23.1) said because it does what you say. Other answers
were, It doesn’t make mistakes, it knows everything and it does not talk. Several boys talked about hardware, that is, how the computer has wires and chips in it. We will discuss what these results may mean when we discuss the results of the clinical interview.

When asked if they thought computers were boring, 92.3% of the boys and 90% of the girls said no. Also 100% of the girls and 91.7% of the boys said they would sign up for a computer course the following year. Even so, only 40% of the girls say they are taking computers because they want to whereas 76% of the boys are because they want to. The girls seem particularly ambivalent on this question. Thirty percent say they take computers because they have to and another 30% say for both reasons. The boys seem more sure about the answer to this question; only 16% say they are using computers because they have to.
APPENDIX B: Rotter’s Locus of Control

Nowicki says because the long version of the locus of control has been tested on over 1000 children, "there is every reason to believe these measures should be reliable and valid on the short scale." Nowicki shows the internal consistency reliability for third grade (Pearson) to be R=.63 and for seventh grade to be R=.66 on the long version. I tested 44 children on the short version (19 questions) of Rotter’s Locus of Control. I then used the results as a relative measure for individual children. Using all 44 children, I calculated the mean number of questions answered with an external locus of control, the range of answers, the standard deviation, and how each question was answered by gender.

I expected children with an internal locus of control to be more environmental in their relationships with the computer. I felt if these children had a greater sense of themselves, they would feel more powerful; thus, they would be more interested in exploring their power and control on the computer. This would mean that children with a greater external locus of control would be more likely to be relational in their interactions with the computer. They would feel less in control of the computer and their external environment.

I then coded each question as relational or external. Questions that were considered to be relational were related to relationships with other people. An example of a relational question is, "Have you felt that when people were mean to you it was usually for no reason at all?" Environmental questions were those unrelated to their relationships with other people. An example of an environmental question is, "Are you the kind of person that believes that planning ahead makes things turn out better?" I then analyzed the tests of the ten case study children for specific questions answered with an external locus of control.

I expected questions not related to their personal relationships to be answered with an internal locus of control by those children considered to be environmental, and questions related to personal relationships to be

answered with an external locus of control for those children deemed to be relational.

**Results: 4. Locus of Control—**

In general, the girls had a slightly, but not statistically significant, more internal locus of control than the boys did. The boys averaged a score of 5.875 (number of questions answered with an external locus of control out of a total of 19) whereas the girls averaged 4.95. The overall mean for both boys and girls was 5.43. The standard deviation was 2.95. The range for both was between one and 10.

The children’s locus of control was correlated with their style of interaction, however, not the way I expected it to be. I found that children who have a more internal locus of control were more likely to use a relational style of interaction with the computer. Children with an external locus of control were more likely to use an environmental approach. This may be because children with an external locus of control are compensating for the feeling of powerlessness in their lives. Because they feel out of control both of their environments and personal relationships they find a place where they can be in control (i.e. the computer) or at the very least, a place where they can work through their feelings. On the other hand, children who have an internal locus of control have no need to control the external environment, therefore they use a more relational style of interaction with the computer.

Children who are relational are more likely to have an internal locus of control because they feel more in control over what happens to them. Yet, for these children, relationships are most important so when conflicts do arise on specific questions of locus of control they are likely to be about relationships with others.
APPENDIX C: In-depth Interviews

The ten case study children were interviewed in-depth on their answers to the gender survey. Their answers were analyzed for common themes. Three major themes were analyzed: The computer as construction kit; the computer as machine or person; and, attitudes toward the computer.

Results:

1. The Computer as a Construction Kit

Both boys and girls saw Lego as a construction kit and discussed it in terms of building with blocks. The descriptions ranged from physically describing Lego, "Plastic little bricks, all kinds of colors you attach together and they are hard to...pull off [from each other]," to describing what one can do with them, "There are little blocks that fit together. They have spaces in them that fit together, all sorts of gears and stuff. And we made different things. And you can make cars, you can put the blocks together to make cars or something that runs with a motor, or that attaches to the computer and write a program about it."

Most of the children saw Logo as a tool you draw with or write programs with. The following description of Logo is typical. "It's a program on the computer [where] you have a turtle [that can] draw stuff and make animation." Two boys saw Logo as a kind of construction kit. One, named Roger, said "If you talk about shapes, you can put things together in LogoWriter, but not really." However, later in the interview he was asked if he preferred working on real objects (3-D) or the computer screen. He answered, "The computer. You don't have to go out and buy all the separate pieces. If you need something you don't have to go out and buy that piece. It's just right in there." In other words, he sees the computer as a self-contained system where anything he might need is either in the computer or can be constructed by him using existing materials.

Below is a section of the protocol with the other boy, Stewart:

I: Do you think there are any similarities [between Lego and Logo]?

S: [Logo] is what we use to program Lego. You get to make stuff, create stuff.
I: What do you think the differences between the two are?

S: When you are on the computer you can't stick two blocks together or something.

I: When you say making or creating something on the computer, what do you mean?


One girl, Florence, also talked about building things with Logo, but when asked about it she said that Lego "is like hands on, you build it and you create something. The other one [Logo] is creating but in a different way. Like typing and stuff and thinking about it instead of having the pieces to hold and to mold with your own hands, you move it in the computer." She does, however, see graphics as something she builds. She states, "It is easier for me to build in Lego than build in graphics on Logo..."

I asked Florence if she really thought about building in both Lego and Logo and she responded, "I think about building more in Lego that in Logo. Usually when I was in there (Lego room) I spent a lot more time in there building than programming. But out here in the circle (where the computers are) I spend a lot more time programming than I do fooling around with the graphics." For Florence graphics is similar to building in Lego, but programming other things and the writing of procedures is not considered by her to be building.

In Florence' discussion of Lego as something you can hold and Logo as something you think about, we see a similarity in the way boys and girls think about the computer and Lego. Most of the children see Lego as being easier than Logo both in creating something and debugging. The reason stated is that Lego is three dimensional and one can "see" where the bug is. One child said in his interview, "Like Lego you can make go to your eye and stuff, but Logo is just a one screen (he means two dimensional)." In Logo, one has to rerun the program and go back to look over the procedures to find the bug. The fact that one cannot see the procedures at the same time as the program is running has also been a problem for some kids. Three kids, two of whom are boys, find Lego hard do because they consider themselves not to be good builders, yet they are three of the top computer programmers in the class (as judged by both their teacher and their classmates). One boy states explicitly, "...I am not a real good builder." The other boy says, "Sometimes the stuff I put together doesn't
work most of the time." The girl could not be specific. She just said, "Everything is hard [in Lego]."

One child describes Lego as being easier to use because, "...It feels easier to make stuff." Another child explains, "With Lego you can see what you are doing. The computer, if you are making a program and you don’t know where the mistake is, you can’t see where it is while you are writing the program." The boy who says it feels easier to make stuff is an example of Sherry Turkle’s soft mastery style programmer. He becomes part of what he is doing and therefore can feel both literally and metaphorically the objects he works with.

One common complaint of both groups of children was that their lack of knowledge of Logo limited their ability to use it. They saw Lego as easier because it seemed obvious what to do with it even if they did not necessarily know how it worked. However, in Logo it was hard to go further if they did not have the knowledge. For girls this was particularly frustrating. They wanted the tools to be useable right away. Their feeling was, "Don’t ask me to build the blocks. Give me the tools and I will find interesting ways to use them." The following is an abbreviated section from an interview taken shortly after the children had finished four weeks in Lego. Both children interviewed were girls.

F: In Lego-Logo there’s never anything that can stop you. You can just keep building bigger and bigger. On the computer unless you are a genius and can build all these new programs, there’s only a certain amount you can do, you know?

B: [Lego] is like playing a game in a way...if you like playing with Lego. It’s also even better because you can make it work and stuff and in Logo it’s much harder to draw and stuff.

I: You don’t think Logo is like a game?

F: In some ways it’s like a game, but since we use it so much it’s just there. We can use it whenever we want so we don’t really take advantage of it.

I: You are saying that Logo is harder because you really need to know a lot about it before you can do really powerful things and that you like Lego because it is new?

F: I think I agree with what I first said because unless you want to sit down for hours and learn everything there is you
can’t keep going and there’s only a certain extent to what you can do.

To these children, the experience of what Seymour Papert calls being fluent is what makes the materials powerful. Not knowing what to do, or not knowing how to use the materials makes the child feel helpless. These children need to build a little at a time, always learning something new. Learning an entire system is too overwhelming. Give them the bricks from which to build, but don’t ask them to make the bricks themselves.

2. The Computer: Machine or Person?

Eight of the ten case study children said that the computer was more like a machine. Two girls said that it seemed both like a machine and like a person. When the boys were asked why it was more like a machine, they usually gave answers like, "It doesn’t understand," or "It doesn’t have human features. It can’t talk." Their responses were generally based on the cognitive qualities of the computer. On the other hand, the girls talked about the computer psychologically or metaphysically.

One boy stated, "It doesn’t have human features, eyes, stuff like that. A machine is artificial intelligence because a human already did that. A human has to do it before a computer can."

Another boy said, "Like a machine because sometimes it doesn’t really know what you mean. If you turn it on and leave it there, it doesn’t do anything. It doesn’t know what to do. It doesn’t act like a human."

When it was suggested to a third boy, Sam, that some people thought a computer was more like a person he responded, "I don’t know how they could think it sounds like a person. Cause it’s not like you can say, will you please give me a glass of water....and it says, 'No, sorry I can’t. I don’t know how to get a drink of water.'" He talks about what the computer can do, not how it feels. Another boy, Roger, said that it was more like a machine because it does the things he does. Then he clarified his statement with, "Because what I put in it does." Again, this is about what a computer can do, not how it behaves like a human or feels.

Although the case study girls were more likely to answer that the computer was more like a machine than not,

57 Papert, Seymour. Personal communication.
their reasons were more affective and relational. They said that the computer "doesn’t have feelings", "it can’t talk to me", "it doesn’t listen to me," or that "it can’t communicate with you."

One girl explained, "...It doesn’t have any feelings and it can’t communicate with you. Well, in a way it can, but not the same way as a person would." In order to probe further the interviewer suggested that some people think the computer is easier to communicate with.

The child answered, "But that’s not like a person, because most people aren’t easy...well...they are easy to communicate with but they have a say on what goes on and a computer doesn’t. You type in and it does it. I mean, unless something is wrong with it. But a person has a say in what [he] can do, what [he] wants to do most of the time."

Later she also says, "...No opinions. That’s another reason why I think a computer is not like a person. It has no opinions at all. It’s all facts."

Another girl said that it is both like a person and like a machine. "You know the disk drive? It has a cover on it and when you open it up it looks like a real machine....This program called Snooper Troops. Have you tried it? On the phone booth. ‘This is agent two calling agent one. Tell me about you’...it sounds like a real person. Spinnaker makes programs like a real person. It’s more like a machine when it doesn’t listen to you. Like my baby sister. She never listens to me. Like a dumb machine."

This girl defines the computer in terms of her relationships with other people. Her sister doesn’t listen to her, and sometimes neither does the computer. In the following discussion she talks about the computer being inconsistent, the way people are.

S: "Sometimes it thinks."

I: "Is is smart?"

S: "So-so. Sometimes."

I: "Is it smarter than a person?"

S: "In third grade I used a computer for a calculator and it works. It’s smart. Then I’d do 999999 times nine and it wouldn’t work and I’d hate it."
The inconsistency of the computer being smart sometimes and not other times is difficult for this child to understand. A machine by its very nature should be consistent. It either knows or it doesn’t, but it can’t do both. And if it makes mistakes, then it can’t be a machine, because machines don’t make mistakes, people do. This child does not attribute the computer’s mistakes to the programmer who programmed it, she attributes them to the computer itself. When asked about making mistakes the child answered, "Sometimes [it makes mistakes]. Sometimes it’s real smart. Sometimes it’s real dumb." Computers that make mistakes and that are inconsistent are more like people, but the computer looks like a machine. For this reason, knowing how to interact with it is confusing to these children.

Another girl said that the computer was more like a machine because it doesn’t have feelings and it can’t do anything by itself, yet, when she describes the computer she says, "It doesn’t seem nice. I mean it doesn’t help you in any way really except if you want...(garble). It doesn’t really help you with your programs or anything. It isn’t nice."

This girl thinks about the computer in terms of relationships as does the other child. Although she considers the computer to be more like a machine, the way she describes it is in terms of human relationships. She talks about it not helping her, and it not being nice to her. Machines don’t have human qualities like being nice, but she wishes they did. Nor does the computer help her. When asked what would make the computer nicer she answered, "If it could really help you with your programs. If you could ask it something like, ‘If I wanted to do this, how could I get the turtle to do this?’ it would answer you instead of not helping...it would tell you how to move." Cooperation is important to this child. She needs to communicate with it, to be able to ask for help and then get it.

None of the children thought that the computer could think. A couple of girls were a bit ambivalent on this question and answered no at first and then said maybe or sometimes. To them it was a difficult question because sometimes it seems like it thinks. The child who earlier talked about Snooper Troops, a computer game involving solving mysteries, felt that when the computer asked for an input such as a phone number and then appeared to do something with it (like call someone), it seemed smart.

The other child, Florence, really grappled with the idea of what it meant to think. She said:
No, it doesn’t think, because people think and they put their thinking into the computer. The computer, well, then it would still have to think. But the computer doesn’t think. It takes...it doesn’t have to think because people put their ideas into it. It doesn’t need ideas for itself because it has so many ideas already.

Another girl suggested that the reason the computer didn’t think was because it did everything so fast it didn’t have time to think.

What is interesting is that half the children believe that the computer is smart even though it can’t think. There was no difference due to sex in this question. Three boys and three girls said that the computer was smart and two of each said it was not. Again, the reason for saying it was not was because it needed to be programmed by someone first.

All five boys said that the computer did not think because it had to be programmed by a person who did the thinking. Stewart said, "You do most of the thinking for it. Like if you didn’t type in the stuff, it wouldn’t do anything. It’s kind of not thinking, but it knows the answer."

Reasons for it being smart were that it knew more than the child, particularly when it came to math. It is interesting that the children perceive the computer as being smarter not because it can think, but because it has more facts in it than the children do. One child eloquently describes it as "...Not smart like we think about it, but it knows things that we don’t. It knows things I don’t know. But the people who made it probably know more [than it]."

When asked if he thought it was smarter than a person he says, "In a way. It’s better at math than I am. I can walk, I can talk, I can feel, I have emotions. And of course, I’m more creative than it is." This child is realistic in his assessment of not only what the computer can do, but what he can do and how the two are different. He is visually artistic and expresses himself through the computer using animation. The computer cannot make his creative pictures by itself, but it can help him by doing the math calculations for him.

Four of the five boys think that knowing something about how the computer works would help them in their programming. One of the two girls who thought so has a high aptitude for and curiosity about machinery. She is the only girl who has taken apart her computer to see what it looks
like inside. She, as we will see later in the case studies, also was an expert at Lego and often helped other children with their problems with gears and motors.

3. Computer Attitudes and Control Issues

In the clinical interview the children commented on what their favorite and least favorite things to do on the computer were. Since the question was open-ended and did not specify the possible answers, the children responded with a wide variety of answers. Some commonalities did exist, however.

As in the gender study, most of the boys preferred computer games. One said that he liked animation and "writing procedures that worked." Three of the girls said that they liked animation. One of these said that she liked "making things move": another girl, Carol, liked "inventing weird things." Carol had spent most of the year working on an animated horse race where four horses randomly raced toward a finish line. Each one was a different color, and since they moved randomly, a different horse won each time. She described liking weird things as "making up new ideas." These girls like making the computer more human by creating and moving human or animal figures on the screen. If the computer isn't human, then they can make it feel more human by having whatever is on the screen imitate human behavior.

One girl, Sherry, saw the practicality of having all the programs on a hard disk so that everyone could share them. She said, "I like the way the network does it because you don't need a [floppy] disk. Because when you need a disk, sometimes by accident you mess up the disk. I don't like that. And sometimes people need the disk you are using....And sometimes they even take the disk without asking and the red light goes on." If that happens, the program is not loaded correctly into the memory of the computer. It can also ruin a floppy disk.

Debugging:

When asked what the children did when a program was not as good as they expected it to be there was a substantial difference between the boys and girls. All the boys said that they would fix it. Three girls said that they would start over, one said she would go to something else, and the fifth girl, Sherry, said she would "kill it." This both implies that it is alive and that she is angry with it. Sherry rarely saved her work, but when she was working on a project, she would start over on a new program that was a new version of the old one while still saving the old one.
This situation was encountered more often with girls than boys. Girls seemed to find debugging strategies more frustrating and would rather start over than try to figure out what was wrong with the existing program. Either they had not learned debugging strategies, or did not feel competent in using them. Another possibility is that girls, in feeling the computer was not helping them, would take out their frustration on it by deleting whatever work they had done.

Most of the children got sick of computers either when they did not know what to do on them, or when they had mistakes they could not fix. Girls were more likely to talk about not getting help from anyone. One girl, Betty, said, "[I get sick of computers when] I’ve been working on them for a while or when they keep saying something is wrong and they keep making mistakes or I keep making mistakes and there’s no one around to ask about it. Or if the printer isn’t working right and I just can’t get it to work right. Even though it’s doing fine the computer says something is wrong. Then I get sick of them."

For Betty it is not clear whether she or the computer is making mistakes. She feels helpless because she cannot figure out where the mistake is, and sometimes nothing seems to be wrong at all. Again, this feeling was more common to girls. They often talked about how the computer did something to them or their work. Sherry said in the first clinical interview, "A person does everything you tell him. A computer doesn’t. Like you tell it something and it’ll mess it up for you." Later, when it was suggested to her that she may have done something that made the computer respond the way it did she said, "Uh uh. I didn’t see no hole. See that’s what a computer does to you. It messes you up."

Although boys saw the computer as being difficult in some ways, they did not think about it in human terms. Stewart, a child who wrote a new and complicated program each week, recognized the computer as being imperfect in its technology, but never considered it to be like a human. He would get frustrated when the hard disk was full and wouldn’t allow him to save a new program, but he recognized that as a limitation of the machine, not as something it did to him personally. Another boy, Sam, states explicitly that the computer does not make mistakes because it is a machine. He says, "No, it doesn’t make mistakes unless a person makes mistakes on telling it what to do. Kind of like ‘disk full’ and stuff, but that’s probably a person’s fault. It can’t make mistakes because it’s programmed not to. It’s a machine." The computer’s limitation for boys is in the
hardware. It is not fast enough, does not have enough memory or colors, or the screen is not big enough.

For girls the issue is different. The computer’s limitation for them is that it is not human. It does not always help them (they like it best when it does), it doesn’t understand English or them, and it does not respond the way a human would. A computer does things to them like lose their programs or erase words. One girl, Carol, said in the first clinical interview:

C: [I think computers make mistakes] because the computer can make an error. And I have to start all over again.

I: What do you mean, a computer can make an error?

C: It could erase some of the words.

I: Because sometimes the network breaks down or something? What do you think Janie? Do you think that’s true? Do you think a computer can make an error?

J: No.

I: What do you think happens?

J: The computer ain’t the one that makes an error. You do. Because you’re the one that’s writing.

I: What do you think about that Carol? Do you think it’s true?

C: Yes. Like sometimes when you go to print it it can erase some of the words. Some of the words don’t come out.

Even when Janie insists that it is the user who makes mistakes, Carol believes it is the computer that does. This is not just a matter of denial; she really believes that the computer is making mistakes. She, like most of the girls, doesn’t understand how it works and has never even seen the inside of the computer. She knows when and where she, herself, makes mistakes on a day to day basis, but when the computer does not understand, it must be making the mistake, not her. Most of the bugs in computer programming are incomprehensible to girls. If they are following the rules for printing something, for example, it should print. Otherwise, something must be wrong with the computer. For them, the worst part is that one cannot negotiate with the computer. It does not understand them, and will not help them.
Domination and Control:

Three of the boys think that computers are most exciting when they win a videogame. Sam sums up what he likes most about a game called Summer Games, "When I win the gold medal." These kids see winning as a measure of their performance. The girls think that the most exciting thing is when they have completed a program that they like and which works. They feel that the computer has understood them. They especially like it when it has new commands in it and they have learned something new from it.

Florence describes her feelings well: "When I'm working on a procedure and I'm almost done and I know I'm going to be right and I know everybody's going to like it and it's big and it has all these different things and I worked real hard on it and then I liked it. I like that feeling that I did it. No mess ups, no nothing 'cause you know a lot of times you can't do what you planned on doing because of the computer." Florence gets satisfaction internally, but even when she does get her program right, she distrusts the computer. You can't always do what you planned "because of the computer."

Issues of control arise for both groups of children. The boys like competing with the computer (as seen in their responses about winning), but they also like understanding how programming works. The fact that they prefer debugging to starting over shows an interest in finding out how something works or why it does not.

One place where we typically saw the control issue acted out was in using Syscon, the local area network. Syscon allowed the children to get into other children's files, change and see passwords as well as set up accounts. Only adults had access to the password to get into Syscon, so some of the children made a game of trying to figure it out. It was usually a fairly easy password to remember like MIT or LOGO. For the boys, breaking into Syscon felt exciting. They found it challenging and equated it with "breaking into the Pentagon." One boy, Roger, once he got into the system sent a note to one of the facilitators. I paraphrase: "Harry, I just got into the system. Just try to keep me out!" For the boys, getting into the system was like winning. Roger, when asked if anything else made him feel like that responded, "Winning on videogames. Breaking a record on my World Games."

Most of the girls never tried to get into Syscon. If they did want to get in, it had to do with protecting their files by giving themselves a password. Mrs. Bocello had
forbidden the children to use passwords (so that the researchers could easily get in to see the kids files), but many of them did anyway. Those who didn’t wanted one more for psychological reasons than anything. No one ever stole files or sabotaged them. Even Roger, a hacker and one who loved breaking into Syscon said, "[Once we were in Syscon] we didn’t do anything. We just looked at people’s files." Sabotage is not fun, the challenge of getting into forbidden territory is.

Florence was one of the few children who was allowed into Syscon. When asked how she felt about being allowed in she said, "I don’t think it’s any big deal. Sometimes the kids will make a big deal out of it....Mrs. Bocello asked me to [give the students accounts] when the thing broke down. We logged everyone back in. So everyone said, ‘Oh, she got Syscon’s password, that’s so unfair,’ but I’d say, ‘Guys, it’s no big deal. I’m not going to steal anyone’s program or take a look at anybody’s password or anything so I don’t care about it.’" Again, Florence concern is not whether she can break into the computer, but how she can help Mrs. Bocello.

Finally, there was one last difference between the boys’ and girls’ attitudes toward and interactions with the computer. We asked, "Are you the kind of person who likes to start things and finish them, start them but not finish them, or finish things other people either start or give you the ideas for?" Four of the boys said they like to start and finish things, and one said he only likes to start things, but not necessarily finish them. Only one girl liked to start and finish things, one liked to just finish things and three only liked starting things.

These answers seem to be specific to the computer, because all of these girls finish their other class work on time. It may be that once again, debugging issues make programming too frustrating for the girls to not want to finish programs they have started. It may also be that the computer is too difficult to communicate with, and therefore, the girls, frustrated, would rather start something new than try to figure out what the computer can’t understand. This is a question that needs further exploration.

Appendix D: The Rey-Osterreith Test

The Rey-Osterreith is a test of spatial ability and cognitive style. I used it to determine problem solving
styles, whether a child analyzes a problem analytically or holistically. I analyzed the Rey-Osterreith to see the child's style of drawing the figure. I considered the child to have a holistic style (this would be consistent with Turkle's soft mastery style) if he drew the contours of the figure first and then filled in the details. I considered him to be analytical (consistent Turkle’s hard mastery style) if he began with details and ended with the whole figure. I then correlated these results with his actual programming style.

Results: 5. Rey-Osterreith--

The children fell into three groups: holistic, analytical, and a mixture of both which we can call integrative. The holistic children drew the contours of the figure first and then filled in the details. The analytical children started with small details and ended up with the final drawing. The integrative group separated the picture into parts, drew the contour of each part and then filled in the details before going on to the next part. These children seemed not only to see the sections as whole parts in and of themselves, but also to see the relationship of the parts to the picture as a whole.

One would expect the children who drew the figure holistically to be more relational and the children who drew it analytically to be more environmental. When I compared the results to how the children interacted with the computer, the children who were more relational did tend to draw the Rey-Osterreith figure holistically whereas the environmental children tended to draw it more analytically. Of the two children who drew it both holistically and analytically, one was a relational child who is analytical in her programming style whereas the other was a relational child who is more holistic in his programming style. There was not enough data to determine gender differences.

There was some correlation between having an internal locus of control and drawing the figure holistically and having an external locus of control and drawing it more analytically. However, larger numbers need to be tested before the results are considered conclusive.

Again, this data suggests that the ways in which children interact with the computer correlates to standard psychological tests. Children who think about the computer in terms of relationships are more likely to be girls, have an internal locus of control, and be holistic. Boys were more likely to have an external locus of control, think of
the computer in terms of controlling their environment and be analytical.
APPENDIX E: Parallel Processing

A series of clinical interviews were conducted to determine the child's style of analyzing a problem and the child's understanding of a complex concept, parallel processing. These interviews have been used to illustrate styles of interaction with the computer in the case studies section of this paper.
APPENDIX F: The Towers of Hanoi

The children were asked to solve the problem Towers of Hanoi using five disks. The problem is as follows: There are three poles in a row. The left pole has five disks on it descending order (i.e. the top one is the smallest, the bottom the largest). The object is to move all the disks to the middle pole using all three poles, but without moving more than one disk at a time, or moving any larger disk on top of a smaller disk.

At first the children were given a physical model of the towers of Hanoi with which to solve the problem. They were allowed to start over if they wished to do so. If the child continued to use trial and error as the method of solving the problem, the researcher started him on a problem of one disk, then two and so on asking if he saw a pattern. If he could not figure it out, the child was given the odd-even rule to see if he would use it or not. When they could solve problem using the physical model, they were then asked to solve it using a computerized model.

The problem-solving techniques were analyzed for the following stages:

Stage one-- the child would randomly choose a disk to move and would debug the problem as he went along.

Stage two-- the child realized (or was told) there was a pattern and tried to figure out what it was, but often had to resort to trial and error.

Stage three-- the child figured out (or was told) the "odd-even" rule and used it some of the time, but often resorted to using trial and error.

Stage four-- the child consistently used the odd-even rule, even when it was not appropriate.

Stage five-- the child realized that the problem could be reduced into a problem of one or two disks, no matter which pole the disks he wanted to use were on.


Clarke, V.V. "Sex-typing of Computing by Primary School Children." Deakin University, Australia, 1984.


