THEY HAVE THEIR OWN THOUGHTS

Children's Learning of Computational Ideas from a Cultural Constructionist Perspective

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SUBMITTED TO THE PROGRAM IN MEDIA ARTS AND SCIENCES
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Abstract

Efforts have been made in recent years to understand how children engage with computational ideas through creating projects using programmable media technologies in the spirit of the constructionist view of learning. Constructionism suggests that children's learning happens particularly well in the context of creating artifacts in the world (Papert, 1993). For five years, I've worked with elementary school children at Paige Academy, a community-focused alternative African-centered school, helping them to create projects using MicroWorlds Logo. These projects have included video games, animations, and interactive stories. I have explored their constructionist learning through paying close attention to how their understandings of computational ideas develop through making their projects. This research presents a longitudinal ethnographic case study of one student, Keanna, and her constructionist learning with Logo.

I have found, consistent with constructionist theory, that as Keanna and her classmates construct projects in Microworlds, they do indeed construct their own understandings of procedures, computational objects, and parallel processes and that their grasp of computational ideas facilitates their engagement with thinking about other ideas in the world and themselves. In this particular school environment, I have also found that their engagement with new knowledge through project construction includes expression of cultural identity and reflection of cultural context. I have developed the theoretical perspective of *cultural constructionism* to extend the constructionist framework to address the relationship I have found between the culturally relevant nature of a school environment and the nature of children's learning of computational ideas.

This dissertation explores a series of learning stories conveying pivotal issues in the development of Keanna's computational ideas and how the ideas influenced her identity as a programmer and as a learner. Keanna reached an accomplished level of technological fluency that was related both to her construction of

projects and her location within the environment of a culturally relevant school. For instance, one theme within Keanna's work is a developing understanding of procedural hierarchy which is intertwined with the meaning of collaboration that is reflected in her school culture and its resonance with her cultural identity.

In this dissertation, I present excerpts of learning stories at different points in Keanna's development from age to 8 to age 12. The longitudinal approach to this research has allowed me to see and understand how sociocultural practices influence the development of design epistemologies. I discuss the theory of cultural constructionism through learning stories from Keanna's work and descriptions of the contexts in which she worked. I will also discuss how the theory can inform educators and designers of children's media technologies of the benefits of including issues of race, gender, class, and other cultural experiences in their practice.

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Dedicated to
the memory of
my father
Lorenzo Samuel Hooper Sr.
and the loving presence of
my mother
Earline J. Hooper

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"I am because we are."

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Contents

Chapter 1

"They have their own thoughts ..."

> *Certainly there are very real differences between us of race, age, and sex. But it is not those differences between us that are separating us. It is rather our refusal to recognize those differences, and to examine the distortions that result from our misnaming them and their effects upon human behavior and expectation* (Lorde, 1995).

Teacher, poet, essayist and activist Audre Lorde's words convey the message that if we don't see our differences, we are not seeing each other. She signals the need to recognize difference and understand how it operates in our lives as way to counteract its negative effects. In schools, the most important characteristic about each other is how we learn. I want to elaborate on Lorde's ideas about the need to recognize difference in the formation of theory and practice on children's learning. Specifically, I examine children's learning of and through computational ideas. As an African American woman, my work is rooted in the belief that if we do not pay attention to the cultural as well as individual differences in children's ways of learning, we cannot acknowledge or influence the obvious imbalances of power and equity that are negatively affecting children's learning in school. My belief is qualitatively different from the idea of crafting "culturally neutral" schools. In my opinion, cultures are sources of strength that are too often trivialized in learning environments.

Issues of difference are largely obscured within dominant views of learning. My dissertation is an inquiry into children's learning of and through computational ideas that aims at making issues of cultural context and iden-

tity visible in listening to children's ways of doing and thinking and a source of strength in teaching them.

The research describing the evolution of a "Logo classroom" is unique in a number of respects. The most obvious of these is time span. I attempt to capture a learning process through documenting and analyzing trends over a period of years rather than weeks or months. This longitudinal approach enables me to capture development more richly and give a thicker description of children's learning than is common in most studies of children's learning with technology.[1] Most important, the evolution was slow enough to allow the expression of identity of individual students and an understanding of cultural aspects of the school community. I held the role of teacher in a Computer Class, which allowed me to learn about children's learning by assisting their natural development (Duckworth, 1987). As I worked with students, my observations of their thoughts drew me to focus on the aspects of culture and identity that have not been deeply addressed in most previous studies of children's learning with Logo. In listening to children and observing their work, in attempting to give them "reason" in their ways of knowing and relating to the world, I was able to grasp their thoughts and actions as expressions of their cultural identities and their embeddedness within cultural contexts.

My research builds primarily upon three avenues of inquiry that are prominent in investigations of children's learning. The first, "construction-

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[1]Thick description is the effort to bring context to stories of experiences. It describes the goal of ethnography to "show that the human situation, the scocial context, or surrounding culture plays a vital role in the human experience we call learning." (Falbel, 1989; Geertz, 1973)

ism," was developed by Seymour Papert as a strand of constructivist theory. Constructionism takes from constructivism the idea that children (indeed all learners) construct their own knowledge and makes one addition – constructivist learning happens particularly well in the course of creating meaningful artifacts in a responsive environment. I make a further addition that constructionist learning happens best when it is resonant with the cultural contexts and identifications that shape children's thinking. I use the name "cultural constructionism" for the approach to teaching based on this idea developed in this dissertation.

The second avenue of inquiry involves the use of technological tools for learning, particularly the MicroWorlds version of Logo. Logo is programming tool for developing microworlds that enable children to understand computational ideas through creating their own projects. In a Logo environment, the computer provides "objects-to-think-with" which children use to think about computational ideas, other aspects of the world, and themselves (Papert, 1980).

Logo environments have been extensively used to explore learning of math and programming from a constructionist perspective (Harel, 1988; Kafai, 1993; Resnick, 1994). A common focus across these studies was on the computational ideas which Logo and Logo-like environments make accessible to children through their creative expression. These studies, however, generally ignore children's race, gender, and/or class experience. Research on developing technological tools for learning and understanding children's learning have not addressed in significant ways issues of cultural difference.

The third avenue to my research are two key notions within the field of multicultural education. Multicultural educators and theorists have established the importance of culturally-relevant teaching (Ladson-Billings, 1994) and analyzed ways in which culture informs children's learning (Hollins, 1996; Shade, 1997).[2] I use these ideas to support my interest in articulating the role of cultural identity in children's learning. I see my personal contribution to this line of thinking on several levels. First, there is the simple fact of bringing the approach to bear on an area that has been neglected. There are so few multicultural studies on the presence of computers and technology that one is obliged to look for an explanation. One certainly cannot explain the neglect by lack of relevance of technology to multicultural concerns. As technology moves more prominently into educational practice its cultural representation becomes increasingly important to all educators. And since technology studies is one of the areas in which people of color are poorly represented, one would expect this to be an area of special interest to multicultural educators. I suggest that its neglect is at least partly the result of the fact that the researchers in the field of multicultural education tend to focus their efforts in humanities and seldom center their concerns in the intellectual content of computation. As a result, their interest in the role of computers in education has been focused on material factors such as equity in access rather than on deeper issues of cultural meaning of computation once access is obtained.

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[2] Ladson-Billings (1995, pp. 476 and 483) defines culturally relevant teaching as a pedagogy that "provides a way for children to maintain their cultural integrity while succeeding academically." She suggests that culturally relevant teaching must meet three criteria: "an ability to develop students academically, a willingness to nurture and support cultural competence, and the development of a sociopolitical and critical consciousness."

This dissertation draws attention to the need for deeper studies. In the course of making an extension to the scope of multicultural studies, I have also made an extension of its theoretical arsenal. For I believe not only that computational ideas are in need of multicultural study but that the field of multicultural studies is in need of computational ideas: specifically, I suggest that computational ideas are a valuable lens for the study of more general processes of learning and that their study casts special light on ways in which cultural identity enters into it.

Rather than continue in this abstract vein, I use a device that shapes the form of the entire dissertation. This is the principle that ideas in this field are better conveyed by concrete stories than by abstract propositions. So I shall tell one.

For over four years, I have conducted learning research using a method combining ethnographically-informed study of a school culture with extended clinical interviewing through teaching Logo in Paige Academy, an alternative African-centered school in an urban community in Massachusetts.[3] The following learning story illustrates how the learning which I have witnessed and facilitated emerges from a strong convergence between the three avenues of inquiry.

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[3] Duckworth (1989, pg. 1) defines extended clinical interviewing as an extension of Piaget's clinical interviews in two ways. One way is to follow development of understanding over an extended period of time, usually weeks or months. The other extension is to involve more than one interviewee at a time so as to reveal interactions of ideas among a group. Duckworth concludes that these extensions "offer a dynamic account of the development of knowledge, rather than a description of a fixed state.

A Learning Story: Shanay's Red, Black and Green

During the school year 1993-94, the colors red, black, and green were a special addition to many of Shanay's Logo projects. Sometimes she included these colors in a project by simply filling-in shapes or drawings (through giving the turtle instructions in LogoWriter) or clicking the mouse (in MicroWorlds Logo). While creating a project with two of her friends red, black, and green became a distinguishing mark in elements of their animation. They made flying people with red, black, and green wings and clouds made of red, black, and green. She made a card with red, black and green shapes stamped around the border. Sometimes her desire to incorporate these colors into a project led her to discover new computational ideas or to think about familiar ideas in new ways. For instance, her creation of the winged people involved her in learning more about the shape editing tool. The border design for her card involved using repeat to create a pattern of colors.

I soon realized during this school year, that the colors red, black, and green were prominent in many aspects of children's lives at the school including art, clothes, decorations, as well as programming projects. During this time these colors were also prominent in broader media and popular culture outside the school. For example, in the popular and news media there was a great deal of discussion about the movie Malcolm X and in clothes primarily for youth, there was an increase in fashions designed to express African-American pride and heritage.

Bro. Joe, Shanay's teacher, told the children about the colors as symbols of African-American pride and heritage. He described the history of the colors as a symbol of Liberation of the black nationalist movement, "Red is the blood that we shed in the struggle with determination and freedom. Green stands for the land and our youth. Black is the color of our faces and reflects our connection to Africa and the common heritage that we share." The students began to call red, black, and green, "African-American colors." They also began to

use the colors in project in all of their classes. Interesting problems began to arise in each project where red, black and green were used.

In the Computer Class adding the colors which the class referred to as "African-American colors" became a regular addition to both Shanay's and her classmates projects. The students considered that these colors were necessary in order for a project to be complete. It was not surprising then, that on one occasion when we were looking for designs to make in LogoWriter, Shanay decided to create a design of squares of increasing sizes with the goal in mind to draw the squares in the repeating pattern of the colors red, black and green.

Shanay's growing squares project

Initially, Shanay worked with the procedure grow.square to make a succession of growing squares, given an input for the size of the initial square. (see diagram below) The turtle drew the squares in the default color, white.

```
to grow.square :size
repeat 4 [fd :size rt 90]
grow.square :size + 10
end
```

She was not satisfied with the design and insisted on changing it to draw the squares in the color sequence of red, black, and green. (see diagram below) Working to add these colors led her to encounter new ideas about her procedure.

Shanay's new ideas about solving the problem

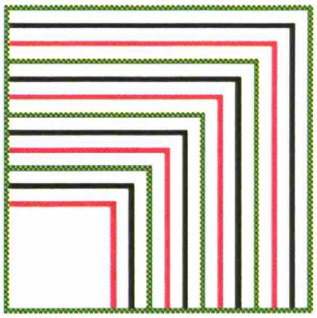
Shanay became invested in figuring out how to draw each square in the color she wanted. She found that adding a color to the first line of this procedure would only make all the squares the same color.

```
to grow.square :size
setc 4
repeat 4 [fd :size rt 90]
grow.square + 10
end
```

She asked me to help her with this problem. I knew she wanted to make the red, black, and green pattern in the growth of her squares and that getting her procedure to do exactly what she wanted would be tedious and possibly frustrating for her. So, I began by offering another option thinking that she might like trying to anticipate when red, black, and green would be generated. I explained that one way she could make the colors different for each square would be to use the procedure above with the addition of RANDOM in the setc instruction. She realized that this option would not allow her to generate the red, black, and green color sequence of squares and decided not to use it.

Continuing her work, she tried placing the setc command in different places in the procedure and learned that a different color would need to be indicated prior to drawing each square of a different size. She also began to realize that each of the three squares that she wanted in a different color would have to be drawn before the procedure was called again in the last line. After several trials and much discussion, Shanay recognized that adding on 10 and 20 to the fd command within the REPEAT instruction for the side of each square would draw each of the three different colors of squares. She produced the following procedure:

```
to grow.square :size
setc 4
repeat 4 [fd :size rt 90]
setc 15
repeat 4 [fd :size + 10 rt 90]
setc 3
repeat 4 [fd :size + 20 rt 90]
grow.square :size + 30
end
```



rbgrbgrbgrbg

Summary

Shanay's work on this project was a pivotal moment for her because she pushed herself to grapple with complex ideas. It was pivotal for me because it made me think of how engagement, identity, and understanding intertwine in the meaning making process. Although this story only scratches the surface of how cultural contexts and identity informs learning, it nonetheless constitutes a case to take seriously and cultivate richer instances.

In this project Shanay constructed her own informal conceptions of recursion, variables, and iteration and put them to use for something important to her. The procedure she created was, for her, "the way that you make growing squares that are red, black, and green." It was also a way that she engaged in constructing her own understanding of these computational ideas. In the context of this learning experience I have seen that an analysis of her learning, as the construction of mathematical ideas given specific tools and investigations, is not enough to fully conceptualize her learning.

To complete her design, Shanay had to think about how to generate a series of growth that would make her pattern. The red, black, and green color sequence increased the level of complexity involved in thinking about the original procedure. This complexity caused Shanay to think about the colors and squares as a cycle of growth. The recursive nature of the original procedure allowed her to think about the growth of the squares. By the end of her project, she had identified the recursive quality of a cycle that has size and color. Recursion for her was basically "the way to make it go back and make red, black, and green again and keep growing."

In order to understand issues that sparked Shanay's engagement with this programming project, one must understand some facts about programming and how children learn it. Children using Logo see two ways of making a pattern. Conceptually, the simplest program would contain instructions for each element in the pattern. So, in this case there would be FD and RT instructions for each square in the final pattern. An obvious disadvantage for many children is that this involves a lot of typing and if the pattern is to be increased in size, more typing would be needed. This perception condition is a way of seeing recursion (or, in other languages, looping) as a labor-saving device. A short program is written and makes successive squares "automatically"— to use a word we shall hear later in the dissertation. But, if the elements are repeated automatically, they will be of the same color. Thus Shanay is caught in a bind between the two ways she knows to make the pattern of nested squares.

One programming idea that appeals to many children as a way to obtain multi-colored results is the use of Logo's command RANDOM. Needless to

say, this idea was squarely rejected when I proposed it to Shanay: she was not looking for colors in any general way. She wanted red, black, and green.

The solution she eventually offered has more subtlety than might be appreciated at a superficial glance. It involved breaking the mindset that saw two ways to make the sequence of squares: programming individual squares vs. recursion. She broke out of the dichotomy by understanding that she could choose the repetitive pattern for the recursion on a different level than the individual square. She wrote a one-by-one program for three squares and then applied recursion to repeating this construction.

Recognizing that a step like this can be a breakthrough for a child is part of the art of being a constructionist teacher. Being a cultural constructionist teacher leads one to pay attention to a further aspect that could easily be missed by educators with an overly "logical-cognitive" way of thinking.

The logical-cognitive approach leads one to note that a new technique had been added to Shanay's set of intellectual tools. It neglects the specific relationship between Shanay and this new "tool." I noticed that for a long time Shanay would refer to the technique by language like "the red, black, and green way." This is not just language: it reflects her way of appropriating a general idea through a specific incident. And the aspect of this that is most significant and also most difficult for me to express in the cognitive paradigm is the emotional content of Shanay's relationship with this idea: one might say that she had "bonded" with it because of its role in solving a very charged problem and this bonding gave it an especially firm place in her toolbox.

Cultural context and identity are certainly present within the process of Shanay's engagement with computational ideas. Shanay's learning story is

one of many learning stories I've witnessed and helped to develop through my participant observation as a teacher and member of the Paige Academy community. In this work, I restitute a genesis of stories over time that suggest a need to integrate the frameworks of: 1) constructionism as a constructivist view of learning, 2) technological tools for learning as a supportive constructionist learning environment, and 3) cultural context and identity as nurturing aspects of schooling, particularly for children of color. As a result, I have formed the notion of *cultural constructionism* to address the overlapping issues which none of these avenues significantly explores on its own. The cultural constructionist perspective builds on constructionism to recognize both technological tools and cultural context and identity as tools for children's learning.

This study offers two main contributions. The theoretical perspective of cultural constructionism offers a model for conceptualizing children's learning that can deal with complexities of cultural difference that are largely unaddressed in constructivist theories. The main contribution of this work to practice in education is to show that if properly guided and supported at the beginning, and given an opportunity to express and build on their ideas and feelings, sorrows, and joys, children of color not only recreate a positive image of self, but more important, they will reach levels of excellency and personal commitment to learning that would otherwise be very difficult to achieve.

This dissertation is divided into four sections:

Chapter 1, the introduction, presents the research as an investigation of constructionist learning using a longitudinal approach of ethnographically-informed extended clinical interviewing.

Chapter 2 is a close examination of one child's creation of Logo projects over four years. It is a longitudinal case study of Keanna's learning through learning stories which describe pivotal moments in her work and recurrent themes in her engagement with computational ideas that give a sense of lived experiences which form the notion of cultural constructionism.

Chapter 3 is a description of the four most salient contexts for exploring children's learning in this study: The learning culture of Paige Academy, the Logo programming language, the pedagogical context of alternative epistemologies, and the Computer Class. These are the locations of my participation and observation through teaching and seeking to understand children's ideas, creating projects and creating computational ideas. This chapter provides a basis for understanding the cultural and technological contexts which I argue are both integral to the process of children's learning of computational ideas.

Chapter 4 situates this research within the path of progress in the research literature on constructionist learning. It is also a statement of my conclusions about the ramifications which the perspective of cultural constructionism holds for improving all children's learning and particularly the learning of children of color in schools along with the design and use of constructionist technologies. In this chapter, I also make suggestions for further research.

Chapter 2

Learning Stories from a Computer Class: Case study of Keanna

"Learning about things should not be at all disconnected from learning about oneself." (Shaw, 1995 pg. 171)

2.1 Understanding Many Through Understanding One

In Chapter 1, I described how my experiences working with students at Paige Academy led me to investigate the intricate relations between cultural issues of race, class, and gender and the process by which children come to new understandings about the world and themselves. Working with children on programming projects in Logo, I have focused particularly on their understandings of computational ideas in connection to their cultural environment and identity. In this chapter, I closely examine the work of one student, Keanna, over a period of four years (1992 - 1996) to identify themes in her learning during programming projects. I present "learning stories" that illustrate how her projects developed and the ideas she grappled with *as they were needed* to make her projects. This student's work and her ideas about programming suggest new ways of understanding the nature of the construction of computational ideas, which could inform instruction for children in other school settings.

Over the four years of the study, she grew from age 7 to 12 and she created ten extensive projects. I provide a description of each of the ten major projects to frame her progress and provide a sense of her personal and cognitive development. I then focus on her growing understanding of, personal involvement in, and contribution to seven of these projects. Most of these projects were completed in collaboration with other children at the school, were presented at outside shows, and gained public recognition of excellency. The learning stories were constituted from the data I have collected through working with Keanna over the years including video, audio, field notes, interview data, and samples of her projects. The chapter concludes with a section that summarizes and relates the various themes I noticed in Keanna's progress over time into broader categories. One major theme in Keanna's stories is the development of her technological fluency, or how she came to understand computational ideas as tools for her expression. Another theme is the emergence of her sense of project as an important learning activity. And there is a theme of expression of her cultural identity nurtured within the cultural context of her school. Throughout Keanna's work, she constructed new concepts in several different areas, including: an understanding of computational ideas and technology, ideas about herself and her identity, ideas about her cultural groups, and a notion of what it means to design and complete a project.

Technological fluency is a concept defined by Seymour Papert and developed during the period in which this research was conducted. It is an idea based in part on this work and on the work of several researchers within the Epistemology and Learning Group of the Media Lab at MIT (Resnick, 1994; Evard, 1996; Martin, 1996; Kafai, 1996; Harel, 1992; Wilensky, 1993). The

concept is based on several ideas. Borrowing from notions of language literacy, it means knowing how to express oneself in computational environments. It also means knowing how to solve problems and manipulate new situations in computational environments. For example, a person who has acquired technological fluency values mistakes and the imprecise knowledge that often emerges in work with computers. Technologically fluent people use knowledge from "bugs," as well as successful problem-solving, as information to explore and find other knowledge (Papert, 1996).

Since Keanna learned computational ideas as she engaged in many complex and substantial projects based on her own desires and interests, she was engaged in constructionist learning, as defined by Papert (1993). Keanna's is a story of growth and transition in many ways. Her projects in MicroWorlds Logo involved her in the construction of computational ideas. Yet more importantly, her enjoyment and achievements became key factors in her construction of self. She gained strength as a learner through her growth as a programmer within the culture of her school. She recreated her own view of what it means to be a programmer, to the point that she began to say that she could "be a computer programmer when she grows up." She developed a view that it was possible to understand how to get the computer to do almost anything she wanted it to do. This might take a long time or might be very hard to do. But she came to believe that it was possible to make the computer do things that would be helpful in her life, and the lives of her family and friends, and that she could learn to create technology that would do those things. She certainly contributed in significant ways to the life of her classmates. Through her help and engagement they performed with such

excellency as programmers that they received public recognition outside of the school. She also contributed to programming becoming a valued activity within the school culture. Her contributions and accomplishments emerged in spite of a challenging beginning to her work with Logo that required a great deal of initial support.

The development of Keanna's work on her computer projects parallels Sherry Turkle's description of the relationships to computers that children have at different stages of development. Turkle (1984) describes how adolescents who have extensive opportunities to work with computers often use them as a part of the construction of identity. Younger children in the eight- to ten-year-old range tend instead to explore different things they can do with computers. During the beginning of Keanna's project work her goals were to figure out what she could do with the computer. Later, as she grew into early adolescence, it became important to Keanna to represent her sense of herself as a programmer.

As a way of introduction to the case study, I describe aspects of Keanna's life and personality that give a sense of who she is and her surrounding environment. The bulk of the chapter is a series of learning stories examining the development of her work and thinking through the construction of her projects.

2.2 Meet Keanna

Keanna lives with her father, mother, and brother in a single family home in a middle-and working-class inner city neighborhood of Boston. Her house is not very far from the school. Both of her parents work full-time. Keanna's parents enrolled her in the Infant Class at Paige when she was three months

old, and her family had maintained a close relationship with the school over the years. Keanna's brother, who is two years younger than she, had also attended the school since infancy. Her father has been involved in teaching music at the school for several years. When I first met Keanna she was seven years old and I was an occasional visitor to the school. Keanna was eight years old when I began to teach Computer Class regularly. I soon began to notice her commitment to her projects, her strong personality and her focused approach to learning.

Keanna enjoyed socializing with her friends. She also seemed to be comfortable spending time alone. She talked about spending time with friends in her neighborhood as well as her best friends from school. She also talked about things she did in her room at home such as creating a scrapbook, reading, or listening to her radio. She enjoyed outdoor activities and sports, particularly basketball and trampoline.

I noticed early in working with Keanna that she often was very determined about doing tasks that she wanted to accomplish. Also, if she didn't want to do something, she was good at expressing resistance to completing the task. Keanna had always taken her work and her homework very seriously. She liked to do what she needed to do. She often talked about school work, saying that she wanted to "get it over with" so that she could then do fun things and not have to worry about her work. Once she had made a commitment to doing something that she wanted (or felt she needed) to do, she stuck with doing the work until it was done.

When Keanna was ten, and one of the oldest students in the school, her teacher Brother Joe and I began to call on her to help other children with their

work. As a teacher and helper in Computer Class, Keanna showed that she was sensitive and observant in her relationships with other people. She was careful in explaining things to other children and could become invested in helping them to solve their programming problems. At times, she seemed to imitate behaviors that Joe and I used, such as asking children to explain what they were thinking. In her Computer Class Evaluation in January 1995, I wrote:

> *"When Keanna sits down to work with someone, she asks great questions, tries to listen, and makes decisions about ways to work with them that helps them to express ideas in writing and in programming."*

She was interested in helping other children develop their projects and she seemed to like emulating the way that Joe and I interacted with them to understand the idea they needed and help them learn it. During summer camp, when few of the children have had experience with MicroWorlds, Keanna had become an assistant teacher in the class.

When Keanna was eleven and about to graduate from Paige, she expressed a sensitivity to others in comments about facing the decision of whether or not to go to a private school in Cambridge the next year. She talked about her view that there are different kinds of people. She described some of her friends as "street," meaning that they enjoyed hanging out at home or in her neighborhood and would be fine in a public school. These friends she said would not enjoy going to a private school, largely because "there would be too many white people there." She considered herself to be able to go to a private school and "like it there" but she also enjoyed "hanging out." This conversation revealed to me some aspects of how she saw herself in relation to other people. She felt able to negotiate situations where she was in the minority as an African American child. She

was also motivated to go to a private school because she wanted to "learn stuff there." She considered herself to be capable of learning difficult material and was eager to achieve in school.

Keanna's construction of herself as a computer programmer and other themes in her development.

Over the years I've worked with Keanna, she developed an image of herself as a programmer and became an accomplished designer and programmer. Her journey to developing this sense of herself is a story of learning about computational ideas, learning about herself, learning within the school culture of Paige, and learning in connection to her developing sense of herself as a capable learner and group worker. Throughout the years, Keanna's efforts paid off. She found her place among her peers in an adventure empowering to all!

When I began working at Paige in 1992, I remember sitting with Keanna and Shanay in the third floor computer room when we worked with LogoWriter on IIgs's. I heard them make comments about being programmers. Keanna made a comment that she didn't want to be a programmer because she didn't want to be a "nerd." I remember asking them what they thought a nerd was. In her mind at the time: nerd = programmer = "white man who only liked to work on computers and talk about them."

Throughout Keanna's work, her sense of self was strongly reflected in her work. She made a powerful transition in the re-creation of herself as a programmer. At first, she worked on programming simply because she wanted to make projects in Computer Class. She was resistant to identifying with programming seriously because of the image she and her friends had of

programmers was "white men with glasses and geeky clothes who sat in front of a screen all day and never did anything fun."

There seemed to be no place in their image of a "nerd" programmer for an African American girl who would grow into an African American woman. Keanna struggled with resolving the apparent conflict between engagement and success in her programming work and her image of herself as a programmer. In 1992 she and her friends first dealt with this conflict by simply doing projects because they wanted to do them and because that's what we did in Computer Class. Students did not call their work programming. They called it "working on their projects" or "writing their procedures."

Two years later, during fall 1994/95 Keanna began to convey a strikingly different message. She said something like, "I'm glad you are our computer teacher because that means that maybe we can be programmers." When I heard Keanna involved in this conversation with Shamia, I began to wonder how her concepts of herself and of programmers had changed. Was Keanna beginning to change her view (of the possibilities of seeing herself as a programmer) because she saw me, an African American woman, caring so much about programming ideas and helping her to learn them? Was she beginning to reconstruct a sense of herself as a programmer through her success on the many programming projects she was developing? Was the idea of her becoming a programmer becoming more comfortable due to the influence of Computer Class as a subculture within the culture of Paige that supported both African American identity and the pursuit of learning new ideas without imposed curricular boundaries but driven by either students' or teachers' interests? As the learning stories show, *each* of these aspects

formed the conditions which caused her sense of herself as a programmer to emerge.

For Keanna's graduation in June 1996, Sis. Angela asked her to write down ideas she wanted to express about her time at Paige and her hopes for the future. Keanna's words were very rewarding and moving to me. She conveyed that she considered her work in Computer Class to be some of her favorite experiences at Paige. And she said that she wanted to become "a programmer of Macintosh computers." Below is a transcript of her speech:

Keanna's Speech at Paige Graduation - Sunday 6/16/96

> *Hello. My name is Keanna Jones, and I'm the graduate from this school. I've been here since I was about three or four months old. I want to be a computer programmer for Macintosh Computers. Sis. Paula and her sidekicks have a lot to do with it. They introduced me to these computers, and that's what made me so fond of them. As I venture out into my new surroundings, I hope to carry most of my memories, and what I've learned from Paige Academy. And if I'm accepted to the Cambridge Friends School, that will be my next school that I go to for my education. I hope to make Paige Academy proud as well as myself. Most of the years here have been great. I'll tell you one thing, and that is that if there is never another Paige Academy.*
>
> *Thank you Sis. Angela and Bro. Joe for teaching us ....*

Keanna's work is an important example of learning for several reasons. Keanna's sense of herself in relation to her work was a thread through her creation of projects. It was intertwined with her coming to understand programming ides as materials for her creative expression. The strength of this interplay between her sense of herself and her emerging understandings of programming makes her work a good case study for exploring issues of constructionist learning using technologies that can benefit children in underrepresented cultural contexts in school. As Keanna's teacher, I find it my duty to convey to the education research community how this journey evolved, how Keanna found her way to excellency, how initial support can

foster personal growth, and how she grew within a learning culture where there is a faith that slow beginnings will lead to unforeseen breakthroughs.

2.3 Learning Stories from Keanna's Projects

The ten learning stories about Keanna's work on her projects are presented here in chronological order. The are grouped in sections according to the school year in which they occurred. Descriptions of situations in computer class and other relevant issues are provided to contextualize her work each year.

2.3.1 1992/93 Slow beginnings or initial learning out of struggle

Keanna's early work with Logo occurred in a Computer Class environment that was more structured than much of her later work. Computer Class was held two or three times per week during this school year.[4] The class usually met in the computer lab on the third floor of the school, where 6 Apple IIgs computers and one Macintosh LC were located. Students took turns working in LogoWriter on the IIgs machines or LogoWriter for the Macintosh through most of the year.[5]

Computer Class sessions usually began with me introducing an investigation that I wanted students to try. My goal in designing these investigations was to help children learn ideas about mathematics or gain comfort with writing procedures. I also tried to structure the activities to help

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[4]See chapter 3 for a more detailed description of Computer Class.

[5] Some familiarity with LogoWriter and the MicroWorlds versions of the programming language Logo created by Logo Computer Systems Inc. is assumed in the telling of these stories.

children develop a sense of accomplishment from creating a construction in Logo that would encourage them to create their own projects.

Each investigation I proposed included a set of procedures and instructions that involved thinking about particular ideas or questions. The investigations also required the use of new procedures or instructions to make a project I defined or the option to use the ideas and make personalized versions of the assigned project. Sometimes I suggested specific ideas to children that I tried to gear to their interests or that involved ideas they seemed to be engaged in thinking about.

This kind of work shaped the flow of Computer Class for about two years. During this time class sessions lasted for different amounts of time ranging from forty-five minutes to one and a half hours, depending on the schedule of other classes each day. The flexible length of time facilitated responding to the tenor of the class or the needs of particular students. During these early years of Computer Class, students usually worked on investigations or small projects over a span of one to four class periods. A sense of more extensive projects, personal design and investment in projects and agenda setting by the students to focus Computer Class on their project work began to emerge during the school year 1993-94.

Learning Story: The Apartment Building in LogoWriter

Keanna's earliest projects were created on the IIgs in LogoWriter and based on investigations I gave to students. She had a tendency from her earliest work in Logo to do what she was asked to do, but also to express an interest in "making her own." Once Keanna began to develop an understanding that procedures could be used to create parts of projects, she began to imagine

projects that were more extensive and challenging than the class investigations I originally provided. Good illustrations of Keanna's work at this time are: her *Elephantbird* project, her *Apartment Building* project, and her work creating pattern blocks procedures for the younger students.

In late May 1993, I noticed that Keanna was becoming comfortable with writing procedures and thought that she was ready to engage in a complex project that required several procedures. I encouraged Keanna to come up with an idea for her own project. She talked about wanting to make a project that had a street scene with people walking. I suggested to Keanna that she work on making a project with "A Street Scene," a set of instructions in the LogoWriter Secondary Series project book. This project is described as defining procedures to make buildings in a street scene out of shapes and then create an animation of a car "driving" along the road. (LCSI, 1989)

Keanna quickly became determined to make her street scene and worked independently to write a procedure for the road. On June 2, 1993, she experienced a lot of frustration that eventually helped her to engage in thinking about some important aspects of what procedures are and how they work. She was trying to debug the procedure she called `SETUP1` that was supposed to place a turtle as a car on the road she drew. She became very frustrated because the `SETPOS` instruction she wrote was not placing the turtle where she wanted it to be, `SETPOS [25 50]`. In her frustration, she said that she couldn't get things to work the way she wanted them to work. I worked with her to explain why the inputs she gave to `SETPOS` were positioning the turtle too high on the screen.

This explanation made it necessary for me to describe the coordinate system in order for Keanna to have a model for how the SETPOS command positioned the turtle. I described the two numbers used with SETPOS as an address for a location on the screen. I depicted the first number as how many turtle steps across from the middle of the screen "you need to go to find the spot "and the second number as how many turtlesteps up from the middle of the screen "you have to go." I mentioned that you need negative numbers to get to other parts of the screen. I tried to tailor my explanation to the knowledge that Keanna needed in order to come to an understanding of the functioning of her procedure. I made a decision to tell her information that would help her to know there was more to figure out in solving her problem in a way that could hopefully resonate with some of her thinking.

I wanted her to realize that it was not her fault that her procedure wasn't working in the way that she wanted it to work. I explained to her that the error message she was getting meant that there was something wrong in the procedure and that she needed to read through it to find the problem. I reminded her that sometimes the problem will be something that she won't be able to fix because she needed more information like how to know the turtle's address. I told her that it made sense that it was hard for her to understand that the turtle was in the wrong place because she used 50 for the y-position instead of -50. She had no way of knowing that the negative sign was so important to positioning the turtle. She left class feeling very frustrated that day, so I decided to spend time with her the next day on getting her *Apartment Building* procedure to work.

The problem: inputs, positions, procedures inside of other procedures and frustration

Keanna worked independently to follow the instructions in the booklet to create procedures to draw an apartment building. When I began to work with her, she was extremely frustrated. This time, her frustration was due to the error messages she was getting when she tried to use procedures she had copied from the project book. She had typed the procedure for the whole building exactly as it was written in the book (see below). She expected the procedures to work because she had previous experiences typing in procedures I gave her or from LogoWriter activity cards. In most of those activities, she was familiar with reading the procedures she needed to type and just enough of the other material so that she knew what the project was supposed to do. In this case, she apparently focused on the procedures and ignored the explanations in the book about inputs. She ignore these explanations apparently because she didn't understand them; consequently, she was oblivious to their importance.

On the flip-side, she also had the procedures for RECTANGLE, PLACE, and SQUARE that were given in the description. She had a sense for what each procedure was supposed to do but was not recognizing why she kept getting error messages when she tried to run the procedure (i.e. "not enough inputs in rectangle"). She had not had enough experience with procedures with inputs to realize that she needed to give inputs to the procedures RECTANGLE and PLACE in order to use them in the APARTMENT procedure. She also didn't realize that she needed to write the WINDOWS procedure and use SQUARE inside of it.

```
to apartment
rectangle ___  ___
place ___  ___
windows
place ___  ___
windows
end
```

```
to rectangle :height
:width
repeat 2 [fd :height
rt 90 fd :width rt
90]
end
```

```
to square :size
repeat 4
[fd :size lt 90]
end
```

The picture she was trying to make is the one below:

I decided to work with her in a way that was rather directive in guiding her through what she needed to do, and yet collaborative in that we were working together to get the problems figured out. I chose this approach in order to help her manage her frustration and stick with her project. I felt that she would stick to it as long as she continued to make progress.

The task she was trying to accomplish was putting the windows onto her *Apartment Building*. This task involved moving the turtle to positions within a rectangle she drew for the outline of the building using the

procedure PLACE which, as it is written in the book, took two inputs for the vertical and horizontal movement of the turtle. She then needed to use basic turtle commands to orient the turtle and the procedure WINDOW to draw sets of windows.

The first error message Keanna had become frustrated with was "RECTANGLE needs more inputs." So we began talking about how the RECTANGLE procedure works by moving the turtle up for the vertical side and then over for the horizontal side. She chose the numbers 100 and 70 and easily added them to her procedure.

```
to apartment
rectangle 100   70
place ___  ___
windows
place ___  ___
windows
end
```

Paula: *So, now the first thing your APARTMENT procedure is going to do is draw the rectangle because it understands how to draw the rectangle now.*

Now we need to make it do the windows...

Keanna : *I want it to be like that.(She picked up the book and pointed to the pictures) I want to write WINDOWS.*

The ease with which she added the inputs to RECTANGLE suggested that she had an understanding of the function of the procedure to draw the outline of the apartment by using the first number for how far up to go and the second for how far across. She knew that the next thing that the APARTMENT procedure needed to do was to draw the windows but this process

was a little more complicated. I pointed out to her that when the turtle draws the apartment, it ends up in the lower left corner of the rectangle. I asked her to show me on her picture where she wanted the windows to be. She pointed to two windows across and three rows down in the same way it looks on the picture in the book.

Frustration with PLACE needing two inputs

We looked at the instructions in the book and realized we needed to figure out what PLACE does so that we could use it to position the turtle to draw the windows. The PLACE procedure was written in the book as follows:

```
to place :across :up
seth 0
pu
fd :across
seth 90
fd :up
pd
end
```

I asked Keanna if she had tried out the PLACE procedure or if she had just typed it in. She said she tried but it just moved the turtle around. I explained to her that she needed to give it two numbers "a number for across and a number for up." While I was explaining, she typed `PLACE 10`. The error message made her very frustrated. I tried to explain:

Paula: *See, it said it takes two numbers, a number for across and a number for up. Two numbers just like you did for rectangle.*

Keanna: *(slumping back in her chair) I hate this!*

Paula: *Now wait. Now stop. Put your hands down and listen. I think I understand something now. I think I understand that you get real frustrated when those yellow words come up there and tell you something went wrong.*

Let me tell you a secret, when you are programming on the computer, you are gonna get those yellow words a lot and all you have to do is read them and if you already are sure you know what they say and they are not telling you any thing new, you just erase them and go on. OK? Do you understand? Because it doesn't help to let them get you all frustrated all the time.

Keanna: *(shrugging her shoulders) They make me sick! "It needs more inputs," that's all I see.*

Paula: *And when it says "Needs more inputs," that's telling you that it needs numbers. It's telling you, "You didn't give me the numbers I need to do this."*

As I tried to explain the need for two inputs, Keanna typed PLACE with one input again and became frustrated again. She didn't yet accept that the way she wished to do it was not going to work.

Keanna: *Oh, see, "PLACE needs more inputs."*

I switched my strategy to describing exactly what she needed to do with PLACE. I recognized that her frustration was connected to dealing with the idea that the procedure needs a certain number of inputs. This was the problem that neither the error messages, nor the explanation in the book, nor my explanations had so for had helped her to engage with thinking about. I chose to guide her through exactly what to do so that she would have the correct formation of the instruction to look at on her page. It seemed more likely that then she would notice the two numbers as inputs and think about how they functioned.

Paula: *PLACE takes two numbers, one for how far over and one for how far up. ... How far over and up do you think it needs to be?*

Keanna typed PLACE 90, again without a second input. So I tried to follow her thinking more and I asked her why she picked 90. She pointed to near the top of the rectangle. I thought that she pointed to the top of the rectangle because she was thinking that 90 would be used in PLACE to put the turtle near the top of the rectangle because 90 is the first number. I noticed that this was not the effect 90 would have because of an inconsistency between the ways that the RECTANGLE and PLACE procedures are written. I described that I noticed that the PLACE procedure moved the turtle across first and then up which is different from the way the turtle drew the rectangle by moving up first and then across. I thought my explanation had confused Keanna because it wasn't fully consistent with her thinking. When I asked her if she understood what I was saying, she shook her head and said "no." So I offered a thought, that was outside of the discrepancies between both the procedures and her thinking so far, for her to think about:

Paula: *Let's just think of it this way. When you are using PLACE, the first number is how far you are going across and the second number is how far you go up.*

Keanna then typed PLACE 90 10 which was the correct formation of the instruction and got another error message, "I don'know what to do with UP." Keanna slumped back in her chair and said emphatically, "Stupid Computer!" I checked the procedure and discovered that the problem was just an extra space before the variable :UP. Keanna's assessment of the

computer as stupid was quite appropriate in this situation, since the error message was an artifact of the weakness of Logo syntax, which is particularly sensitive to spaces. So, it was easy to let her know that the error message could be eliminated simply by adding a space.

Her own way of thinking about PLACE

Paula: *(still looking at the procedures on the flip-side)*

Look at how your PLACE procedure is written.

Keanna: *What's wrong with it?*

Keanna's response was in an attitude assuming that I asked her to look at her procedure because something was wrong with it. I actually wanted her to engage in recognizing how it works.

Paula: *Nothing is wrong with it now, but you can read it to help you.*

(pointing to the procedure and moving my hand as the turtle)

What you are doing with PLACE is you said, Set the heading to 90, take the pen up." If you set the heading to 90 Keanna, the turtle is facing this way. So if you say go forward, it is going to go that way. So that's what you did, you said SETHEADING to 90 and go forward whatever number you put for across. And then, what's the next thing it does?

Keanna: *Setheading.*

Paula: *To what?*

Keanna: *Zero.*

Paula: *OK, so zero is this way. And then what do you say to do next?*

Keanna: *FD up.*

Paula: *FD :up which is going to be the second number you give it. Does that make sense? Sort of? Kind of? Just a little bit?*

Keanna: *It makes sense.*

Paula: *It makes sense, OK. So, let's try it this time.*

Later in the conversation, though, when we actually began to use PLACE, she decided to change the way the turtle moved so that it went up first and then across. She made her own decision to think about PLACE moving this way which she did not seem to connect to my explanation about the discrepancy between the way the RECTANGLE procedure worked and the way the original PLACE worked.

Paula: *When you do PLACE, the first thing its going to do is go FD 90 (pointing horizontally to the right)*

Keanna: *But it ain't heading that way*

Paula: *That's a good point, but it's gonna be heading that way.*

Keanna: *(sighs)*

Paula: *Because the first thing you do in PLACE is what?*

Keanna: *SETHEADING 90*

Paula: *So its going to be heading this way first (pointing horizontally to the right)*

Keanna: *I don't want it to go that way!*

Paula: *Which way do you want it to go?*

Keanna: *Up!*

Paula: *So you want it to go up first? Then you are going to have to change it so that its SETHEADING to what first?*

Keanna: *Ummm. Zero!*

Paula: *So you want it to SETHEADING to zero first because you want it to go up first. So we better change this so that instead, the first number shouldn't be across, it should say what? (pause)*

Keanna: *Up!*

Paula: *OK, so we better change it up here so that the first number that it takes in will be the number that goes? What?*

Keanna: *Zero!*

Paula: *(typing in the changes and pointing to the procedure) No... (hesitating) Yeah, that's true. You are right, that goes to the zero heading, so that's going to be* `:UP`. *The second number it takes in will go to the ninety heading so that's going to be called* `:ACROSS`

OK, so it's going to setheading to zero, then it is going to go forward `:UP` *and then we want it to set the heading to what?*

Keanna: *Zero! Ummm. Ninety!*

Paula: *Ninety. And then forward [what?]*

Keanna: *Zero.*

Paula: *No, instead of FD* `:UP`, *FD [what?]*

Keanna: *Forward* `:ACROSS`

Paula: `FD :ACROSS` *OK, now try it.*

This process created the following procedure:

```
to place :up :across
seth 0
pu
fd :up
seth 90
fd :across
pd
end
```

She then tried to use `PLACE 90 10`, deciding that both 80 and 90 would be "too big" because they placed the turtle too high in the rectangle. She tried `PLACE 70 10` and decided it was a good position. We then added her numbers for PLACE to the APARTMENT procedure.

```
to apartment
rectangle 100   70
place 70  10
windows
place ___  ___
windows
end
```

It seemed as though Keanna became more comfortable with the PLACE procedure because she made it function similar to the RECTANGLE procedure. She did not explicitly associate this understanding with the relationship I had tried to point out to her. When she modified PLACE, she was making it her own with the ideas that she came to her own understanding about.

Procedures inside procedures and Making things happen "automatically"

When we tried seeing how the whole procedure worked so far in the command center, Keanna typed APARTMENT PLACE.

Paula: *Do we need to do PLACE again now?*

Keanna: *Oh, Yeah!*

Paula: *Because PLACE is inside of APARTMENT*

(She types just APARTMENT and it works.)

Keanna's next task was to finish creating the windows of the apartment building. She became even more assertive about her ideas and took back control over typing and changing the procedures. She settled into using her

PLACE procedure as a tool to move the turtle into positions for drawing her windows by figuring out numbers as inputs. Her clarity about adding calls to the PLACE and WINDOWS procedures from her APARTMENT procedure was an indication that she began to think of these procedures as subprocedures inside of APARTMENT.

```
to apt1
rectangle 100 70
place 70 10
windows
pu bk 40 lt 90 bk 70
place 40 10
windows
pu bk 40 lt 90 bk 40
place 10 10
windows
end
```

Keanna's picture of an apartment building and the procedure that draws it.

During the construction of the windows, she expressed an interesting thought that her procedures would put the windows on the building "automatically." The idea of procedures making things happen automatically came up at other times in hers and other children's work. This was one of the first times I noticed this idea which became a theme in many of the student's thinking about procedures. In this case "automatically" meant that she didn't have to tell the turtle to move through the path of drawing the two squares across for each row of windows. She described the WINDOW procedure "doing it for her" each time.

Reflections on the Learning Story: Procedures, Self-determination and direct support from her teacher

This story characterizes two themes within Keanna's early work creating Logo projects. It describes her initial thinking about procedures as pieces of a project and ways to make things happen "automatically." It illustrates a style of work that was an interplay between working in a self-determined independent way and relying on support from others who could help her.

The *Apartment Building* project was significant in developing Keanna's thinking about how procedures work inside of other procedures, how procedures take inputs, and how to read error messages and read through procedures to debug them. This was the first time Keanna dealt with procedures inside of procedures and procedures with inputs, to a great extent she worked on her own. She was determined to make this project and I was able to provide support that helped her realize that reading through the procedures and the error messages are parts of the process of "getting it do what you want it to do."

Keanna's frustration was a part of her construction of understanding her procedures. Even though she wanted very much to have the turtle draw the apartment building, she had to struggle through her resistance to thinking about how the procedures worked. I decided to explain the function of the procedures and commands she needed to use when she was frustrated. When I explained something that she understood, we moved forward. When she didn't understand or wasn't thinking of the process in the way I described it, she let me know. Sometimes it seemed like her way of figuring

out how to solve the problem was to have me explain things as a background or reflection to her coming to her own understandings. I didn't think that she would think about the procedures in the ways that I was describing unless what I said resonated with her emerging thoughts in some way. My goal was to keep thoughts going in the air so that she would try different things and not stay stuck in generating the same error messages.

In the background of most of the classes are several calls from students for help. "Sister Paula, Sister Paula, Sister Paula, I need your help." "Brother Joe, can you show me how to do this?" "Brother Isaac, can you make this drawing look right for me." Keanna had a tendency to try to figure out how to make things on her own at first but when her attempts were not fruitful within the boundaries of her knowledge and patience, she wanted help and could complain a lot until she got it. In observing the classroom culture to which she was accustomed I found practices that supported her expectations for help from an adult.

Bro. Joe often worked with students in a collaborative way on their problems. His approach exemplified a style of teacher-student interaction I observed at Paige that conveyed, "I'll work with you to solve this problem." "I'll work with you to do something I feel is important and I want you to find interest in doing." Or, "I'll work with you and share how I think you can solve this problem and listen to how you think about solving it."

I took an approach of trying to directly guide her discovery when I told her the changes I saw that she needed to make to debug her procedures while also listening to her ways of thinking about it so that we wrote the program in a way that she understood. The way I approached working with her was

consistent with the kinds of adult-student interactions she was comfortable with within the school culture. The approach of being directive, yet collaborative and responsive to children's understandings is consistent with forms of direct talk and nurturing styles of teaching that are considered culturally-relevant for African American children (Delpit 1995, Brice-Heath 1977).

The approach I'm describing as direct guided discovery is in opposition to the open-ended "pure" discovery method that is often advocated in the literature on progressive education and constructivist teaching. If I used a pure discovery approach, the questions I would have asked Keanna might have been similar to the following: "Why did you type `PLACE 90`? or "What do you notice about your procedures?" These kinds of questions would be geared to probe her thinking about the problems she was trying to solve. My assessment of Keanna's situation was that using an approach that was too open-ended would leave her vulnerable to giving up on the project because of her level of frustration. I knew that she was more accustomed to a direct style. I also noticed that Bro. Joe used various styles of teaching in response to the situation as a way attend to students learning needs than using only a discovery method. The practice of having a kind of "grab bag" of approaches to teaching is associated with teaching that best attends to the needs of students who belong to cultural groups who are outside of the mainstream (Delpit, 1995).

2.3.2 1993/1994: The beginning of a series of collaborative projects

This year we began working primarily with LogoWriter; by the end of the year, we changed into almost exclusively working with MicroWorlds Logo.

(LCSI, 1993, 1995) Another Macintosh was in the Group 3 classroom on the second floor. Students took turns working in Logo Writer on the IIgs machines or MicroWorlds on the Macintoshes through most of the year.

Accompanying the shift in computers and software was a shift in the focus of control over the class agenda. By the end of this school year there was a clear shift in the agenda of class becoming focused on students making their own projects rather than adding their own ideas to projects provided by me.

By late winter, Keanna's work took an interesting turn from creating projects on her own to creating projects together with her friends. Her individual project were much like the *Apartment Building*. For instance, in the Fall, she created a LogoWriter animation on a theme the class had chosen, of *Elephantbirds*. She discussed and shared the projects she made alone with others. In January, she began to create projects collaboratively with her friends.

Learning Story: Wacky World, with Shanay and Shamia (January and February 1994)

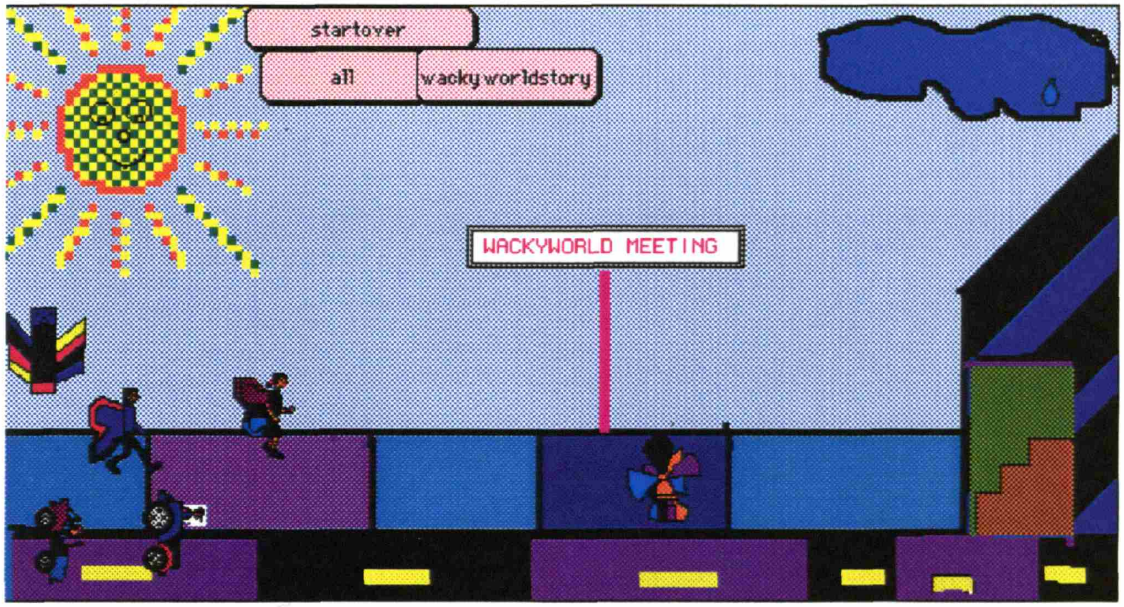
Keanna's first collaborative project was called *Wacky World*, which she created with Shanay and Shamia during January and February of 1994. Part of the motivation for this project began with creating an entry for Compufest 94, a computer programming and computer graphics design contest for children sponsored by the Boston Computer Society.[6] When Shamia, Shanay, and Keanna asked me if they could work together on a project, I said they

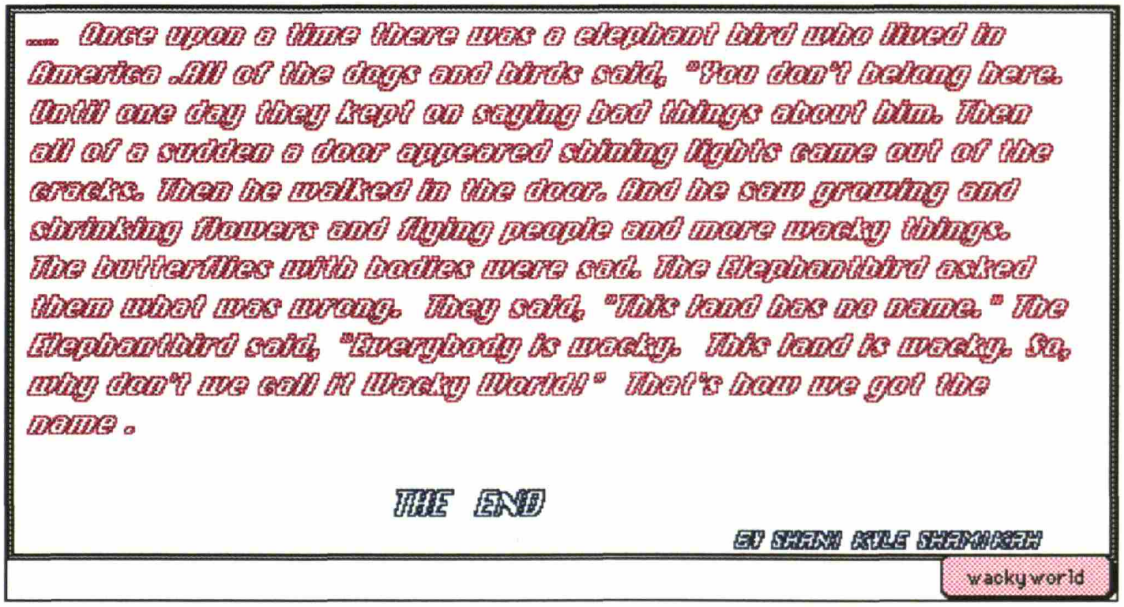
---

[6] The students chose to enter the contest when we received a notice about it in the mail. The contest became a source of motivation for the students work for the two years in which we participated.

could as long as they figured out a way for each person to keep working and not spend too much time letting one or two people just watch while another person worked on the computer. We discussed working on separate computers and combining the different pieces of the project they created in the end.

The group came up with the idea of making a world that was "wacky" by making all of the things in the world look and perform actions that are impossible in the real world. For instance, people with wings who can fly, cars that go up into the air and down onto the ground as they move down the street, a sun with a blinking face on it and a single raindrop that falls down onto a flower, making it both grow and shrink. The animation depicts all the people moving along a road that goes across the screen and disappearing into a door to "*The Wacky World Meeting House.*" The final version of this project has one page with an animation of all the characters going into the *Wacky World Meeting House* and another page with a text box containing a story they wrote about *Wacky World.*





Two pages from *Wacky World*.

The idea for this project was sparked by their work with an *Idea Project*[7] depicting a growing bee and dog we created for students to think about the use

[7] *Idea projects* were projects written to illustrate a programming idea or feature of Logo that I wanted students to think about using in their projects. They were designed and written by my UROPS and me. I usually asked students to begin a class session by playing with the *Idea Project* and figuring out how it works. Examples of *Idea Projects* are: *The Mouse Party, The*

of SETSIZE and SIZE. Children were also inspired to bring narrative into their work by witnessing their classmate Ashe work on a project he called *The Wiz 3*. The project was his rendition in MicroWorlds of the movie "The Wiz", complete with Dorothy and the traditional band of characters, a yellow brick road, munchkins, and The Emerald City.

Keanna was particularly interested in making the flowers grow and shrink in *Wacky World.* She spent a lot of time coordinating the shapes of the people and the cars. She was very engaged with getting all the people to appear to go into the meeting house and have the door shut behind them. Through this problem, she engaged in thinking about how the order in which the turtles was made would effect their appearance behind or in front of the door. She thought about having the door appear closed once all of the characters were inside or once the procedure that moved the characters was finished. These issues involved thinking about the control of the program.

Reflections on: *Wacky World*

During her work on this project, I began to notice her interests in grasping programming ideas and using them as seeds within part of a larger project. She was excited to figure out how to manipulate MicroWorlds and write the procedures the group needed. The understanding of procedures which she struggled with during the time of the *Apartment Building* projects had developed to an understanding of procedures as a way to make the actions in the current project. Her confidence in her programming skills during *Wacky*

Crazy Shapes, Astronaut, and *The Muffin Man.* These projects and their use in the class are discussed further in Chapter 3 within a description of elements of Computer Class.

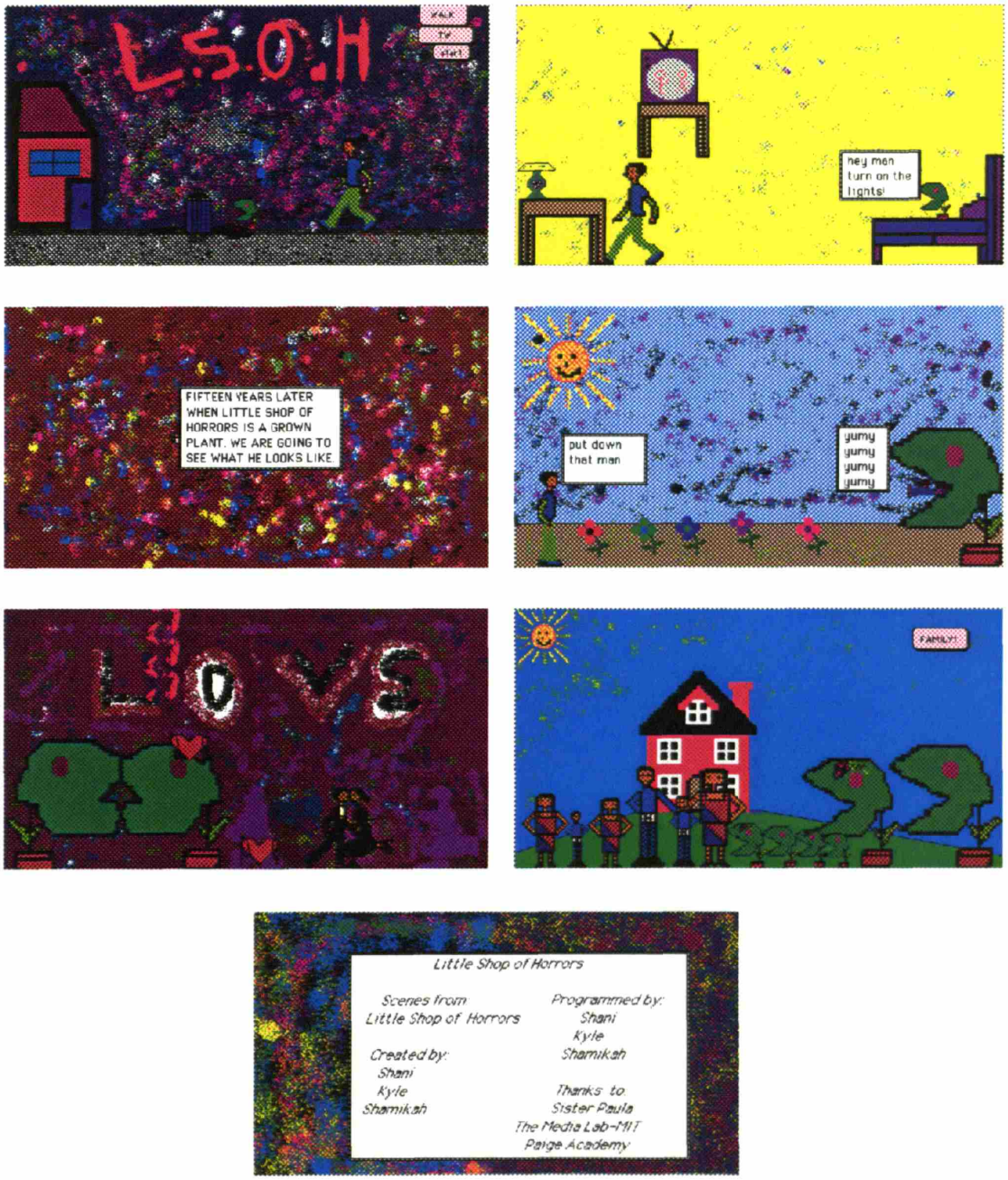
World had also increased since her initial work. Writing procedures was one way she became assertive in helping the group to get the project done. She was focused and clear in explaining the problems that needed to be figured out at each step of their process. She was assertive in explaining the solutions she had figured out to her collaborators as well as working out solutions with them. She continued to exhibit and expand these qualities in her next project, *Little Shop of Horrors*.

Learning Story: *Little Shop of Horrors* with Shamia and Shanay (March - August 1994)

The desire to work with her friends was an important force in the production of a series of five projects that Keanna created with other girls in the class over the course of two years. For Keanna and her collaborators, the desire to create projects together shaped both what they did and how they did it. The second collaborative project, *Little Shop of Horrors (L.S.O.H.)* began in Spring 1994 with Shamia. In the summer, when we were asked to give a presentation at MacWorld, Shanay joined the project. The girls gave a presentation of the project at the MacWorld 94 Kid's Showcase.

The idea for the project emerged from Shamia's excitement about recently having seen this movie. The girls were both intrigued by both the man-eating plant named Seymour and by the boy who brought the plant into his house to live with him. They were again motivated by Ashe's creation of *The Wiz3* project which put an idea into the class community for making projects that were "like movies."

The final version of the project is an animated "movie" that unfolds across eight pages. The girls designed each page to depict their interpretation of a scene from the movie but by the time they had developed several pages in the project, they decided to change the narrative so that they created their own ending. Keanna created most of pages 1 - 5, although in the beginning she worked with Shamia on the first page. Page 1 is an animation of the character they called "the Boy" walking across the screen, picking up the plant in the middle of the screen and carrying it into his house. On Page 2, the Boy walks into his bedroom and the plant is sitting on his bed. Textboxes appear to show the characters dialogue. The plant says, "Hey man, turn on the lights!" The TV and the lamp then turn on. Page 4 is a screen containing text that moves the story along, "Fifteen years later, when Little Shop of Horrors is a grown plant, we are going to see what he looks like." Page 5 depicts the boy yelling to the plant who has a man in his mouth, "Put down that man!" but the plant eats the man and says "Yummy! Yummy! Yummy!" Page 6 was made by Shanay although the girls decided together for her page to make a particular plot twist. On this page both the plant and the boy find female counterparts and fall in love. Shamia created Page 6 in which the Plant and the Boy both have developed large families. Everyone of the characters disappears into a large house and the house bulges at its sides. The song "We are Family" is played on this page with a caption saying, "We need to move!" Page 8 is the Credits Page with textboxes displaying credits the girls wanted to give to themselves and people who assisted them.



The final version of *Little Shop of Horrors*

For the first few months, the group's focus was to make the animation for the scene where the man finds the plant and takes it into his house. The children had to draw new shapes for the boy to bend down and pick up the plant. Their first programming problem was to figure out how to get the boy

to pick up the plant and have the plant and the boy move across the screen together. This problem required them to coordinate their use of LAUNCH and talking to the two turtles (one turtle with the boy shape and one with the plant shape) so that the simultaneous motion would make it look like the Boy was carrying the Plant.

Keanna and Shamia also worked diligently during early phases of the project on developing the *L.S.O.H.* theme song. They were intent on making the music sound authentic. Originally, they planned for the song to play through the whole animation. This plan was changed in the summer when they decided to just play the theme song through the first page and then recorded another song, "We Are Family" for the last page. In April, they created the theme song using the melody editor. They spent a great deal of time sounding out the notes of the melody to the point that they were satisfied. Then one month later in May, they decided they were not satisfied with the sound of the computer playing the melody and they decided record themselves singing the theme song instead. They spent a class session focusing on getting the vocal production they liked. By the end of this session, they had enlisted the help of three other children in the class to sing on their recording.

Keanna's assertiveness and understanding of programming ideas led her to adopt the role of coordinating the programming of this project. Her key position became clear when the group decided that her pages would be the first ones in the project. This made her responsible for setting up the story line and made her WALK procedure the top-level that was key to making their project "work like a movie." There was an unspoken understanding among

the group that Keanna was both interested in and capable of pulling the whole thing together.

Thinking about procedures inside other procedures

The three girls came to work at the Lab to finish their project for the MacWorld presentation during four days prior to the presentation on August 4. They spent about four hours working on the project each day. We had lunch together and had snacks. We worked at the Media Lab because it was easier for us to focus on the work away from the busy atmosphere of school and the network technology and faster computers made it easier to merge, backup, and review the work. The girls felt it was special to come to MIT and work in the computer labs.

The overall problem they faced during this time was to achieve their goal of getting their project to "run like a movie." There were several tasks (sub-problems) involved in solving this problem since they had created their pages on separate computers. They had to figure out how to combine the separate pages into one project on one computer. There were basically four parts to solving this problem: merging the graphics pages, copying and coordinating the shapes and turtles, merging the procedures pages, and editing the procedures so that the whole animation could be run by three buttons (one for setting up the pages, one for launching the animation, and one for the theme song).

When Keanna and Shanay worked on editing the procedures so that the project would run like a movie, they described that "like a movie" meant that the whole project would work from buttons on the first page. When they made their pieces of the project on separate computers, Shanay created

buttons for each of her animations. She had buttons for procedures to make the girl and boy run towards each other and kiss, the girl plant and boy plant to move together and kiss , and the hearts to fly up into the air and pop. But when her page ran within the whole project, she didn't want any buttons to be on the page. They felt that if you had to press buttons to get things to move on each page it would make the project more like a video game than a movie.

Shanay's page with buttons

This "movie making" goal set the stage for several conversations about procedures during the process of combining their separate parts into one project. Beginning to set up the project to be like a movie required getting Shanay's procedures inside Keanna's WALK procedure. In the following excerpt from the second day at the Lab, Keanna explained how her WALK procedure needed to be changed by adding Shanay's procedures so that WALK would run everything. The following dialogue occurred after I told Keanna and Shanay that I didn't quite understand what they meant by getting their project to "work like a movie." This conversation took place in the

Lego/Logo Lab. Mitch Resnick had come in to look at the girls' work. In this dialogue, Keanna took the lead and asserted her way of thinking about how, and why, the procedures needed to be combined. It is a good example of the independence Keanna asserted when she understood what she needed to do.

K: *Now listen, Sis. Paula.*

P: *OK, I'm listening.*

K: *OK (pause) Go on the flipside, Shanay.*

S: *Why?*

K: *Just go on the flipside, Shanay. (pause) Thank you.*

OK. Do you see my WALK procedure? Wait. Wait, now you do that WALK procedure. This isn't my real WALK. But her WALK procedure, she would put her- What's your thing named?

Her BOY and GIRL procedure in my WALK procedure.

P: *You mean, her procedure called LOVE makes the boy and the girl move. Doesn't it?*

S: *Yes.*

K: *You put her LOVE, her G. WALK her B. WALK, her G. RUN and all her, both of her three procedures in **my** procedure.*

M: *I see so, LOVE, it launches GIRL. RUN and it launches BOY. RUN. So it makes them both do it at the same time.*

K: *Yeah.*

S: *And she wants to take-*

K: *All.*

S: *This procedure, the GIRL. RUN and the BOY. RUN and LOVE and put it in the WALK procedure.*

K: *In **one** procedure.*

S: *So that we only have three buttons on the screen instead of a whole bunch.*

We'll have WALK, START, and the music instead of a whole bunch of buttons over the whole screen.

K: *And so we put her* `PLACE` *and* `BEGIN` *procedure in my* `START` *procedure as* ***one procedure.***

S: *Yeah.*

(8/1/94 transcript excerpt)

```
SHANAY'S PROCEDURE'S  8/1/94

TO G.RUN
T5,
SETH 270
REPEAT 5 [SETSH 52 FD 6 WAIT 1
SETSH 53 FD 6 WAIT 1 SETSH 54 FD 6
WAIT 1]
END

TO B.RUN
T4,
SETH 90
REPEAT 5 [SETSH 37 FD 6 WAIT 1
SETSH 38 FD 6 WAIT 1 SETSH 39 FD 6
WAIT 1]
END

TO LOVE
LAUNCH [G.RUN]
LAUNCH [B.RUN]
END

TO PLACE
T4,
SETPOS [10 -95]
T5,
SETPOS [210 -95]
END

TO B.PLANT
T2,
SETH  0
REPEAT 5 [ FD 6 WAIT 1]
RT 90 FD 13
SETH 180
REPEAT 5 [FD 6 WAIT 1]
END

TO G.PLANT
T1,
SETH 0
REPEAT 5 [FD 6 WAIT 1]
LT 90 FD 13
SETH 180
REPEAT 5 [FD 6 WAIT 1]
END

TO PLANT
LAUNCH [B.PLANT]
LAUNCH [G.PLANT]
END

TO BEGIN
T2,
SETPOS [-197 -71]
T1,
SETPOS [-70 -71]
END


TO POP
ASK [T10 T8 T7 T6 T3] [SETH 315
REPEAT 10 [FD 15 WAIT 2] SETSH 50]
END

TO POP1
ASK [T10 T8 T7 T6 T3] [SETSH 3]
T3, SETPOS [15 -117]
T6, SETPOS [15 -82]
T7, SETPOS [16 -48]
T8, SETPOS [17 -13]
T10, SETPOS [18 21]
END
```

KEANNA'S WALK PROCEDURE 8/1/94

```
TO walk
t3,
seth 270
setsh "boy1 fd 85
setsh "boy2 fd 85   setsh "boy3 fd
70
setsh "boyb
setsh "boyp
t1,
seth 0
fd 55
launch [t1, seth 270

repeat 9  [fd  12 fd 12 fd 12]]
launch [t3, repeat 9 [fd 12 fd 12
fd 12]]
WAIT 10
page2
t1, setsh "boy1 seth 270
  setpos [70 -83] repeat 10 [fd 20
wait 2]
t.lamp,
setsh "lamp setsh "lampb setc 44
fill
T6, SETSH "TD
WAIT 40
PAGE3 wait 40
page4
WAIT 10
T2,
SETSH "LITTLE
T1,
HT
wait 20
T2,
SETSH "G
end
```

KEANNA'S WALK PROCEDURE 8/3/94

```
TO walk
t3,
seth 270
setsh "boy1 fd 85   setsh "boy2 fd
85   setsh "boy3 fd 70
setsh "boyb
setsh "boyp
t1,
seth 0
fd 55
launch [t1, seth 270

repeat 9  [fd  12 fd 12 fd 12]]
launch [t3, repeat 9 [fd 12 fd 12
fd 12]]
WAIT 10
page2
t1, setsh "boy1 seth 270 setpos
[70 -83] repeat 10 [fd 20 wait 2]
t.lamp, setsh "lamp setsh "lampb
setc 44 fill
T6, SETSH "TD
WAIT 40
PAGE3 wait 40
page4
WAIT 10
T2,
SETSH "LITTLE
T1,
HT
wait 20
T2,
SETSH "G
wait 10
page5
LOVE
PLANT
POP
PAGE6
IN
wait 40
PAGE8
end
```

In the transcript above, Keanna was adamant about the idea of adding Shanay's procedures into hers in order to make their project "like a movie."

When she says, "You put her LOVE, her G.WALK, her B.WALK, her G.RUN and all her, both of her three procedures in **my** procedure," she is engaging with the idea that putting LOVE into her procedures will also put G.RUN and B.RUN there. When they actually made the change, she wrote only LOVE in her WALK procedure indicating that she understood that G.RUN and B.RUN were subprocedures to LOVE.

Reflections on the Learning Story: Constructing Procedural Hierarchy through Collaboration and Technological Fluency through Making Projects

The task of putting all the procedures into one in *Little Shop of Horrors* began to shape Keanna's thinking about procedural hierarchy. She began to consider how to combine procedures. Keanna thought about putting all the procedures into one procedure as the way to combine the procedures that her friends created into one project that presents a sequential narrative, i.e. a movie.

From a constructionist perspective, constructing the project helped her to engage with constructing an idea that was new to her about procedures. Her discoveries and learning about procedural hierarchy were constructed out of the task of constructing this complex project with her friends. Their collaboration involved them in thinking together and getting their procedures to work together. Her engagement with the problem of combining procedures came not only from making the project but also from making a project with her friends. The value of collaboration within the school culture of Paige and at Paige as sub-culture of broader African American culture created a connection between her understanding of procedural hierarchy and the involvement of culture in her learning. The cultural meaning of collaboration in which Keanna was situated made her

way of understanding hierarchical structures of procedures culturally relevant for her.[8]

Over the course of this project Keanna and her friends developed a greater fluency in programming. The tasks of merging pages, coordinating shapes, and revising procedures became a familiar process for them. They learned more possibilities for ways to implement their ideas. Their project became more an expression of their ideas and less a struggle with the intellectual overhead of learning how to program and use the technology. When Keanna and Shamia began the *Little Shop of Horrors* project in March, it was a big task for them to write movements and shape changes into their procedure for making the Boy move across the screen. When they finished the project in August, they had developed strategies not only for programming individual animations but also for consolidating several projects into one project through merging and revising the programming.

2.3.3 1994/95 Collaborative projects continue

During the school year 1994/95, most of Keanna's project work involved developing three successively more complex collaborative projects with the other older girls in the class. It had become clear that working together was their preferred way to create Computer Class projects. Keanna's efforts to collaborate became pivotal in her understanding of computational ideas such as procedural hierarchy which she referred to as "procedures inside other procedures."

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[8] Connections between culture and learning will be pursued further in Chapters 3 and 4.

Learning Story: *The Magic Circus*

In the fall, Keanna worked with Shanay and Shamia to create *The Magic Circus*. This project was created on a pretty tight schedule with the goal of presenting the project in Washington, DC at the annual conference of the Institute for Independent Education[9] at the end of October. The girls' idea for this project emerged out of a spontaneous discussion about homeless people that had been occurring off and on in their class during the week we began to develop the first Computer Class projects of the school year. The project turned out to be an expression of the girls' vision of providing a "solution" to what they perceived as a struggle that people with little money would have.

The girls decided to create an original animated story about a homeless person but weren't sure at first what kind of story they wanted to make. Keanna eventually advocated for the story line of a circus because the separate acts made it easy for them to each create their own part of the circus that could be combined to create the whole project. They started off with a plan for creating seven acts, but eventually scaled down to four acts plus a title page and story. Keanna's pages began the magical circus. She created the title page depicting the big top of the circus, the second page with an animation of dancing horses, and a third page with a girl diving into a pool of water. Shanay created a magical act with a see-saw that threw two rabbits into the air when a 700 lbs. weight fell on it; when the rabbits touched a patch of brown in the sky, they turned into flying horse people. Shamia's act was a line of dancing girls on a pink stage.

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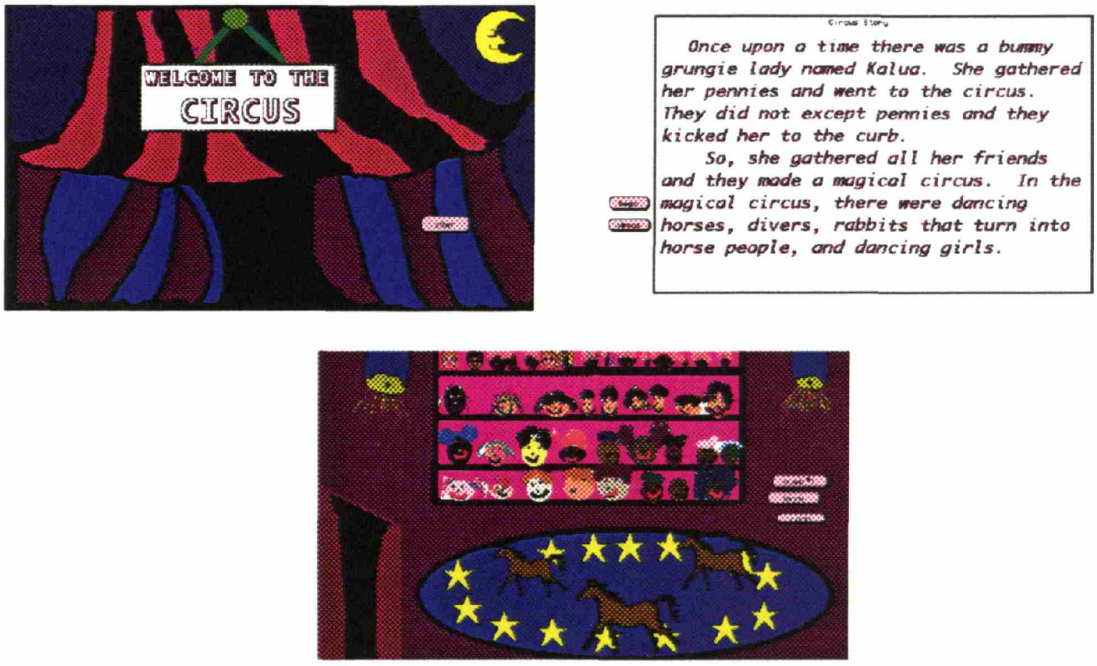
[9]The Institute for Independent Education is one of the national organizations that advocates for, and addresses, issues of independent schools focusing primarily on children of color. The institute is located in Washington DC and directed by Joan Ratteray.



Pages from the *Magic Circus*.

Keanna facilitated the group's organization of the narrative for the projects with an understanding that the circus narrative would also organize the programming. Each person could create their own part and then put it together into the whole. She led the group in planning to use the idea of procedures inside of other procedures by structuring the top-level procedure, `CIRCUS`, into a procedure that would hold subprocedures from each person for their page. When Keanna created the *Little Shop of Horrors* project, she wrote the commands for her `WALK` procedure and then added other procedures in for the other girls' pages. Keanna decided that the `CIRCUS` procedure would just hold the procedures for the actions and page changes for each girls circus act. This meant that she wrote separate procedures for the actions on her pages too, as shown:

```
to circus
page1
wait 60
page2
wait 30
launch [horse]
launch [music#1]
wait 30
page3
wait 30
launch [swim.m]
dive2
page4
wait 30
rabbitfly
horsefly
page5
goall
end
```

Even though each girl had a page that was her focus, they did a great deal of collaborative work to create each page. The night before we left for Washington, DC, the students had a sleepover at the school during which they worked for several hours on their projects. The girls worked together to help Keanna design her dancing horses page.

Reflections on the Learning Story: *The Magic Circus*

The fact that Keanna chose to use a narrative structure that would organize the work for creating the project was connected to her understanding of modularity. Making the CIRCUS procedure with subprocedures that ran each part of the project was Keanna's way of thinking

about procedures working inside of other procedures. Her use of this plan with her friends indicated that her thinking about the modular nature of programming was connected to thinking about how to create a project with three people. During this project, I recognized for the first time that Keanna had learned to think about procedural hierarchy as a way to collaborate with her friends. Her struggle to grasp this idea was authentic in its situation within their work.

Learning Story: *A Town Called Spookton*, with Shanay, Maisha and Shamia (November 1994 - February 1995)

During the winter Keanna, Shanay, Shamia, and Maisha created a huge branching story game project called *A Town Called Spookton*. They entered this project in Compufest 95 and in April when prizes were awarded, they won first place. *A Town Called Spookton* was inspired by Halloween and by Keanna's interest in clicking on the turtle to make actions happen.

Programming the turtle became a seed for an adventure game

Keanna became interested in giving turtles instructions when the class took a field trip to the Media Lab to create Lego/Logo projects for a telecommunications demo with students in New York City.[10] The screen interface for Lego/Logo included an option to choose a picture for a switch to click on to send ON or OFF commands to ports on the interface box. Keanna was very curious about this feature and when we got back to school, she

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[10] Students from Paige shared their Lego/Logo project over a video conferencing system at the NYNEX office in Cambridge with students at both a conference site in a hotel and a school site in New York. Students in New York could control Lego/Logo projects remotely through an Intenet link to the computer at the NYNEX office in Cambridge.

asked if the turtle could do "things like that." I explained to her that you could give the turtle commands in its instruction box that would run when you clicked on it. This experience was the beginning of her developing an understanding of programming turtles. The other aspect of this feature that she noticed and was interested in was creating shapes for the turtle out of pictures that are cut or copied from a picture drawn on the graphics page. In this situation, her understanding of programming turtles was linked to thinking about interface design.

The first idea she pursued using this feature was making a museum with clickable pictures. Her plan was to make clicking on the pictures take the user into a world inside the pictures that was other parts of the museum. She never became satisfied with this project because the quality of the museum pictures. She felt that she could not get the pictures drawn in the way she envisioned. She also seemed to be ambivalent about the direction she was pursuing in developing this project on her own. She became so frustrated that she stopped working on the idea of a museum project. She turned to working with her friends again and they developed the idea of making a haunted house adventure game which became *A Town Called Spookton*. This idea progressed as she and her friends began to see programming the turtle as a way to create branching throughout an adventure story. Once she began to see the idea of "putting instructions inside turtles" as a seed for a project that she and her friends were excited about, she was satisfied and committed to creating the project.

At times during the creation of this adventure game project Keanna and her friends made comments about how creating this project, which hinged on programming the turtles, was a new way of creating projects. They were

aware that Keanna brought a new way of programming which used the turtle as a clickable object. They talked about this project as different because it had very few procedures.

In their three previous projects, writing procedures was pivotal to their construction. It had become a common notion in the class that making projects meant a process of writing procedures on the flip-side for actions to happen on top of the backgrounds and using the shapes they created for the front-side (or graphics page). They were accustomed to controlling their procedures with buttons or by typing in the Command Center. So they recognized that the "action" of this adventure game was created by the interaction of the user clicking on a turtle that was an object within a scene, reading the instructions on the pages that resulted. The "action" of the game was dependent on which turtle was chosen and how the choices progressed, forward or backward, through the narrative.

Below is Keanna's description for Compufest95:

Description

Keanna

My friends and I made a projects called "A TOWN CALLED SPOOKTON". It's based on Halloween but Halloween is passed so we made it scary like Halloween. It's very fun but nothing moves but it's still fun. You see all different types of creatures some are funny and some are weird. Oh yeah, there are a lot of GAME OVER's so be aware.

It has four levels. I made the first level.

My level is about these trick or treaters going door to door but they don't move. When you click on the house you will sometimes go to game over pages but you might get lucky.

Shamia made the second level.

This level is about ghosts and goblins scary stuff.

It's about picking and making choices.

Shanay made the third level.

This level is about making choices

and picking out of scary old dusty chests.

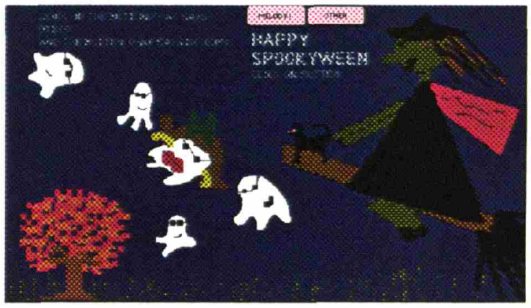
And Maisha made the last level.

This level is about finding a key and going to a very fun HALLOWEEN PARTY !!!!!!!!!!

Then we merged it together as one. At the end of the levels, it gives you a clue. The project is very special because it took four months to do it. We hope you have as much fun playing with it as we did creating it.

THANK YOU!!!!

The project was structured around trick-or-treaters who were exploring haunted houses along a street in the town called Spookton looking for a party. Keanna created the initial pages that setup the story and the street of haunted houses. Clicking on the houses took you "inside" the houses by going to pages that portray the adventures inside each house. A dark room with huge eyeballs dangling from the ceiling. A room with ghosts in the air. Many pages led to GAME OVER and only a few would develop the path to finding the party favors, the key, and the balloon that led to the party.



Keanna's pages from *A Town Called Spookton*.

The Merging Process

Each girl made five to ten pages of the project and by the end, there were over 30 pages. The process of merging and setting up all the pages in one project had become familiar to the girls in this group. This project carried another level of complexity in the merging process because of the large number of pages. There were so many pages that we quickly ran out of space during the merge.[11]

This phase of the project led the girls into thinking about the computer's memory and system management because we had to pay attention to how the program dealt with the computer's memory to run their project. We learned from Brian that it is important to stamp and then cut all the objects, such as turtles and text boxes, that didn't need to move or be clicked in the project because each object took up memory. Then, the girls had to make sure to only copy shapes for turtles that were used to perform an active function

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[11] I wasn't sure of all the steps we could take to complete the merge so I called Brian Silverman, Director of Research and Development at Logo Computer Systems Inc., at LCSI, where MicroWorlds was developed. I asked him to help us figure out strategies for how to get all of their pages into one project. Brian actually didn't know if it was possible for the software to manage so many pages but he made several suggestions about managing the computer's memory.

because there were not enough shapes in the shape editor for turtles that were just for decoration. After they trimmed down the project so that objects on the screen would use as little memory as possible, we learned that it would help to increase the amount of memory that MicroWorlds used to run as an application on the machine we were using. The girls were very proud that they made a project that was so complicated that it tested the bounds of the software. They commented that "their project was so great that the programmers couldn't even figure out what to do."

The merging of their project took on an air of importance when the problem of managing the memory came up that contributed to their focus on developing strategies for the steps they needed to take to finish the merge. They created a long chart of all the pages, turtles, and shapes they needed to coordinate for the merge. It took a long time and the work was tedious because they decided to do a lot of renaming of turtles and shapes in order to keep track of everyone's objects. They devised a classification scheme for naming each person's shapes. They counted the number of essential shapes that each person had in order to make sure they had enough empty cells in the shape editor.

page1	"t1	"t2	"t3
shapes	"house	"housee	"htgh
page2	"t4	"t5	"t6
shapes	"ghost	"door1	"door2 "door3

A section of their organizational chart

The problem of organizing and managing all the pieces of their project in order to create the whole project was very "real" for them. They complained very little given the extent of the details involved in this management. And once they devised a strategy, they asked for very little help. During this process, they asked for my help only to check the accuracy of their chart; otherwise they followed through on their own in a very determined way.

Using procedures to name buttons

There were only a few procedures that were written on the flip-side for this project. Three of the girls wrote procedures, each for a different purpose. Keanna wrote procedures that allowed her to make the buttons on the first page make more sense. She put the PAGE2 command into a procedure she called OTHER. She put the MELODY1 instruction into a procedure she called MELODY. She used the procedures OTHER and MELODY to give her buttons the labels she wanted them to show. In both these cases she used writing a procedure as a way to name the button what she wanted to name it. This use of a procedure showed her understanding that the button acts not only as a way to launch a procedure but also a way to label a process. Shamia wrote procedures on the flip-side that were actually tools to draw shapes on her pages that were squares, triangles, and stars of different sizes. Shanay needed procedures to generate the key and the balloons as well as give random selection of choices to find these items in mystery boxes.

Keanna's procedures

```
TO OTHER
PAGE2
END

TO MELODY
MELODY1
END
```

Shamia's procedures

```
TO TRI :SIZE
PD RT 30
REPEAT 3 [FD :SIZE RT
120]
END

TO  SER :SIZE
PD RT 30
REPEAT 5 [FD :SIZE RT
144]
END

TO SQ :SIZE
PD
REPEAT 4 [FD :SIZE RT
90]
END
```

Shanay's procedures

```
TO BOX
SETSH 35 WAIT 10 SETSH 33
WAIT 30 SETSH 35 PAGE20
END

TO KEY
SETSH "CHESS WAIT 20 SETSH
"KEY WAIT 30 SETSH "CHESS
END

TO BOX1
PAGE21
T2,
SETSH 14
END

TO BOX2
PAGE22
T3,
SETSH 15
END

TO CHANGE
MAKE "RAN RANDOM 3
IF :RAN = 0 [BOX]
IF :RAN = 1 [BOX1]
IF :RAN = 2 [BOX2]
END

TO CHANGE2
MAKE "RAN RANDOM 3
IF :RAN = 0 [KEY PAGE28
STOP]
IF :RAN = 1 [PAGE24]
IF :RAN = 2 [PAGE23]
END
```

Reflections on the Learning Story: *Spookton*

Keanna's idea about using the turtle in a new way as an interface for a game was the seed for the design of this project. She took the ideas of

1) putting procedures inside turtles, and 2) giving turtles shapes that were sections of background scenery, and used these ideas to make the turtle into an interface for interaction in a branching story/adventure game. Her work creating museum pictures was her early development stage of this project. She tested out the idea with several false starts in trying to get an effect that was satisfying to her. She became frustrated with the images she created. She also struggled with whether to pursue this project on her own or collaborate with her friends because her friends were not gravitating to the museum idea. Once the idea of the Halloween project began go emerge, she became settled, committed, and assertive with her work. Constructing this project used her idea as a seed that her friends were eager to join in and create.

Again, as she had in the *Little Shop of Horrors* project and *The Magic Circus* project, her work began the project, setting its narrative, mode of interaction, and atmosphere. She initiated the story line with a witch to introduce the story, the page with the trick-o-treaters, and the street of haunted houses. Her leadership in the design and programming of the projects she created with her friends was a part of her process of engaging with computational ideas.

Learning Story: *The Fairy Tale Project* - with Shanay, Maisha and Shamia (April, May, June & August 1995)

The *Fairy Tale* project began in late April of 1995 when the class began to focus on projects they would like to do until the end of the year. Between the time we turned in entries to the Compufest 95 and the middle of April, we took some time to do projects that involved the whole class in similar work.

The bulk of the class project work was a series of projects that we called the *Sentence Generation* project. This project was an effort to implement an idea that Joe felt strongly about of bringing computer project work together with work with grammar and parts of speech. We combined work with programming text manipulation and interaction with word games we created to play on and off the computer. The students went through phases of resistance and high interest in these activities. After we concluded this project, the students were eager to return to creating projects that were developed from their interests.

I originally had in mind that everyone could work towards presenting their projects at the Graduation program in June. I thought it would be nice to have a goal of sharing our projects with the broader Paige community because we had rarely done this kind of sharing. Most of the time when projects culminated in sharing outside of the classroom, they were either for the Compufest or for demo fairs at the Media Lab.[12] As the projects began to develop during May it became apparent that it would be too difficult to get all the students ready for a public presentation as well as too time consuming during the program for everyone to present. So by the end of May the plan became giving a presentation of *The Fairy Tale Project* at graduation as one of the creative presentations in which Shanay and Maisha, the graduates in 1995, were involved. Following graduation we planned an Open House at the school where all of the students could show their projects no matter what

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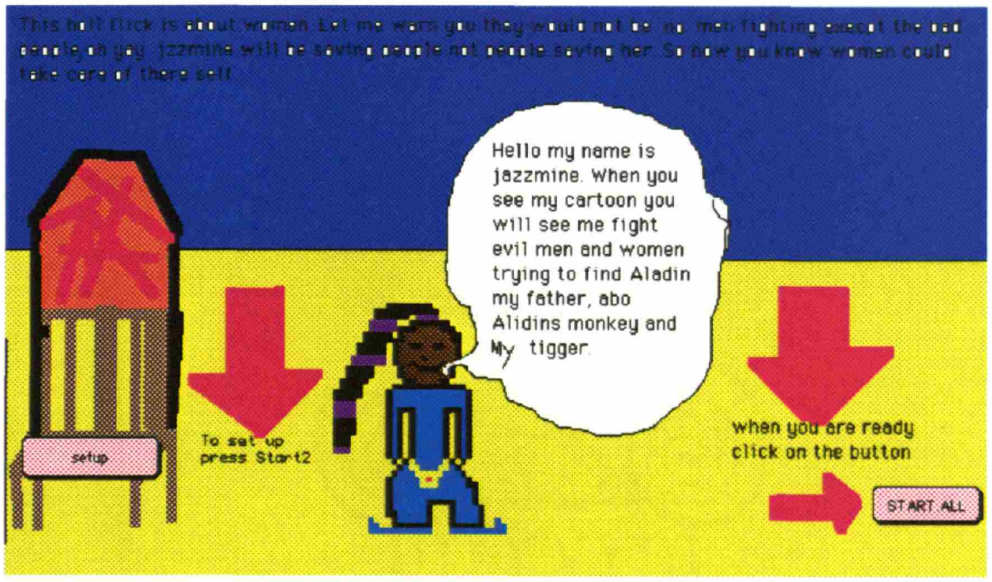
[12] Digital Expression, Digital Life, and Things that Think were Open House events where sponsors and visitors from all over the world came to see research projects at the Media Lab.

their state of completion. We prepared poster-sized printouts of students' projects so that the students were represented the Open House.

Initial design of the project

Keanna, Shamia, Shanay, and Maisha planned *The Fairy Tale* project as their new collaborative project with a great deal of enthusiasm. This project involved more complexity in programming for each girl as well as their assertive expression of cultural and gender identity. Each girl made her own version of a fairy tale that had been made into a Disney movie. The unifying theme for the project was that each of the new versions of what they called "Disney fairy tales" would have the female lead character, who is usually saved by the male protagonist, instead saving the man. The first page of Keanna's version of *Aladdin* set up this plot twist. Keanna's *Aladdin* was followed by Shamia's rendition of *Cinderella*. The third project in the whole cartoon was Shanay's version of *Snow White*. The last project in the series was Maisha's adaptation of *The Little Mermaid*.



Keanna's introduction to *The Fairy Tale* project (see next page):

"This holl flick is about women. Let me warn you they would not be no men fighting execpt the bad people, oh yay jazzmine will be saving people not people saving her. So now you know women could take care of there self."

Keanna's Aladdin

The final version of Keanna's *Aladdin* is a story told through ten pages led off by the initial page where Jasmine introduces the project. Jasmine searches through the castle for her father and Aladdin who are being held by the evil Jafar. First, she runs through the Hall of Kings. Then she searches behind a row of doors in the Hall of Queens. Here the Genie pulls her into his home and tells her to go through the General Store and the market to find her tiger. She created intricately detailed backgrounds for the store and the market. When Jasmine walks through these areas she finds her tiger, the monkey and the bird. The Genie appears to tell her where to find her father and Aladdin. On page 6, she arrives in the area of the Hall of Queens where she finds the hostages and Jafar. The animation on this page carries out the duel between Jasmine and Jafar which Jasmine wins and saves the day. Keanna continues the plot twist in a way that describes her version of "happily ever after" for Jasmine and Aladdin. She depicts an elaborate wedding between the two followed by snap shots of their honeymoon trip to Disney World. The final page is a family photo of Jasmine, Aladdin, and their three children. "The End."

The drawings on her pages were incredibly elaborate (i.e., the hardware store page). She used the drawing tool with great skill and expressiveness.

She developed a way to draw a shape, select it and copy it on the background that was similar to stamping.

Two big procedures with sections

The incredible detail of Keanna's drawings on her pages was accompanied by two rather elaborate procedures which ran her whole project. The procedure she called START ran all of the action on her pages and played the theme song she and Shamia called FIGHT. The other procedure, SETUP, is used to set the positions and shapes of the turtles on each page to their starting states. Keanna worked out the animation for each page separately and developed some of her own ways of using the text editor for editing. But she did not separate the instructions for each animation into separate procedures. She apparently delineated the code based on the commands to change pages. For instance the commands for page 4 where Jasmine finds her tiger and the walk across the room and through the door, follow the command for PAGE4. Keanna knew that she could use subprocedures for each animation but she chose not to put the instructions under separate headings. She apparently thought of her programming in this way because she was creating her own procedure and not incorporating anyone else's into hers. This is an indication that procedural hierarchy was a programming style that was connected to her collaboration with others. (See Appendix for Keanna's *Aladdin* procedures.)

Creating a new technique: using textboxes as procedure editors

When Keanna created her procedure for *Aladdin*, she used textboxes in a way that had not been modeled to her or necessarily intended by the designers of MicroWorlds. As she created her lengthy procedure for her animation, she

became frustrated with having to switch to the procedure page and read through everything in order to make her changes. One day I noticed her copying sections of her procedure into a text box. She edited the text in the text box and then copied it into the Command Center and ran each line before she made changes to the actual procedure. When I asked her why she was doing this, she said that it was easier to have everything on the front so that she could look at each part and change it better.

Keanna understood the text boxes to be objects that provided characteristics she needed to help her debugging. She had used text boxes to tell stories, print words, and create labels prior to this invented technique. She utilized the features of textboxes to create an editing tool for herself

Reflections on Learning Story: Leadership and Identity

Keanna's role in the group

It seemed by this fifth collaboration that Keanna's role in the group was to lead off the project. Her pages again both began the project and greatly influenced its structure. Her plot developed through several pages where Jasmine ran through different parts of the castle looking for Aladdin and her father, the king, in order to save them from Jafar.

Expression of cultural and gender identity along with cultural style

For an African American girl, what does it mean to rewrite a Disney movie so that the protagonist is an African American woman? Keanna and her classmates used their power in creating these projects to create the cultural representation that was most meaningful to them. The cultural context of her school as a place that explicitly supports her cultural identity

and assertive expression of all aspects of her identity nurtured her steps to create this project. She took very seriously the fact that the project should be the way that she wanted it to be. There is cultural humor in the portraits in the Hall of Queens and the Hall of Kings. Her development of the happy family ending reflects gender messages that surround her and with which she identifies. Overall, there is a message of empowerment in their theme of "women saving men, not men saving women."

2.3.4 1995/1996 Projects programming choice

During Spring and Summer of 1996, Keanna developed an interest in projects that involved people in making choices. She created three projects that pursued this theme. These projects also reflected choices that were important to her life. In *Different Keanna* she created choices of clothes to wear and choices of girls and boys of different cultural backgrounds to dress. *Fat Freddy* was a project about making healthy choices of foods to eat. *Jenny's Careers* was the final project in which I worked in an extended way with Keanna. It depicts several choices of future occupations for an African American girl named Jenny. It also utilizes video and audio to provide a multimedia presentation of Jenny as a woman at work.

These projects were also the first extensive projects in over two years that Keanna did on her own. Although she was creating her own project, rather than a joint project with her friends, she and Shamia continued a kind of collaborative thinking through sharing ideas and informing each other's thinking. When Shamia chose to make a clothes changing project, Keanna decided to make one based on the same idea. When Keanna got the idea for *Fat Freddy* as a project to choose healthy foods, Shamia developed an idea for

a game that pivoted on the idea of food choice. It wasn't until Shamia couldn't continue to work during the summer that Keanna worked independently. At that time, she was coming to the Lab with Christa and they usually worked separately without commenting nearly as much on their projects. Christa did end up working with Keanna on the Computer Programmer video for her *Jenny's Careers* Project.

In each of these projects, Keanna showed aspects of the technological fluency she had developed over the years through gaining proficiency at using software tools and programming ideas to create her projects. Through her construction of these projects we see that the nature of computational knowledge, for her, is a system of interaction between her current understandings of computational ideas, the ways in which she relates to and uses the technology, her expressions of her identity through her projects, and her incorporation of cultural experience into her work.

Creating projects is a clear and purposeful activity for her. Creating projects is something that she chooses to do, enjoys doing, and challenges herself by doing. She extends her understandings of computational ideas such as variables, the coordinate system, computational objects, and procedures through using these ideas in the creation of her projects.

Learning Story: *DIFFERENT KEANNA*: The clothes changing project (April - June 1996)

Keanna decided to make the project she called *Different Keanna* when she became interested in the Idea Project we wrote for Shamia that provided an example procedure for dressing a puppet in different clothes. Shamia had

asked us to make procedures that would help her create this kind of project from an interest she held from reviewing *Puppet Theater*[13] more than two years before. A student, who was in a course taught by Mitch Resnick at MIT, brought it to Paige for the students to critique. All the children at that time were critical of the fact that it wasn't possible to add new options of clothes for the puppets to wear. Keanna and Shamia were interested in making a version of this software where they could make the kinds of clothes they wanted to make and be able to add additional options.[14]

Keanna's version of the clothes changing project

Keanna planned her clothes changing project to consist of five pages. Four of the pages contained a different character and a set of clothes to choose from for the character to wear. The clothing was grouped in categories such as Shoes, Pants, Shirts, and Dresses. Each piece of clothing is a turtle. There is also a turtle on each part of the person's body, Leg, Eyes, Head, Foot, Body. The clothing selection is made by clicking on a piece of clothing which causes the corresponding turtle on the person's body to change into the same shape as the turtle that was clicked. The first page of this project which Keanna chose to make was a page for selecting the person the user wants to dress. She

---

[13] Puppet Theater is a simulation on the Apple IIgs designed by Mitch Resnick, Steve Ocko, and Alan Shaw and published by Sunburst. In it two puppets are on a stage and the puppets' clothes can be changed by rotating through outfits on the puppets.

[14] This is an example of several times, many of which were on visits to the Computer Museum during Spring 93, when students wanted other software they used to be more "constructionist," because they felt they should be able to add their own features, characters, or actions.

completed three of the four pages, leaving the one for the white/peach boy "Under Construction."

The programming of choice was a representation of real decisions that are made in her life such as what to wear to the mall or what to wear to school. It also represented an aspect of her view of the world and behaviors that are familiar to her. She sees that race is important to recognize in representing how someone is dressed. Her idea seemed to be, "You can't just see what they wear, you also see who they are."

Pictures from Keanna's clothes changing project.

"So people won't think I'm racist.": programming turtles to represent cultural diversity

On the first day that Berenice showed the students the *Idea Project,* Keanna said that she wanted to make her project provide the option of racially different people to dress. She asked me to show her "how to ask people which person they want to make." She said, "I'm going to let them choose a boy or a girl and they can be black or white." She changed the shape of the turtle named "t1"into a square shape of a light skin color and created a "t2" turtle giving it a a dark skin color square. She labeled the squares "White Person" or "Brown Person" respectively. Her plan was to select the person's race by clicking on one of the colors. Next, she said that she wanted to use "one of those boxes so that people could choose Boy or Girl." Keanna was asking for a reminder of how to use the QUESTION and ANSWER commands to setup dialogue boxes. Once I reminded her of how these commands work, she programmed the turtles so that after clicking on a skin color square, a dialogue box appeared asking the user to type either Girl or Boy. She wrote the procedures CHECK, CHECK1, CH1, and CH to check the answers that were typed and go to the page for the selected person.

The t1 turtle labeled "White Person" held the following instructions:	The t2 turtle labeled "Black Person" held the following instructions:
QUESTION [DO YOU WANT A GIRL OR BOY?] CHECK CHECK1	QUESTION [DO YOU WANT GIRL OR BOY?] CH CH1

```
TO CHECK
IF ANSWER = "GIRL [PAGE3]
END

TO CHECK1
IF ANSWER = "BOY [PAGE2]
END

TO CH1
IF ANSWER = "BOY [PAGE5]
END

TO CH
IF ANSWER = "GIRL [PAGE4]
END
```

Several weeks into work on the project, she became adamant about not using choices of Black and White because she observed that people are not just Black and White. She asked, "What about people who speak Spanish? They have light skin but they are not white. What about white people who get tanned? They have brown skin but they are not black." Keanna decided to change her labels of "White" and "Brown" to "Peach" and "Brown" in order to convey a sense of including everyone with this representation of skin color. Keanna said this change was important "So people wouldn't think I was racist."

For Keanna, choices of culturally diverse girls and boys was important because of how people might see her. She understood her representation of people in her project as also a representation of her views of the world. She was very concerned that this project express her value of cultural diversity.

She used programming turtles and dialogue boxes as ways to represent her views.

Keanna chose a way of programming choices that made sense to her

- (fieldnotes from May 1996)

Last Friday we discussed two ways of making the clothes change that Berenice and I wrote to help Shamia and Keanna with their projects. Keanna thought that Berenice's program (see CHOOSE below) was "easier" to change because just one line would need to be added in order to add a piece of clothing. The sample procedures I wrote (see `version2.easier` below) created changes with a different procedure inside of the turtle for each piece of clothing. This set of procedures was my interpretation of the easier way that Seymour had suggested. I thought it would be easier because it avoided the process of keeping track of the turtle that was clicked on.

```
; Choose lets you select an item
to choose
if (who = "jeansturtle)  [leg, setsh "jeansshape st]
if (who = "glassesturtle)  [eyes, setsh "glassesshape st]
if (who = "shortturtle)  [leg, setsh "shortshape st]
if (who = "hatturtle)  [head, setsh "hatshape st]
if (who = "pantsturtle)  [leg, setsh "pantsshape st]
if (who = "shirtturtle)  [body, setsh "shirtshape st]
if (who = "suitturtle)  [body, setsh "suitshape st]
if (who = "sweaterturtle)  [body, setsh "sweatershape st]
if (who = "shoesturtle)  [foot, setsh "shoesshape st]
if (who = "sandalturtle)  [foot, setsh "sandalshape st]
if (who = "noshoesturtle)  [foot, setsh "noshoesshape st]
```

```
if (who = "capturtle)  [head, setsh "capshape st]
if (who = "nohatturtle)  [head, setsh "nohatshape st]
if (who = "sunglassesturtle)  [eyes, setsh "sunglassesshape st]
if (who = "noglassesturtle)  [eyes, setsh "noglassesshape st]

; Restart over
if (who = "redo)  [start]

; QUIT
if (who = "quit)  [stopall]
choose
end

;version 2.easier
to shirt1
shirtturtle,  setpos [-199 -86] setsize 76
end

to back.shirt1
shirtturtle,  setpos [90 140] setsize 40
end

to shirt2
sweaterturtle,  setpos [-199 -86] setsize 76
end


to back.shirt2
sweaterturtle,  setpos [168 142] setsize 40
end

to shirt3
suitturtle,  setpos [-199 -90] setsize 76
end
```

```
to back.shirt3
suitturtle,  setpos [244 142] setsize 40
end
```

The girls had already had one day of working with the PUPPET project that used the CHOOSE procedure before I showed them the version I thought was easier. Keanna was not bothered by the WHO command and its function in the following conditional statement, keeping track of the value of the turtle that was clicked and setting the shape on the character's body based on what was clicked.

```
IF (WHO = "JEANSTURTLE)  [LEG, SETSH "JEANSHAPE SETPOS
[- 209 -90 ST]]
```

Keanna's comments indicated that she had begun to think about the conditional statements that formed each line of the procedure in the following way: "It is the way to click on the jeans and make the legs on the boy change to wear jeans."

I asked Keanna to think about the ways that both of these strategies work and make her own choice about which one to use for her project. She considered using the separate smaller procedures of version2. easier to make the change, but she had become comfortable with thinking about each line in the CHOOSE procedure as described above, and she chose to continue to use the CHOOSE procedure as her model. Keanna thought about the CHOOSE as made up of statements such as the one above for each piece of clothing. This way of thinking made it easy for her to envision adding one line for each

additional piece of clothing. Or, changing each line in similar ways when a problem with all the clothing surfaced such as adjusting their "fit".

Keanna's first use of the CHOOSE procedure was to use it to make the page where an African American girl can be dressed. When Keanna drew her own shirts, pants, shoes, and dresses and ran the procedure, she encountered a problem of the clothes not showing up in positions on top of the girl's body. She added SETPOS commands to the statements to create meticulous adjustments for the turtle's position to make the clothes, as she described, "fit" the girl.

```
to choose
if (who = "jeansturtle)  [leg, setsh "jeansshape st setpos [-203 -129]]
if (who = "glassesturtle)  [eyes, setsh "glassesshape st]
if (who = "shortturtle)  [leg, setsh "shortshape st]
if (who = "hatturtle)  [head, setsh "hatshape st]
if (who = "pantsturtle)  [leg, setsh "pantsshape st Setpos  [-202 -123]]
if (who = "shirtturtle)  [body, setsh "shirtshape st setpos [-201 -78]]
if (who = "suitturtle)  [body, setsh "suitshape st setpos [-200 -78]]
if (who = "sweaterturtle)  [body, setsh "sweatershape st setpos
[-200 -78]]
if (who = "shoesturtle)  [foot, setsh "shoesshape st setpos [-207 -124]]
if (who = "sandalturtle)  [foot, setsh "sandalshape st setpos
[-205 -109]]
if (who = "noshoesturtle)  [foot, setsh "noshoesshape Ht]
if (who = "capturtle)  [head, setsh "capshape st]
if (who = "nohatturtle)  [head, setsh "nohatshape ht]
if (who = "sunglassesturtle)  [eyes, setsh "sunglassesshape st]
if (who = "noglassesturtle)  [eyes, setsh "noglassesshape st]

; Restart over
if (who = "redo)  [start]
```

```
; QUIT
if (who = "quit)  [stopall]
choose
end
```

She used an understanding of the coordinate system as vertical and horizontal positions of the turtle. She also saw a relationship between the details of drawing her clothes and the fine tuning she had to do with the numbers. Later, when she created *Jenny's Careers* it became important to her to create a technique that allowed her to make the clothes fit the girl exactly without using SETPOS.

When it came time to make the procedure for the "brown boy's page," Keanna used the CHOOSE procedure as her model but changed the naming of the values for the shapes and turtles. She chose to name the turtles and the shapes in a way that I thought was more abstract, by using the same names for the shapes of the clothes and the turtles for the clothes. She considered it to be it easier to keep the same names even though turtles and shapes and different objects.

```
to happy
if (who = "dress1)  [body, setsh "dress1 st setpos [-211 -102]]
if (who = "dress2)  [body, setsh "dress2 st setpos [-210 -131]]
if (who = "dress3)  [body, setsh "dress3 st setpos [-190 -103]]
if (who = "pants1)  [leg, setsh "pants1 st setpos [-200 -119]]
if (who = "pants3)  [leg, setsh "pants3 st setpos [-211 -131]]
if (who = "pants2)  [leg, setsh "pants2 st setpos [-194 -119]]
if (who = "shirt1)  [upperbody, setsh "shirt1 st setpos [-219 -90]]
if (who = "shirt2)  [upperbody, setsh "shirt2 st setpos [-212 -84]]
if (who = "shirt3)  [upperbody, setsh "shirt3 st setpos [-219 -90]]
```

```
if (who = "shoes2)  [foot, setsh "shoes2 st setpos [-215 -142]]
if (who = "shoes1)  [ foot, setsh "shoes1 st setpos [-209 -131]]
if (who = "shoes3)  [foot, setsh "shoes3 st setpos [-213 -154]]
; if pick turtle [turtle2, change]
; Restart over
if (who = "redo)  [start]

; QUIT
if (who = "quit)  [stopall]
happy
end
```

For Keanna, the functions of "dress1 as the name of a turtle and "dress1 as the name of the dress shape for that turtle were not so different. The different objects were working together to accomplish the same task and she focused more on the relationship of their tasks for the turtle name and shape name. Her renaming of the names of the turtles and shapes was her choice to express their similar function rather than their difference as objects. She understood the names of the turtles and the shapes to be similar in a way that they should have the same rather than different names.

When we discussed the idea of naming the variables she chose to use her own rationale and strategy for naming which also gave her a sense of ownership of her procedure. She was aware that making this change to the procedure made it more her own and less using a tool that we gave her. When a visitor who Keanna knew was very knowledgeable about Logo asked her how she made her procedures, she pointed out the HAPPY procedure and said, "I copied the procedure and made my own."

Learning about naming variables helped her to make the pages she wanted to make in her clothes changing project. She made a decision to write the procedures with what seemed to me to be a more abstract way of naming variables in *Different Keanna.* But the nature of the abstraction of the programming was not what was most important to her. She wanted to think about a way to create new variables that she thought was "easy" to use to make her project do what she wanted it to do.

Keanna's intuitive understanding of a need for generalizing a procedure with data abstraction

- (fieldnotes May 11, 1996)

Yesterday, (5/10/96) Keanna spent a lot of time drawing shapes for clothes for her black boy puppet. She wants a page with appropriate clothing for each of four different people: a white boy and a white girl, a black boy and a black girl. She asked for an "easier way to make the different pages with different sets of clothes work." She wondered if it were possible to make one procedure that could work with the clothes on each of the four pages.

Keanna's questions seemed to be a part of realizing that what she wants to do is a little more complicated than just adding new clothes options. She realized that she could write a new "CHOOSE" procedure for each page by copying the procedure and modifying the new turtle names and shape names for each new piece of clothing. She had already used this strategy to rewrite the model to create the procedure HAPPY for the second page. She anticipated that continuing this strategy for two more pages would require more typing than she wanted to do, and take up more time than she wanted to spend. She said, " I want to do the same thing I did with him but be a girl on a different page. I want to pick the stuff to go on the girl the same." She seems to be asking for the CHOOSE procedure to become more generalizable so that values for the turtle shapes on each page can be input to one procedure and the procedure doesn't have to be written four times.

Is Keanna asking in an informal way for another level of abstraction that will manage the process of choosing clothes? Her question shows her thinking (at least intuitively because she knows it is possible) about generalizing the CHOOSE procedures by adding variables that will take values of the clothes that are appropriate to the character that is being dressed.

This is a situation where Keanna's need to represent cultural diversity and inclusion in her project led her to theorize about a new programming idea. Her desire for several pages created the problem of how to program the selection process on each page. She asked if there was a way to use "the same procedure for each of her pages." She asked this question when it became very important to her to create four different characters and sets of choices for clothes to dress the characters. I was excited that she saw the possibility of using one procedure that could process the data for each page.

I couldn't figure out a way to help her write the generalized procedure and help her understand it that wouldn't distract the flow of her independence in her work. I felt it was important for her to keep feeling her own flow in doing the work and in ownership of the work. I told her that it is possible to make one procedure that would work for all of the pages but that it would probably be easier for her to keep moving forward by continuing her strategy of writing a separate procedure managed the choices on each page.

Her thoughts about the possibility of a procedure that could change the clothes on each of her pages reflect that she had an intuitive sense about making the procedure an "abstraction" that she could reuse. The context for this question was her commitment to what she described as being "not racist" by having pages with four different characters. This new idea about

procedures was specifically connected to the message she wanted her project to convey.

A technique for tiling the floor and technological fluency

There were several instances in which Keanna created her own technique of using tools within MicroWorlds to create pieces of her project and where her invention of these new techniques reflected her understanding of computational ideas. Tiling the floor in the *Different Keanna* project was one of these instances.

Keanna created the background for the page to select clothes for an African American girl with some definite decorating ideas in mind. She labeled the page with a sign saying "Welcome to Macy's" because she wanted the page to invoke the scenario of dressing the girl to go shopping at the mall. She also created an array of square designs across the bottom of the screen to give the effect of the girl standing on a tiled floor.

She was very deliberate in the way she created the tiles for the floor and added them to the background. First she drew a design for the initial tile in a blank shape. She used the drawing tool to create a rectangular shaped tile design made of purple and green concentric rectangles with an asymmetrical design of colors in the middle of the rectangles. Then she stamped the shape four times to make a row of tiles. Next she copied the row of tiles and pasted it thirteen times across the page in order to cover the bottom half of the screen, creating the picture of the tiled floor. Once Keanna had the floor done, she erased the shape of the rectangle she originally used.

Keanna's use of the shape editor to create her tile shows that she understood the shape editor to be a flexible tool which she could use to invent techniques for creating pieces of the background graphics and not just a tool for drawing turtle shapes. She understood that she could create a picture on the page and then copy it using the selection tool so that any part of the background could be selected, copied, and pasted. She used these features of the drawing tool to build the part-to-whole relationship that she needed to create the design. There seems to be a conceptual relationship between her use of one rectangular tile to build the whole floor and her awareness in creating collaborative projects with her friends that a superprocedure that runs their whole animation has to contain separate procedures that each person has made. In a sense, she used the rectangular tile shape as a subprocedure to build the rows and the rows as a subprocedure to build the whole floor.

When she erased the original tile she made, she was trying to get rid of shapes that were unnecessary so that blank shapes could be available for creating more clothes. She considered the rectangular tile shape expendable because she had used it as the tool to make the floor; once the floor was done, the tool was no longer needed. She also felt confident that she could generate the shape and use it as a tool again if necessary. She modeled this process in explaining how she made the floor to Brian S.

B: *How did you make this background?*

K: *I went like this... {Brings up a shapes window} Then I went to colors, I went to the dark colors. Then I went like that, {Draws a square} and I went like that, {draws another square} and then I went to different colors. And I just got lighter and lighter and lighter.*

B: *But how did you get all those copies up there?*

K: *Then I made a turtle... and then I, then I stamped it, and made a long row. OK, I made long row. And then I... went this way, and then I did Control C. And then I went like that, you know.*

B: *Yeah.*

K: *Then I put them together.*

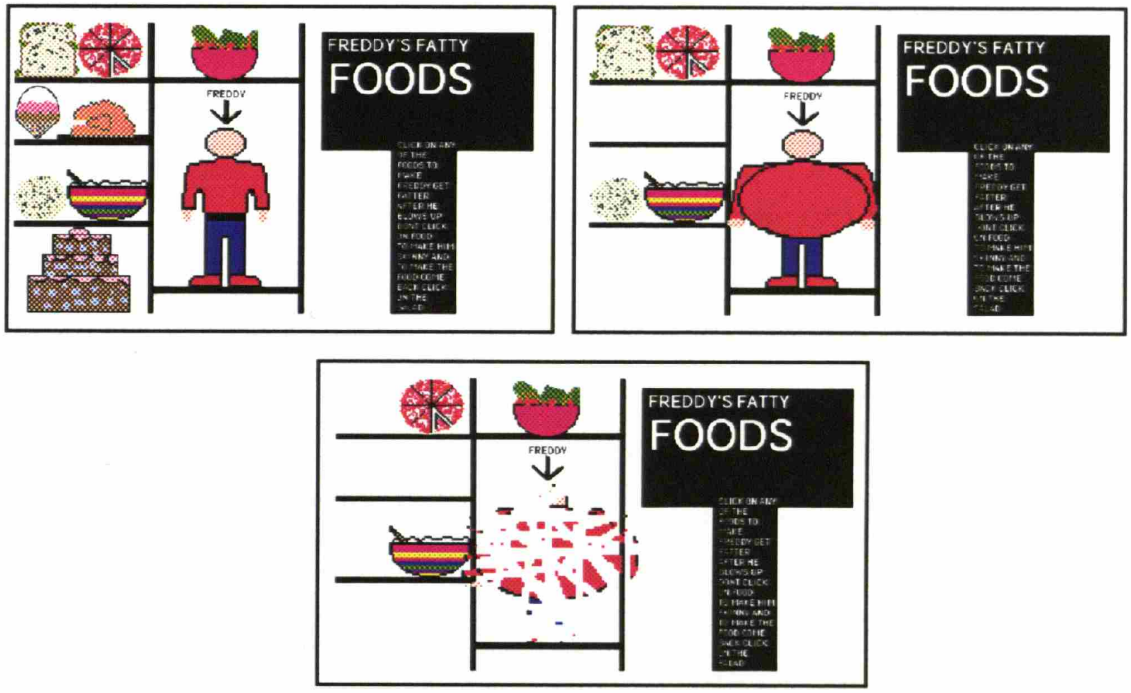
B: *And then you got whole groups of things.*

K: *Yeah. But, I'm not going to do that right now. OK.*

Learning Story: *Fat Freddy* (July 1996)

The *Fat Freddy* project was the first project that Keanna created when she came to the Media Lab in the summer. We weren't sure how many times the girls would be able to come and work during the summer so I asked them to try to come up with a project they could accomplish in a few days. Keanna took this goal seriously and was able to organize and design her ideas for *Fat Freddy* so that it was a reasonable goal to finish her project in a few days.

Keanna's plan for this project continued the theme of "making choices" because she enjoyed making choices in the clothes changing project. She said that another making choices project would be "fun." The *Fat Freddy* project involves clicking on choices of seven "not healthy" foods. Each click makes the character Freddy get larger until he pops.



Pictures from *Fat Freddy* project.

She and Shamia both began similar projects on the same day and their projects revealed concerns about themselves along with some new ideas about programming. Keanna came up with the idea for this project from seeing the movie *The Nutty Professor*. Keanna had gone with Shamia's family to see *The Nutty Professor* the previous weekend. Keanna pointed out that in the movie, all of the nice characters that Eddie Murphy played were 3 - 400 lbs. Keanna said that the movie "was not about him *becoming* that big because he was already that big ." But the large sizes of his characters started her and Shamia's thinking about "*becoming* that big".

Concerns of 10 and 11 year old girls

The concern about becoming fat was becoming more a part of their discussions in a way that was characteristic of older girls who are entering adolescence. They were concerned about what makes people gain weight and

how they make those decisions for themselves A lot of their discussion in the beginning of this project about nutrition was framed by making decisions about which foods to depict as the foods that make the characters in their projects get fatter. Keanna chose to make shapes for pizza, a big turkey, cookies, cake, ice cream, a bowl of mashed potatoes, and a "not healthy sandwich" as the "not healthy" foods.

Keanna created a bowl of salad that when clicked on, made Fat Freddy return to normal size. She originally planned to have a picture of the man lifting weights as the way to make him become normal size again. But, she couldn't get the picture drawn in a way that she liked. Her dissatisfaction resulted in her drawing the picture of the salad in the bright colored bowl as the shape for the turtle that would reset the man's size using the SETUP procedure. This is an example of an experience that Keanna began to have more often during the late Spring and Summer where she became frustrated and rethought an idea because she couldn't get her picture created in a way that felt satisfying to her.

```
to setup
everyone [st]
t1,
setsh 13
end
```

Programming the effect of growing: drawing on a previous idea

She worked with an awareness of what aspects of the programming she could do on her own and which parts of the project she would have to learn

how to do. On her own, she created all the graphical pieces of the project i.e. the graphics for the set up of the screen, the shapes for the foods, and the six shapes for Freddy from "skinny" to "popped." Then she asked Isaac and me to watch as she modeled the changes of Freddy growing that she said she wanted to happen "automatically." She successively clicked on the shapes of him in different states of "fatness" in the Shapes Page and in turn clicked on the turtle to change his shape to each one. She wanted us to help her figure out a procedure to have the man do what she modeled "get bigger automatically each time you click on a fatty food." Her understanding of "automatically" was apparently that the procedure would perform the process that she modeled.

She recognized and commented that the procedure she needed would be similar to the procedure for the growing flower in*Wacky World* because it also made size change automatically (refer to the *Wacky World* story in section 2.3.2). She remembered the idea of making turtles grow which she used in the *Wacky World* project three years earlier although she didn't remember the specific statement that was used. She made a connection between that earlier process to make a flower grow and the "growing" she was currently trying to program to make Freddy grow. She wanted us to provide the specifics for her idea and help her to make it work.

We talked about the fact that the flower in the earlier project got larger by increasing the size of the turtle with `setsize size + 1.` The process she wanted for Freddy was a different idea because she planned to make him increase size by changing the shape of the turtle. But she understood the processes to be similar because each statement made size change automatically. We described to her that each of her shapes had to have

numbers that were in order. We discussed how the shape could then increase by 1 for the turtle shaped as Freddy, similar to how the size had been increased by 1 for the turtle shaped as a flower. The resulting statement for the effect she wanted was `setsh shape + 1`. Once this statement was written, she understood how it provided the effect she wanted of changing the shape "automatically."

Programming the selection: wanting a new strategy that she knew must possible because it was simpler than her previous process

Keanna continued her interest in creating projects that gave people choices as well as her thinking about how to program the process of making selections. Once she had the process of making her Freddy turtle grow, she asked for an alternative way of programming the selection of choices than she had in *Different Keanna*. She said she wanted an easier way to make select changes than "writing the whole procedure with the 'who' and everything." She wanted to have the result of clicking on one of the food turtles to be the direct increase of Freddy's size rather than a process of checking and then causing the change.

Her independence with programming the selection process once she had the statement for the growth, seemed connected to her recognition that this project was simpler because she wanted clicking on each turtle to cause the same effect. Whereas in *Different Keanna*, the process required different responses to clicking on each turtle. All the fatty foods made Freddy get fatter. She took the `setsh shape + 1` and wrote the big-small procedure. Then she wrote the name of this procedure in the instruction box for each of the turtles

shaped as foods. She understood that clicking on any one of these turtles would cause `t1`, (the Fat Freddy turtle) to increase size. This solution accomplished her goal of a simpler way to program the selection process. It was also a simplification of the problem of causing different effects based on which turtle was selected.

```
to big-small
t1,
setsh shape + 1
end
```

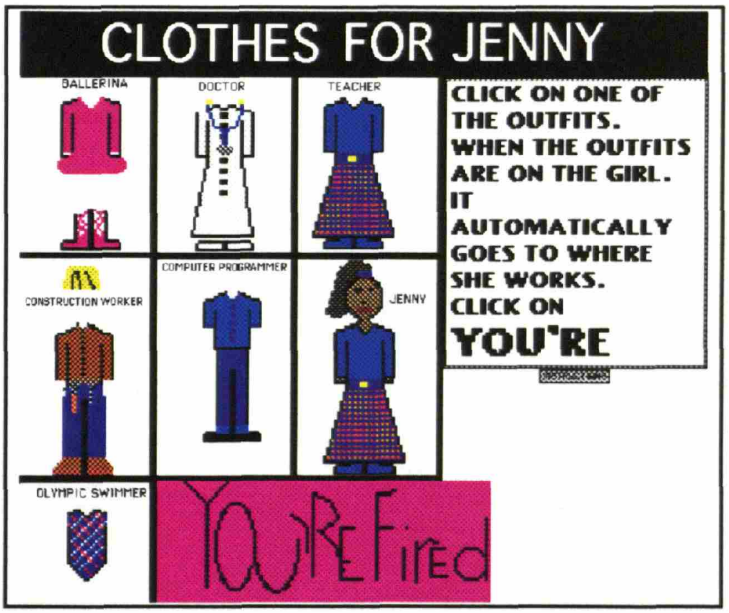
Learning Story: *Jenny's Careers* (July & August 1996, and occasionally in 1997)

- (memo #10 on Keanna and Christa 7/10/96)

> Keanna/Keanna was in a pretty good mood yesterday. I wonder if having her birthday helped a lot. She had thought about what she wanted to make for her next project. Of course her best explanation of it was when she first told me about it as we rode in the car over to pick up Christa from her day camp at the Timulty School.
>
> She wants to make a project with a woman who can have different "occupations" (a word that she asked me for). Her description was something like, "When you select clothes for her to wear for her different jobs, she goes to a page that has a background for the place where she works." K. seems to be thinking about the idea that choosing different clothes can also be extended to choosing different scenes.

Jenny's Careers is a project that allows the user to choose occupations for Jenny, an African American girl who is depicted as a women at work. In this project, the user can choose one of six careers for Jenny: a construction worker, an Olympic swimmer, a newsreporter, a doctor, a teacher, or a computer programmer. Keanna's construction of this project reflected her work on some of her own identity issues. Her identification with the character she created for this project, Jenny, conveys the message that she sees

herself as growing into an accomplished African American woman who has many choices of occupations available to her.



First page from *Jenny's Careers.*

Designing clothes for work and making them fit

Keanna began making this project by meticulously drawing the outfits that Jenny would wear for each occupation. She was concerned about making her clothing look realistic and appropriate for the job. She asked questions like, "What color is the stethoscope that a doctor wears? What color shirt is good for a construction worker? How should I make the construction worker wear her hair? What do computer programmers wear to work?"

Keanna developed a technique for drawing the clothes so that they would fit on her character without having to set the position of the turtle that put the shapes of the clothes on the girl. Adjusting the position of the clothes to

fit the character had been a tedious process for her in making *Different Keanna*. Initially, she drew the shape of Jenny from scratch and not by modifying a preexisting shape. She then set up the shape of each new outfit by copying Jenny's shape into a blank shape. She drew most of the clothes by drawing on top of the shape of Jenny so that shape of the body became a template for the clothes. Her techniques assured that each outfit would be in proper placement with Jenny's head and feet. She was proud of achieving her goal of creating clothes that she knew would fit on the girl's body.

In creating clothes for this project she expressed a working knowledge of the space of the shape editor and how to maneuver in it. For instance, when she made the Teacher outfit, she decided it would be similar to the Programmer except for the teacher would be wearing a skirt. So, she copied the programmer shape and modified the pants into a skirt before changing the design and colors. In modifying the pants, she used lines in the shape editor as measuring tools to create the length of the dress. Her use of the lines as measuring tools expressed her thinking about the relationship between the arrangement of pixels in the shape editor and sizes of shapes she created and edited.

This technique also allowed her to easily make the picture of Jenny at work on the construction worker, teacher, and swimmer pages where she used her own drawings of Jenny. She could copy the whole shape of Jenny dressed for these occupations and copy them onto the pages. This technique did not generalize well to creating the ballerina because she wanted to show the ballerina in motion. Keanna became very frustrated with drawing shapes of the ballerina's body in different positions so that switching the shapes would show realistic motion. It is very difficult to create realistic movements

using the 2d, low resolution of the MicroWorlds shape editor. Usually Keanna would adjust to the constraints of the representation but realism was incredibly important to her in this situation. She eventually became so frustrated that she decided to erase the ballerina and change the occupation to newsreporter.

Interface design

Once the clothes were done, she set up the interface for the project on the first page by dividing the screen into sections: one section for the clothes for each occupation, a section for Jenny, a section for instructions for how to operate the project, and a reset button labeled "I QUIT." Her plan was to make the clothes function as an interface to automatically go to a page that showed Jenny doing a job. For instance, clicking on the swimsuit would dress Jenny in the suit and go to the page where Jenny was shown as an Olympic swimmer. In the final version of *Jenny's Careers*, clicking on the swimmer goes to the "swimmer" page, plays the video clip from the Atlanta Olympics and returns to the starting page.

As she set up the interface, Keanna also created a new blank page for depicting each job. Once Keanna had the pages for the jobs set up, she began to create the depiction of Jenny doing the job on each page.

Building on previous ideas for programming choice to program the interface

The ease with which she set up the interface for clicking on turtles shaped as clothes to change to different pages reflected that she understood programming the turtle as a feature in her repertoire of materials for creating projects. Similar to thinking about creating *Fat Freddy*, Keanna said that she

wanted an easier way to make the clothes change than "writing the whole procedure with the 'who' and everything." Her plan to program the turtles was her own way to select from the choices of occupations for Jenny that didn't require the checking procedure, CHOOSE, that was used to choose clothing in *Different Keanna.*. The function of the CHOOSE procedure was to select clothing based on the results of a conditional which used the state of the current turtle reported by the instruction WHO (refer to*Different Keanna* Learning Story).

In *Jenny's Careers,* her idea was to write instructions inside in each turtle that initiated a sequence of processes: 1) changed the outfit Jenny wore, 2) changed to the page depicting Jenny doing the job, 3) ran the procedure to play the video or perform the action, and 4) returned to the original page. She wrote these instructions in different ways. She understood that different parts of the actions for "automatically going to where Jenny works" could be written as procedures. In most cases she started off writing the instructions in the turtle and then abstracted them into procedures. For example, the turtle for the Computer Programmer, t6, held the following instructions which call the PRO procedure:

```
T8, ST SETSH 60 WAIT 30 PAGE6 PRO
```

```
to PRO
RESETQUICKTIME "C-PRO.MOV C-PRO.MOV PAGE1
end
```

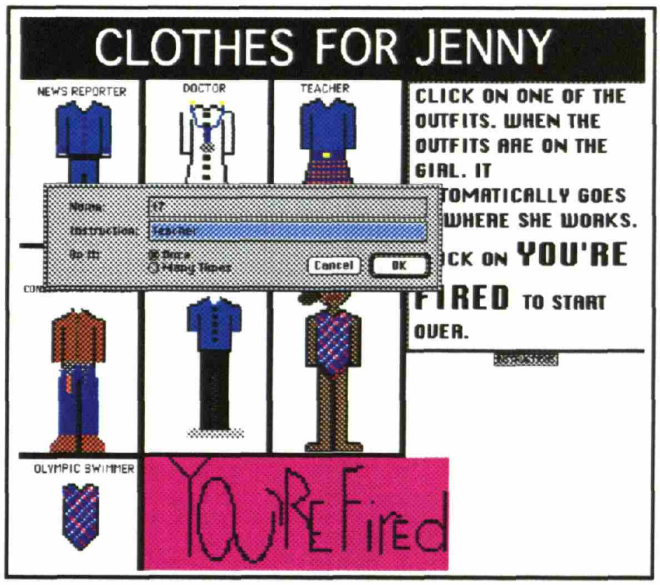
The instruction inside t7, for the Teacher held just the procedure, TEACHER. The procedure TEACHER held all of the instructions for the changes:

```
to teacher
T8, ST SETSH 59 WAIT 10 PAGE3 movie start wait 240 page1
end
```

The instruction inside t2, the turtle for the Doctor, held the following instruction which accomplishes all of the steps in the process of presenting Jenny at work.

```
T8, ST SETSH 44 WAIT 30 PAGE4 resetquicktime "ERMovie ERMovie page1
```

She knew that there were a variety of solutions to her problem. Keanna understood that it was much easier to program the turtle to make the changes than to write a procedure which checked to see which turtle was clicked and ran instructions based on the result of a conditional, as she did in *Different Keanna*.



Procedure inside one of the turtles displayed in a dialogue box.

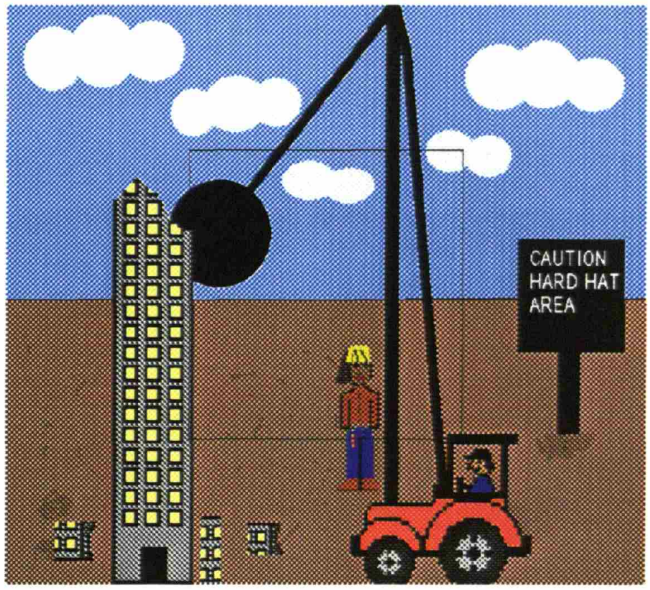
Her new design of the programming accomplished two aspects of the problem she wanted to solve in May: to make one procedure that could make the choices on each of her pages for dressing different characters and make it easier to add more choices. In this case the strategy she devised of programming the turtles to change the clothes and go to the page showing the work made it easy for her to add more occupations. With this strategy in mind, she added options until she had five jobs, doctor, teacher, construction worker, Olympic swimmer, ballerina (which later became a newsreporter), and computer programmer.

Constructing her own identity through creating possible futures for "Jenny"

As Keanna finished drawing the clothes, we began to talk about different ways she could show Jenny doing her job. I had mentioned to her that her project seemed to be a good one for using video and I told her that she could learn how to add video if she wanted to try it. Keanna was excited about

using video clips. We discussed different places we might find video clips such as videos from a store or library, videos recorded from TV, videos we could record with the HI-8 camera, or searching and downloading from the Web. Then her plans emerged. We proceeded to search for video she could use. She wanted to use video for all of the jobs but the search became difficult when we tried to stick to her main criteria. It was important to her that the video depict an African American woman doing the job. It was a difficult quest to find representations of African American women in each occupation. As a result, through compromise and innovation, she was able to create a depiction of Jenny at work in each occupation with which when felt satisfied.

Keanna knew that she could use MicroWorlds graphics and animation to create pictures of Jenny at work. But she only wanted to do this as a last resort. With all of the sources we could search, we knew that it was probably possible to eventually find images of African American women but it felt like the search could go on for a long time before we were totally successful and Keanna wanted to keep her project moving forward. Images of African American construction workers and swimmers seemed like they would be the hardest to find. We spent a little while searching the Web and consulting video stores but to no avail. The construction worker image was the greatest compromise because it ended up being a picture of Jenny at a construction site to which we recorded sound of Jenny controlling the drop of a wrecking ball.



Keanna's construction worker page from *Jenny's Careers*.

Keanna started out wanting to draw the background of the Teacher page as a classroom and have the video clip be an example of what Jenny was teaching. She initiated the page by drawing a classroom similar to her own at Paige with lots of desks and tables around the room, decorations on the walls, and students moving around. She decided pretty quickly that this scene was too hard to draw. She erased this idea and decided to draw what she called a "college classroom" because it would be easier to draw. Keanna envisioned a college classroom as large room with chairs in rows and columns and the teacher standing in front of the room teaching on a raised area like a stage. Since modifying the classroom to fit what she could draw comfortably meant not only that she drew a college classroom, but Jenny became a college teacher, a professor. Keanna wanted to know about the African American women professors at MIT and what their classrooms are like. I told Keanna that there were only three African American women professors at MIT but

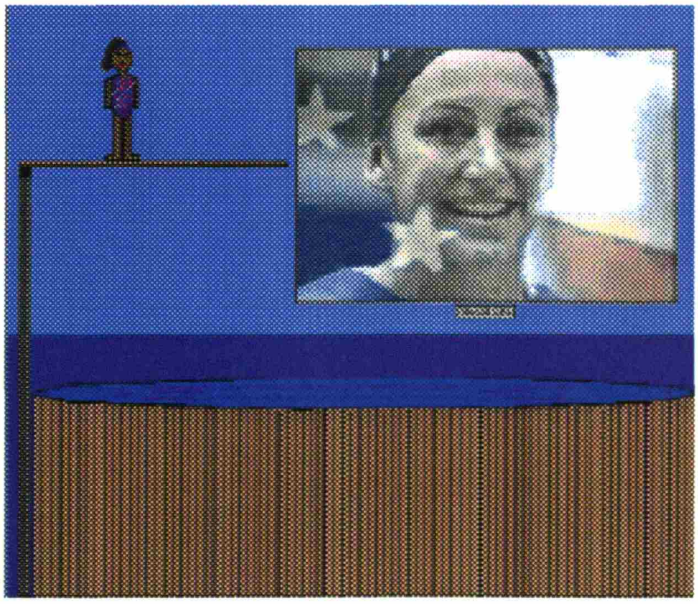
that I knew two of them and would be glad to call and find out if one of them could talk to her about the classrooms where she teaches. I called Professor Paula Hammond in the chemical engineering department and she was glad to talk with Keanna about the classrooms where she teaches. Keanna was able to learn that many classes are taught in labs that are in some ways similar to her classroom at Paige. She did get confirmation that some classes are taught in lecture halls that are very much like the picture she drew. She felt satisfied with the plan for her page when she her ideas were validated by an African American woman professor.

She asked me to find a video of animals that she could use as the video her professor was showing in class that day. I brought in a National Geographic video which had a large collection of clips about birds. Selecting this video raised issues about keeping the video clip short because digitizing the video would take up a lot of memory on the computer and make it difficult to run on some machines. But the clip needed to be long enough to convey the idea she wanted. Keanna chose a clip showing humming birds that she felt was short and interesting.

Another issue that looking for videos raised was time. It takes a lot of time to look through a video and find a good clip. It also takes a lot of time to digitize and edit a video clip, particularly for the first time. I didn't want Keanna to get bogged down in watching the video so that she kept a sense of progress with her project. Yet she needed to see enough of the video to make her own choices. With the National Geographic video, I previewed the video enough to have a sense of how the video was organized. I described the sections to her and she was able to focus in on the hummingbird video segment pretty quickly. Once she chose the clip and timed it, we talked about

the digitizing process but she chose to let Isaac use the digitizing software and create the clip for her.

We found the Olympic Swimmer page on the Atlanta Olympics website. The clip was short so that it didn't need to be edited. It didn't take up a lot of memory. We discussed the fact that these characteristics made it easier to add to the project. Keanna liked the montage of several different swimmers that it presented. However, none of the swimmers were people of color. Keanna knew that there had been a woman in the swimming events of African descent from a Caribbean nation. This seemed to make her feel more satisfied with using the video. She created a background with Jenny standing on a diving board to provide the accurate picture of Jenny.



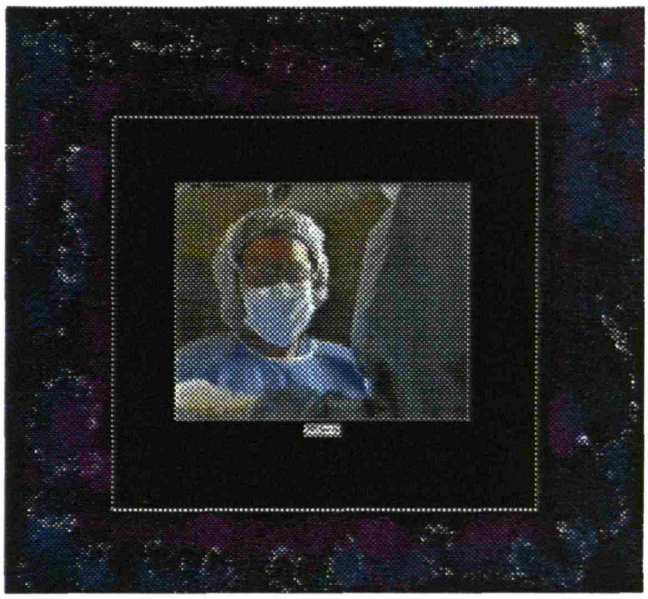
Keanna's swimmer page from *Jenny's Careers*.

Videos as computational objects and personal expressions

Keanna knew exactly what she wanted to show on the "doctor" page. She asked me to find an episode of *ER* where "the black woman doctor is working

on someone in the emergency room and then taking them up to surgery." Her goal conveyed the message that she wanted to portray Jenny as a strong African American woman doctor who was working hard and in charge. Luckily an episode which featured the African American woman who is the head of surgery was on that week and a friend of mine was able to tape it. I was again hesitant to let Keanna spend a lot of time watching *ER* because getting involved in watching the show would take time away from working on her project or she might get impatient with watching the whole show to find the clips she wanted. So, I previewed the show and noted the points in the show with scenes of the doctor she wanted at work. I showed these scenes to Keanna and she made the decisions about how to use them.

Keanna expressed an understanding of editing video that I didn't realize that she had. She chose the sections of the video which she wanted to use and she knew the clips could be strung together on the computer and cut so that they told the story the way she wanted it to be told. She planned an edit of the clips so that her video would alter the role that the African American woman doctor played in the original episode. In the show, the plot accented the selfishness of the white male medical student. But Keanna decided to cut and rearranged the clips at places that made the video and audio focus on the actions of the doctor, who in her project represented Jenny. In this way, she edited the video to tell the story that she wanted to tell.

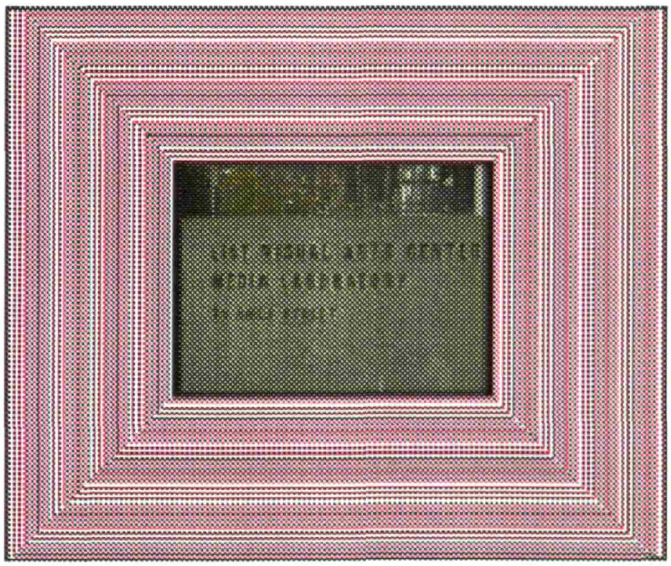


Keanna's doctor page from *Jenny's Careers*.

To what extent do the possible futures for Jenny represent Keanna's thoughts about her own future? The development of the Computer Programmer page gives some indication of an occupation she envisions for herself. When we began to think about videos for this page, we felt there was a slim chance of finding images of African American woman programmers in any published media, although we talked about the fact that we had met an African American woman who was doing software development for Microsoft at our first visit to MacWorld in 1994. Keanna became excited about the option of making her own video by shooting with the Hi 8 camera I used to collect data. We talked about the possibilities of filming one of the three African American women I knew who were doctoral students in the Computer Science department but decided it would be too hard to track them down. Keanna suggested that I play the part of Jenny as a computer programmer. She said that she wanted Jenny to wear a blue denim shirt in

the video which will match the clothing she drew in the shape for her project. She asked me if I could bring mine in to wear during the recording we planned for the next time we met.

During our next session, I told Keanna that I was a bit shy about playing Jenny in the video. I was hoping that she would choose to play the part herself, and she did. She said, "How about if I play the computer programmer?" The denim shirt fit just fine. We decided that I would do the camera work. Christa wanted to join in the video making so she and Keanna discussed a story for the video that included both of them.



Keanna's computer programmer page from *Jenny's Careers*.

The final version of the video has three scenes. In the first scene Keanna, playing the character Jenny, is seen going into the MIT Media Lab work. The second scene shows Jenny walking down a hallway and checking her mail

while also chatting with a colleague, played by Christa. They chat about taking students along to a conference on the Internet and telling IBM to stop sending them mail. In the last scene, Jenny walks into her office and reads a Stickie she made on her desktop which says, "Check Email." She sips from a cup next to her keyboard and says, "OK, time to get to work!"

Then we worked through the process of recording, digitizing, and editing the video. The girls decided to try several takes of each scene, knowing that we could choose to digitize only the one that we wanted. They knew that scenes could be cut during the process of digitizing or editing. They chose not to control the video editing software but were eager to watch all the takes to and tell Isaac what parts they wanted him to include. They directed the formation of the video. Keanna chose to be more involved in this process than she had with the other videos in this project despite the tedious aspects of video editing. The ownership of the video kept both of the girls involved in the technical steps of making it a part of the project.

When Keanna planned to include the occupation of Computer Programmer in her project, I was curious to see how she might express identification with this role. She had expressed in her graduation speech two months before that she wants to become a "programmer of Macintosh computers." Several times since then she had expressed curiosity about what it is like to be an African American woman at MIT. She queried Isaac about what people learn when they come to MIT and wondered what kind of engineers people can learn to be at MIT. She declared that she wants to come to MIT to learn to make computers. Her taking on the role of computer programmer in her video was part of the idea she had been developing for several months: thinking through what it could be like to be a programmer.

Her sense of herself as a programmer has changed over the years she has been creating programming projects. In 1992, she did not identify with her image of programmers. She and her classmates rarely called their work in MicroWorlds programming, preferring to call it "working on computer projects" or "writing procedures." *Jenny's Careers*, as her final project as a student at Paige is a testament to her reinvention of her notion of what it means to be a computer programmer, and do programming to include her identity through her creation of projects, and the invention of her own new ideas.

Commitment

When Keanna returned to creating the newsreporter page that had originally been a ballerina, she came up with a plan that was a little different than her previous pages. She drew a picture of Jenny seated at a desk with a large computer and screen on it. The view of Jenny is from the rear and her hair is styled in dreads. The action on the page is of an image of a newspaper on the screen spinning around and growing until it is a very large size and can be read on the screen. The problem of creating the newspaper and the animation is what Keanna was working on when we ended sessions in the summer. Keanna held onto this problem all during the school year. I invited her to demonstrate her project for three special events and each time she continued to work on this problem. Finally, during the summer of 1997, when she came to the demo day for the 2B1 conference at the Media Lab, she finished creating the growing and spinning newspaper and was incredibly happy about her achievement.

Chapter 3

Contexts for Exploring Children's Constructionist Learning

This chapter is a description of the four interrelated contexts that created a supportive environment for Keanna and her classmates' construction of their projects. The first context is the learning culture at Paige Academy, the setting that supported students' project construction through child-centered, culturally-relevant teaching. The second, the programming environment of MicroWorlds Logo, was conducive to constructionist learning by making computational ideas accessible to students through objects that they could use for their creative expression. The third, a teaching context largely informed by alternative epistemologies was central to the formation of my study. The fourth, Computer Class, was the context within the culture of Paige Academy where Keanna and her classmates used MicroWorlds Logo as the construction material for their projects and the primary site for investigating their ways of knowing.

Keanna's learning occurred within Computer Class as it developed over the years into a learning environment that nurtured a sense of long-term engagement in personally and culturally meaningful projects. In this chapter I describe and discuss the relationship between Keanna's work (as described in Chapter 2) and these four contexts.

3.1 The Culture of Paige Academy: Culturally Relevant Teaching Conducive to Constructionist Learning

> *Paige Academy is a community-based, independent, publicly and privately funded, non-profit child care center and elementary school. It provides education for 120 children ages three weeks through sixth grade.*
> *(from the Paige Academy Handbook for Parents)*

The learning culture at Paige Academy is an important aspect of contextualizing and understanding Keanna's learning. In this section I discuss the culturally relevant and child-centered nature of the school program at Paige. This section begins with a description of the school and the elementary program delineating characteristics of its historical roots, philosophy, physical setting, and curricular structure. Images of the look and feel of learning and teaching that were prominent in Keanna'a classes during the time of this research are provided to highlight the conditions that nurtured her project construction, the culturally relevant nature of the school, and the emergence of her identity as a strong learner.

The visions of teaching and learning that helped to birth Paige Academy and shape its culture are expressed below in the reflections of one of the school's founding members and the current Principal/Head Teacher of the elementary school, Joe Cook (Bro. Joe). I chose to work most closely with Bro. Joe for this research because he had experience with using computers with his class, was interested in working with me to help Computer Class become a positive experience for the students, and there was a strong resonance between his beliefs and practices about teaching and learning and my vision of constructionist learning.

As a child, I failed to see the connection between education and life until I was in the ninth grade. As a boy growing up in a rural, segregated city, I spent many hours at home providing entertainment for myself and my friends, reading, experimenting with different ideas and theories, and tinkering with all sorts of things. Most of this took place in my basement: a medium-sized, unheated room with two closets. We could do anything that was safe in this space, which even included chemistry, biology, and rocketry experiments! Looking back, I now see that every single event we did in that basement was educational, even though we had no formal teacher. We simply used our minds well.

We acquired books on various subjects as we needed them. We discussed and made collective decisions as to how our "research" would be done. Kids of virtually all ages were included in our basement space, though we only included girls when we had special events demonstrating our "results" or at other times when we had a chaperon. We were quite a productive group with diverse interests, and we were committed to helping each other with a project when help was needed. You could say that that space was our little village.

Our topics of reflection and study would have amazed teachers at almost any elementary or junior high school. We dissected animals and kept others as pets. We developed magic inks and analyzed chemical properties in foods (such as starch and sugar). We built complicated telegraph systems and learned the Morse code in the process. We studied the solar system, pretended to be astronauts in outer space, and created jet and rocket propulsion systems with a ballpoint pen and phosphorous. We built nearly everything from scratch and only occasionally ordered kits. We corresponded by mail with science and chemistry businesses from Portland, Maine to Portland, Oregon, as well as Gilbert, New Jersey. We analyzed objects under a microscope, used a magnifying glass to set paper on fire, and even built a cloud chamber to study the traces of alpha and beta particles disintegrating from radioactive nuclei! We created gun powder and developed a solid fuel for rocket launching. We made kites, repaired our own bicycles, built scooters and wagons and basketball hoops. We designed miniature cities, equipped doll houses with electric lights, and built electromagnets. You name it and we tried it, and not once did we have an adult there telling us what to do or how to do it. Sometimes we did ask questions of adults or of older children when we needed to, but the basement space was basically our territory.

There were other times, though, when we organized events for the larger community. On weekends we set up a 16mm projector, rented or bought films, and charged 15 cents to see a movie, selling soda and popcorn for a dime. (We were also budding entrepreneurs.) We organized a band, wrote songs, and performed them at teas, society meetings, and talent shows.

Surely countless numbers of boys and girls did these sorts of things. We were by no means unique. But what I find amazing is that not one of my teachers at school really knew or seemed to care what I did at home, nor did they bother to visit our basement space and find out. Not until the ninth grade, that is. All along I was just a passing, mediocre student. My older brother and sister were different: they were star students. By comparison, I was a lost cause. Then my ninth grade science teacher heard about what I was doing and asked me to bring in my work so the class could see. Nearly every week I brought in a different project. I became absorbed in science class after that. Through this teacher, I learned that my work — indeed, myself — had a place in school. I soon became one of the best students, and my

excitement and inspiration soon spread to other subjects as well."
(Cook, 1992)

3.1.1 Background (Philosophy and History), Physical Setting, Class Structures and Schedule

The mission of Paige Academy is to offer a comprehensive, developmentally-based academic program for infants through elementary school age children in the Boston metropolitan area. Paige Academy's educational philosophy and lifestyle provide an environment that fosters individual worth as well as collective responsibility. This African American philosophy promotes the following seven principles: unity; self-determination; collective work and responsibility; cooperative economics; purpose; creativity; and faith.
(from the Paige Academy Parents Handbook)

Paige Academy is described as an alternative African-centered school. Many times Angela Paige-Cook, the Executive Director, has told me that this description is not one that people at Paige Academy use for themselves because "We are just being who we are. We don't need to give ourselves a label to be who we are with each other. People outside need to call us something so that's the description that they use." I use the term African-centered to acknowledge the school culture of Paige Academy as a subculture within broader African American society. This term also brings focus to the elements of cultural relevance at Paige Academy that are rooted in addressing the needs of African American children as well as children of other cultural backgrounds whose families choose this school environment for their children. African-centered teaching at Paige Academy is outside of the traditional paradigms of public schools within the United States in its attentiveness to creating a resonance between home and school cultures for all children and particularly African American children. This attention to cultural environments and identities is a hallmark of successful and equitable education which are major trends within multicultural education (Banks,

1995; Delpit, 1995; Mehan, Okamoto, Lintz, and Wills 1995; Ladson-Billings, 1994; Nieto, 1992).

BACKGROUND: HISTORY, PHILOSOPHY AND GOALS

The historical roots of Paige reach far back through a family legacy from Angela Paige Cook (Sis. Angela), one of the school's founders and its current Executive Director. The school is named after Lucy Paige Williams, Sis. Angela's great aunt who, during the Reconstruction Era, opened her home in Richmond, Virginia to neighbors and their children, teaching them basic survival skills. Her "schools of benevolence" inspired members of her family to recognize the value of well-trained, dedicated teachers. (Paige-Cook, 1990)

Paige Academy was founded in 1975 in Roxbury, Massachusetts by a group of young educators, activists and artists who expressed their resistance to racism in the early seventies through political theater. They were also involved in the alternative school movement that the government was funding at that time. Both Black, Asian, and White activists who were committed to anti-racist work and alternative education were part of the founding group. This group began the project of Paige Academy out of their commitment to form a school where children from infancy to sixth grade would learn not only academic subjects but a way of viewing the world that would help them not only to survive but to thrive in a society in which they would face potentially constraining experiences of oppression.

The school grew directly out of an activist theater company called The Black Ghetto Theater company. Paige Academy began when participants in this political theater group decided to extend the theater into a school. It became a school with a strong performance component, linking students with

a performance project, outside of the school environment. The school's roots in theater, dance and music continue to grow today. Throughout the time of this research children from Paige Academy continued the tradition of studying African drum and dance, performing all over the greater Boston area as "The Paige Academy African Drum and Dance Troupe," and presenting original plays and musicals. This is an important aspect of Paige because it is one confirmation of the connection between life outside of school and life in school by respecting and nurturing the significance of performance in African American society (Collins, 1993; Asante, 1989) Members of the Paige community value both the teaching of "academic" subjects and the teaching of dance, drumming, and theater.

The school's founders chose to base the philosophy of the school on the Nguzo Saba, the Seven Principles of Kwanzaa. The Nguzo Saba were adopted as a framework in which to live and developed naturally into a strategy for teaching. These principles are a part of a deliberate effort at Paige to connect African American experience with awareness of and pride in African heritage.

Kwanzaa is an African American holiday. It was developed in the late 1960's as a result of the American Civil Rights movement and a growing understanding of African theologies and community relationships. Using West African harvest festivals as a foundation, Dr. Maulani Karenga delineated these Seven Principles as those that keep a community growing, learning and its members in support of each other.[15] On each day of the

[15]For more information about the Nguzo Saba or the constuction of Kwanzaa as an African-American celebration of cultural identity, see *The African American Holiday of Kwanzaa* by Maulana Karenga (Los Angeles: University of Sankore Press, 1988) or *Kwanzaa: A Framily Affair* by Mildred Pitts Walter (New York: Lothrop, Lee, & Shepard, 1995).

holiday, community groups of families and friends gather and one of the Seven Principles is celebrated by finding examples of each Principle within the community.[16] Paige Academy both celebrates the holiday and adopts the Principles as collective goals and values for the school community.

The Nguzo Saba–the Seven Principles of Kwanzaa

1. *Umoja* — Unity: to work and learn together in an atmosphere of love and respect for self and others.
2. *Kujichagulia* — Self-Determination: to help build minds geared for positive movement, and for making dreams come true.
3. *Ujima* — Collective Work and Responsibility: to struggle together to reach the goals we have set for ourselves, and to overcome all obstacles.
4. *Ujamaa* — Cooperative Economics: to pull together all of our resources to build a strong, beautiful school, both materially and ideologically.
5. *Nia* — Purpose: to develop and substantiate a positive direction in which to guide and lead our children.
6. *Kuumba* — Creativity: to expand and develop the creative potential inherent in all children.
7. *Imani* — Faith: to believe and have confidence in ourselves and our progress, and to know that together we can build strong minds to make for a brighter tomorrow.

These Principles, although derived from specifically African and African American experience, reflect other educational movements as well. For example, the principles are echoed by many of today's multicultural education theorists whose theories and practices address the reform of education for all children (Banks 1995; Nieto 1996; Sleeter 1996). These sentiments are also reflected in the reform movement of cooperative education (Johnson and Johnson 1993; Schiendwind and Davidson, 1997). And lastly, the implications of holding to these values within an educational

[16]Kwanzaa is officially observed from December 26 - January 1 each year.

institution are consistent with the arguments of critical school reform theorists (Apple, 1995; Darder, 1992)

The Principles of the school are related to the elements in alternative epistemologies (see section 3.4). These Principles exemplify many of the foundational ideas that theorists of multicultural education and school reform have proposed for informing teaching practices. The principles and goals are related to each other. For instance, the goals of fostering individual worth and collective responsibility are expressed in the Principles of Unity, Self-determination, Collective Work and Responsibility, and Cooperative Economics. These goals relate the institutional vision of Paige to the perspective of culturally relevant teaching expressed by Gloria Ladson-Billings in her study of teaching styles of successful teachers of African American children (Ladson - Billings, 1995).

In addition to the Seven Principles, the school defines its institutional goals as follows:

- To provide an excellent educational experience for young children and their families.
- To create a school community that is founded on Nguzo Saba, the Seven Principles of Kwanzaa.
- To develop the arts and sciences as a vital component of the curriculum.
- To provide an infant care program in as much of a family setting as can be artificially created.
- To involve parents actively, in a non-patronizing way, in the life of the school.
- To provide an environment that fosters individual worth as well as collective responsibility.

LOCATION AND PHYSICAL ENVIRONMENT

Driving through the neighborhood in which Paige Academy is located you would not expect to see a school. It is a neighborhood with large old houses that have either been renovated many times or beg for new renovation. There is a sense of history among them yet the apartment buildings around the corner evidence the latest wave of gentrification. The street where the main campus is located has a row of former brownstones, now apartments, across the street from the school's playground. On this street where you would not expect to see a school, you find three Victorian houses that driving by, you wouldn't notice as school buildings but if you are walking down the street, the beautiful signs that say "Paige Academy" with pictures of children of the school's butterfly logo would catch your eye. And when you turn towards the sign, you would see behind a beautiful garden, children climbing on brightly colored playground equipment and hear the voices of them playing. The school's location in this comfortable neighborhood appeals to a sense of community and family life. This is a place for children to feel comfortable. This is a place where families can say "I'm taking my child to Paige," rather than "I'm taking my child to school."

The first house on the street is a large red house where the administrative offices, the infant class, and the preschool are located. The second house is a large white house where Sis. Angela, Bro. Joe, and their family of four children live. This house is also the site of many Paige community events such as Board meetings, concerts, and parties. Next on the block is the Bury Rock Garden and Playground. The new playground stands as a testament to the latest grassroots organizing effort in which Paige teamed up with City

Year[17] during the summer of 1996 to build the new playground. Behind the white house is a vegetable garden and a system of ponds that seem to be getting larger every year even though the space is the same. The big blue house that is next on the block is the building for the elementary school, usually referred to in the Paige community as "28".

Going into building 28, we can get a feel for the surroundings in which Group 3 children are learning. It feels just like going to visit someone's house. When you enter the school, you have to take off your shoes. Most students and teachers have a pair of slippers to change into in their cubby. Once inside, one can tell that the former bedrooms, living rooms, and hallways have been converted to withstand the stress of active public use. But they have not lost their feeling of "home." The large living room space in the front of the building is the Umoja Room where the whole school gathers every morning and many community events are held. The next room down the hallway is a small classroom with a loft that is usually a classroom for the youngest students. The back of the first floor is a kitchen where mostly vegetarian meals are cooked for the whole school.

The oldest students' classroom is a large room on the second floor with a fireplace and tall windows that face the front of the building. Children each have their own desks and a "cubby" in the hallway for their coats and bags. There is a small room adjacent to the classroom with sliding doors that at times has been an office and for the past two years has been the Computer Lab. There is a second classroom in the back of second floor that is sometimes used for regular group classrooms and sometimes functions as a room where

[17] City Year is a national service program for young adults, ages 17 - 23, to participate in a year of community and civic service along with leadership development.

Art, Music, or Science classes are held. On the third floor, is a large room that is lined with shelves of books. It is sometimes called "The Library." And, for my first two years at Paige, it was The Computer Lab. There are several big tables in this room that usually hold current construction projects or science projects. There is room for children to work and sometimes classes are held here with small groups of children.

STRUCTURE: CLASSES AND SCHEDULE

The community has made an effort over the years to convey the African-centered ideals and family feeling in the school through several practices that have become integral to the school's culture. The small class size, the multiage groupings, flexibility in scheduling, and the variety of classes contribute to the family feeling of the school. Classes flow from one to the other with an awareness of a time schedule but also an awareness of giving time to things that need to be done. These are some of the ways in which time schedule and class structures function to facilitate an attentiveness within the daily life of the school to children's learning needs and cultural identities.

The elementary school, sometimes referred to as The Junior Class, has had two or three multi-age classes over the time that I've been involved with the school. Group 1 is usually a class with approximately twelve four and five year olds. Group 2, has had as many as six six- and seven-year olds. Group 3 has had six to ten children. Group 3 students have ranged from eight through twelve years old, particularly in the years when there are only enough children for two groups.

I was working at Paige for a long time before I heard anyone talk about what grade a child is in. The children identify themselves as being in "Group 1," "Group 2," or "Group 3." The first time I heard a grade level associated with a child was when students in Group 3 were talking about when different children were going to graduate. In this discussion, it was important for them to identify who was in third, fourth, fifth or sixth grade, because the sixth graders are the graduates each year.

Most of the children at Paige are African American. During the time of this research one European American child was in Group 3. Several Latino children have been in Group 3 for shorter periods of time. Almost all of the children come from middle or working class families. A few students come from upper middle class families and several children are from low income families. Regardless of cultural background or socioeconomic situation, any family who wishes to have their child attend Paige is interviewed and the best possible financial arrangements are made for their attendance.

The children are taught in multi-age groups by one head teacher per group. Yet, the children interact with many different adults during the day for the several different classes. Music, Art, Spanish, Creative Writing, and Math and Science inquiry activities are taught by consultants who come a few days a week. These classes usually emphasize African American heritage and experience. Music class emphasizes styles of jazz and blues in children's singing and learning to play instruments. Art emphasizes concepts of visual art as a means of both individual and collective expression. The school's cook often teaches Cooking classes. The After-School program brings other teachers for activities such as Theater and African Drum and Dance. Visitors are also welcome to share expertise that will be useful to the students. There

is an attitude of welcoming anyone who has activities to share that will help students think about useful ideas. When I asked Bro. Joe about coming to the school to teach Computer Class, he gave the response I have often seen him give to visitors or people in the Paige community who express an interest in working at the school. His message is, "Let's do this because it is a good thing to do, we will learn something new, learn about ourselves, and learn about each other."

No matter what time of the day you come to Paige, there is an unaffected atmosphere of warmth and welcome when you walk in the door which seems very different from what I have encountered in most public schools. The school day at Paige begins with "Umoja (Unity) Circle", also referred to as "The Ritual." Many students have already been at school for a few hours before the beginning of Umoja Circle. They have been playing in the Umoja Room with Nintendo or wooden blocks, or in classrooms or out on the playground. And they have eaten breakfast in the kitchen where the cook has prepared pancakes or oatmeal or eggs and toast or the children have prepared their own cereal.

The students, teachers, and visitors who are present gather each morning and sit in a circle to begin the Umoja Circle. A "monitor" for "Circle," is chosen each day by a teacher and is usually one of the children and occasionally is a teacher. The ritual begins with a brief meditation during which soft music is played. The monitor then leads the group in call-and-response reciting of the Nguzo Saba introduced in the following way:

> *"We are here to open ourselves to each other and to the Universe, by these Seven Principles ..."*

Then everyone sings the school song "Love is Something that you Give Away[18]" Next, the monitor leads the group in saying the following Affirmation:

"We are beautiful people. We will grow, learn, and become strong!"

The next part of Umoja circle varies depending on the circumstances. Usually children choose a few games for the group to play or songs for the group to sing. Circle can also include discussions of some of the Seven Principles in connection to events that have occurred at the school. Visitors are invited to introduce themselves. Anyone in the circle can offer to share things they have brought from home to share, events they would like to tell about, or songs they would like to teach. At the end of Umoja Circle, children go off into their groups for classes, often with a chant of good wishes for the day, "Good-bye Group 3, yes indeed!"

Here is a schedule for a "typical" day for Group 3 during the time of this research:

9:00 - 9:30	Umoja Circle
9:30 - 10:30	Reading/Language Arts
10:30 -11:30	Art with Sister Susan
11:30-12:30	Math
12:30-1:00	Lunch
1:00-1:45	Recess
1:45-2:45	Music with Bro. James
2:45 - 3:30	Science
3:30	Beginning of After-School
3:30 - 4:30	African Dance Class with Sis. Fatou
4:30	Snack
5:00 - 6:00	Free play, clean-up, and parents pick up students

[18] This folksong was written by Malvina Reynolds

It is difficult to describe a day at Paige that could be called "typical" because it is almost as likely for students to go through a schedule similar to the one below as it is for students to experience the one above:

9:00 - 9:30	Umoja Circle
9:30 - 12:00	Performance at Boston City Hospital
12:00 - 12:30	Lunch
12:30 - 1:30	Recess
1:30 - 3:30	Baking cakes to sell to parents and teachers to raise money for a field trip to King Richard's Faire
3:30 - 4:30	Gardening with Bro. Joe
4:30	Snack
5:00 - 6:00	Playing with Nintendo until parents arrive

These two very different types of schedules might raise a concern about the overall time spent on academic subjects. However, as students moved through a day like the second one illustrated above, there were many moments where learning of ideas that are within major subject-matter areas occurred. These moments are the kinds of learning experiences that do not fit into more traditional approaches to elementary school teaching and curricula. The teaching and learning at Paige were driven by purpose and goals that were authentic for the students and their teachers. In the following section, I give examples of these purposes and goals through images of teaching and learning for Group 3 with Bro. Joe.

The life of Group 3 each day reflects a commitment to involving children in real experiences and a responsiveness to their learning needs. In fact Bro. Joe has described that a major purpose for developing a schedule and sending it home with children each semester is to communicate to parents an awareness of the activities the classes plan to do. Making a schedule is not

intended to convey a plan that each day, during that particular time, a particular class will always be held. Nor is it intended to imply that there is a rigid approach to teaching the Math class that is on the schedule 11:30 - 12:30 on Tuesdays. Sometimes it seems as though the schedule is created so that there is something to deviate from. Many times the schedule will flow as it is planned. But the schedule is intended to be flexible and responsive to requirements of life at Paige as well as of academic structuring. Large blocks of time are scheduled for classes and there is an understanding that times can be extended if the students are "hot" in their work on a particular project for a particular class.

My interpretation of the role of the schedule on the life of the school is that it functions as a framework to support, rather than control, learning. In fact, there is dialogue flowing through each day, from teachers-to-teachers, students-to-students, and students-to-teachers about what is going to happen next. For instance, Bro. Joe checks in with Sis. Susan to see when she will be done with her Art class with Group 1 before he brings his Reading class to a close. When I come for Computer Class, sometimes it makes more sense to work with only a few students at a time because this can juxtapose well with Bro. James introducing new instruments to the students in Music. So, we split up the class and work with three or four students for about 45 minutes and then we switch groups.

3.1.2 Images of Learning and Teaching

I chose Paige Academy as the site for this research because there is an atmosphere of authentic, engaged, culturally relevant learning there and these characteristics are conducive to constructionist learning as well as

culturally relevant teaching. Learning there is authentic because it is not determined by scores on standardized tests but by the involvement of children and teachers in developing relationships with ideas. Efforts are made to teach all of the subject matter that children typically encounter in elementary school as well as areas that are particularly valued within this school culture. I consider teaching there to be culturally relevant because explicit attention is paid to nurturing each child to learn while attending to students' home cultures.

Bro. Joe's teaching is responsive to children's needs and ideas. He is excited about learning for himself as much as for the students. He is both strict in the sense that he holds the children to certain standards and also flexible because he expects different things from different children based on who they are as individuals. He teaches Algebra to the student who will be graduating that year because he feels that this student "needs to do some work with Algebra." When he teaches lessons geared towards the younger students, the older students often participate, and when he teaches lessons for the older students, the younger students are always able to listen in and sometimes participate. He manages the class in ways that attend to each child's needs and to the needs of the group. I have never heard him use comparison between students' performances as a way to talk with the students about their work. He talks about what he expects each child to do because of what he knows each child to be capable of and he wants each child to contribute to the group.

Bro. Joe approaches children's collective work in ways that seem natural to what he believes and is common practice in the school. He gives instructions similar to the following to the group, "You can all work together

to figure out how to solve this problem." And he monitors the situation so that if he notices that some children are not involved or the group process is not working, he tells children things to do that will help. In a science and math activity one day, I heard him say to Lori as she was wandering away from the group, "Lori, write down the numbers that they are finding in measuring with the pulleys so that we can use them to set up new experiments when they are done." He drew her back into working with the group by instructing her to do a task that was helpful to the whole group's work. I have often seen Bro. Joe use this approach to help students to become engaged in academically challenging tasks.

EMERGENT CURRICULUM: CONTENT FORMED FROM TEACHER'S AND STUDENTS' INTERESTS AS WELL AS TEACHER'S ASSESSMENT OF NEEDS

In schools with traditional forms of instruction and curriculum, it is easy to predict what students will be doing by looking at a predesigned curriculum, either in the form of a textbook and/or curriculum guidelines that are mandated by the school district. The content of classes at Paige is not influenced by a textbook or a set of imposed guidelines. In contrast, the content of classes at Paige constantly emerge from a complex system of influences. These influences are: 1) ideas that the teacher decides, because he believes that individual children or the group as a whole could benefit from learning or at least being exposed to them, 2) ideas that the teacher is interested in learning and feels that the students will benefit from encountering, 3) ideas that the children have about what they want to do, and 4) interesting opportunities that come along. Learning stories, such as the one below, represent types of the emergent curriculum that were integral

to the learning culture which Keanna and her classmates experienced at Paige.

King Richard's Faire

In the Fall of 1994, Bro. Joe was reading *The Mists of Avalon* by Marion Zimmer Bradley for himself and with his son Antonio who was 11 at the time. He was so interested in the book that he decided to have the students read a collection of stories about King Arthur and the Knights of the Roundtable. The collection of stories he chose was written for upper elementary grade level. He talked with the children and with me about why he found *The Mists of Avalon* to be so fascinating. He was attracted to the view of this historical era as told from a woman's perspective. The students knew that he had a sincere interest in this book and analysis of the story and its historical implications. Reading these stories and thinking about questions that arose from the reading became the focus of Reading class during most mornings for Group 3 for several weeks. Discussions came up about all kinds of facts, interpretations, and questions connected to the story. The group raised questions about "what Black people were doing" during this time in the history of England. So, Bro. Joe and the students started research on the presence of African people and influences in medieval England, such as trading and the Moors.

During the fall in New England there is a very popular Renaissance fair called "King Richard's Faire." Joe asked the students if they would like to go to visit the Faire one Saturday. This offer ignited a spark of interest that kept the students going on several different projects for weeks. They baked cakes and held bake sales to raise money for entrance to the faire as well as spending money. They researched and designed costumes that would be appropriate to wear to the faire. They watched movies of tales of King Arthur.

During the bake sales, each child kept track of the money he or she made from the cakes they baked and sold. Their accounting actually caused an interesting dilemma of how to split up the money if some students hadn't sold enough for their entrance and spending money yet a few had more than enough for their trip. There was a heated and tedious discussion of how to deal with this issue that lasted for over 45 minutes. I was impressed by the time and effort that the seven 8-11 year old students in Group 3 that year devoted to resolving this issue and how Bro. Joe for the most part only facilitated the discussion without making any decisions for them. In the end, it was decided that the students who made a lot of extra money would contribute enough so that everyone could get in. Beyond that everyone was responsible for their own spending money.

After about a month the seed of studying tales of King Arthur in fiction and historical facts of the time had grown to fruition. Projects related to this reading had become a unit of study connected to every major subject area, Math, Social Studies, and Reading and Language Arts. Sometimes it was clear when work on this project was associated with a particular subject area and sometimes it wasn't. For instance, I didn't hear students speak about the accounting for the bake sales as though it were an activity for Math class. But, most of the reading of the book of short stories happened during times that were scheduled for Reading.

DIVERSE APPROACHES TO TEACHING

"At Paige we will both play and work..."
- Paige Academy Handbook for Families

A variety of teaching approaches are used at Paige. I have observed several classes that reflect the message in the statement above that making learning fun and purposeful are common denominators in instruction at Paige. Bro. Joe has clearly incorporated this message into his teaching, along with others that convey the child-centered and culturally relevant nature of the school. The way that Bro. Joe teaches is as much about reading students' energy and responding to the "vibe" of the classroom as it is about choosing an approach that will provide content. In play and work, he also encourages children to express their interests and their cultural identities. The following learning stories are images of children engaging with mathematics that are typical experiences at Paige.

Multiplication Rap

When I came in to class one day, Joe was deeply involved with the students in the task of writing a multiplication rap. My sense was that he chose to do the rap because there were several eight- and nine-year olds in Group 3 who didn't have their multiplication tables memorized but also because he really thought it would be fun to make a rap. One of the eight-year-olds, Raz, had recently done a rap in the recording studio with his father who is a famous drummer and percussionist. I had noticed that the students often spontaneously began singing raps and other songs from the radio when they were working on their own.

It made complete sense to do a multiplication rap because the rap would help make multiplication more fun and personally meaningful for the students. It did not seem out of the ordinary or contrived for Bro. Joe to be creating a rap based on multiplication with his students. The project emerged as an authentic way to help children think about the tables because listening to rap, singing rap and writing rap was a clear hit in the youth culture that the students valued. It was both play and work.

There is a different way of thinking about teaching going on here than in schools that follow curriculum in prescribed ways. Bro. Joe used rap to teach times tables in a way that was qualitatively different than the typical image in which a public school teacher might use the setting of a grocery store or candy shop for story problems. This typical approach is based on the assumption that placing the assignment in a familiar background for the children will cause them to have more interest in the task. Bro. Joe's approach was different because he and the students are engaged in a "real project" that involves as a by-product some of the ideas he as their teacher wanted them to learn. The way of thinking about teaching and learning that is common in Bro. Joe's classes expresses an epistemological distinction between making learning fun because it supports "real" engagement with ideas, and a "sugar coating" of knowledge proposed by an adult so that children will take it in more easily. The children in Group 3 might not care to play "grocery" but they did indeed care about creating a rap–even a multiplication rap because in this case making the rap was as important as learning the times tables!

The following story is another example of real engagement with mathematical ideas:

The Pond

One of the first lessons I observed at Paige was four children in Group 3 digging a hole in the backyard of the school. I asked what was happening and discovered that the children were building a pond. *What were they going to do with it?* Put goldfish in it. *How did you decide how big to make it?* It had to be small enough so that the tarp we have will cover the dirt and sink deep enough so the fish will have room to swim. *Whose idea was it to build the pond?* Brother Joe wanted to make it and asked us to help. *What class is this?* We don't know, we are just helping Bro. Joe make a pond. *What things did you have to figure out?* We had to measure the tarp and figure out how deep and wide to make the pond. We think it can hold around six big goldfish. *Why do you think it will hold six goldfish?* And the conversation went on...

- from fieldnotes of dialogue with students Fall 1992

How was Bro. Joe teaching in this experience? He was teaching by asking the students to help him do something that he wanted to do and by asking them to work on a communal project that would improve the landscape of the school. When I came into the yard Bro. Joe had left the students alone for a while with their shovels, tarp, a yard stick and an understanding of the task at hand. They were involved in thinking about the mathematics of estimating how deep they could dig the ditch given the size of their tarp. They were engaged in scientific inquiry about how many goldfish could be sustained in the pond. The fact that they didn't seem to care what "class" they were in was an indication to me that they were accustomed to engaging in this sort of authentic learning.

Similar to the Multiplication Rap, the authenticity of this project is derived from the students making something that had real purposes of

helping their teacher and beautifying the landscape of the school. Two other pedagogical distinctions are important to recognizing the nuances of the learning culture at Paige. Bro. Joe's posing of this particular problem is very different from the deliberately designed projects commonly used in project-based classrooms that are based on currently popular views in math education reform of constructivist teaching. In this paradigm teachers are encouraged to design problems, materials, and questions to pose which will guide children to engage with particular ideas. Bro. Joe posed the task with an awareness that the children would encounter math and science ideas that they were capable of figuring out. Leaving them to work on the project themselves expressed a confidence in the questions they would pose for themselves and the ways they would find to think about accomplishing the task. In thinking about children's learning through making projects, one is left in this situation to consider how their learning might have been different if the whole idea of building a pond had been initiated by them rather than by Bro. Joe. As I continued to spend time at Paige, however, I observed another kind of experience that at first seemed to pose a stark contrast to the pond lesson.

"Math Class"

I saw students spend a period of time which they considered to be "math class" working on workbook pages. Sonji, 7 yrs. old, worked on his assignment of three pages of 2-digit addition and subtraction problems. Shanay, a fifth grader worked on two pages of reducing fractions. Bro. Joe circulated through the class showing children the algorithms that were appropriate for their current pages. Almost every child was working in a different book. The idea of using different books came from the fact that almost every child in the mixed age class was in a different grade level. At the end of class, almost every child checked in with Bro. Joe

about how many workbook pages they needed to do for homework.

The apparent contrast between the teaching through making the pond and the teaching in math class with workbooks seems at first to reflect very different styles of teaching. In the pond construction, children engaged in defining and solving problems inherent to completing the task. They could identify the success of their efforts by their progress in building the pond and Bro. Joe's appreciation of their work. The workbook work was an assignment with the goal of getting all of the answers "right."

Although the similarities between these situations may not be as apparent as the differences, they are more reflective of the teaching style that is considered ideal at Paige. In both "classes" the children enjoyed their work. They enjoyed the accomplishment of math book pages they could do on their own. They also enjoyed digging in the dirt and figuring out how to build the pond. They were engaged in both activities because they knew that Bro. Joe cared about the work he has asked them to do, and that he would work with them on what he wanted them to learn. He allowed them to become interested in successfully learning their math facts because he did not make right or wrong answers the validation of their learning. He has an attentive "fatherly" manner in explaining how to correct their errors and try new arithmetic operations. Students at Paige learn that both kinds of lessons are fun, different, and authentic ways to learn in school. It is the very contrast between the activities, together with Bro. Joe's consistency and engagement in all of them that create the social bond and trust so characteristic of Paige.

In the years I have worked with Bro. Joe, he has not centered the descriptions of his practice in a constructivist framework. However, the similarities of the above activities relate to constructivism in practice. His teaching of both lessons exemplifies a recognition that children learn through their active experiences of the world. He wanted them to engage in thinking about how to make the pond as well as help him make it. He wanted them to engage in thinking about computation as well as work through their notebooks with his help. Even though popular notions of constructivist teaching might question the validity of both of these lessons, they do manifest the foundations of constructivist theory within this culture.

A Camping Trip

Bro. Joe helped children to learn by responding to their interests, asserting his own interests, making learning experiences fun and worthwhile. His teaching helped to create a culture of learning for Group 3 where children expected to be interested in what they do, and appreciated by those who guide their interests.

Another good example of responsiveness to children's interests, real purpose, fun, and attentiveness to individuals as well as the group, is the camping trips that Bro. Joe takes the students to. He takes the students camping because he likes to go camping and he knows that they will enjoy doing it with him. I have never heard him say that he takes them camping because he wants them to learn about math and science ideas through planning and doing the shopping for the trip. These camping trips are much more like a family experience than a school trip in the sense that they go on the trip because it is something that would be fun to do together. Yet, Bro. Joe

was very pleased by and aware of all the learning that came out of the planning session prior to their trip in June of 1995.

During this planning session, Shanay, who was the oldest child in the school, took charge of writing lists on the board of the things they would need. Students planned the equipment they would need to take. This list led to discussions of why flashlights and sleeping bags are important. They also discussed why certain kinds of dishes and utensils are more helpful than others. Shanay recorded the foods they wanted to take and the plans for their menus. This discussion of menus ranged from which kinds of foods would last without much refrigeration for four days to what kind of expense would be involved in the quantity of different types of foods.

Bro. Joe knew that the students would learn a lot from taking charge of this planning. That is why he asked them to do it and participated in the discussion as an interested adult, not a controlling teacher. He let them know when things were reasonable or unreasonable. When they asked questions that he didn't have answers to, he told them honestly as much as he knew. It is typical of his approach to teaching to give students a lot of the control, yet guide them so that they don't get too stuck. Or if they do have difficulties, they know that he will support them in redefining what they are doing or rethinking their plans.

STYLES OF INTERACTION

Students in Group 3 are immersed in learning through ways of interaction that are comfortable to them. They bring their cultural style to the language of their interactions. The various interactional styles are reflective of a variety of African American genres of discourse. For example call-and-response is

central to the Umoja Circle which begins each day and several of the songs that students enjoy singing. Children are encouraged to give answers in narrative forms relating personal experiences to ideas in classes across subjects.

Classes at Paige are alive with talk whether students are discussing among themselves during free times or times for independent work or talking with teachers there is almost always a buzz of conversation. Classes are almost always highly energetic. In contrast to the norm in many traditional classrooms, children expect to be able to talk freely and be active unless the class structure makes it necessary for everyone to be quiet and focus. For instance, listening to stories read aloud, focusing on a lesson being given by Bro. Joe to the whole class, or listening to directions for an upcoming activity are times when the purpose of the class requires children to sit quietly and listen. When children are working on projects or assignments at their seats they know that they are free to talk with one another. They are also assertive about asking questions or making comments during presentations.

Students are taught to recognize and use different language forms as appropriate in different contexts. (Delpit, 1995, p. 53) Sometimes classes are conducted so that children raise their hands to respond to teachers' questions and offer comments. Sometimes discussions emerge informally and are pursued in a style where students and teachers offer their thoughts spontaneously with the teacher acting as a facilitator.

The interactions in classes encourage natural spontaneous discussion and debate as well as structured and planned expression. Every year I worked with Group 3, at least once during the year students wrote essays for

presentation in an essay contest. One year they wrote about Martin Luther King Jr. for an essay contest sponsored by the Black Student Union at Suffolk University. They also wrote essays about their views on drugs for an essay contest sponsored by a nearby convent. They gave poignant and well written speeches. They had many spirited discussions about issues as they practiced their talks that reflected language forms that were also comfortable for them outside of school. Bro. Joe values their natural expression as an indication of their learning as much if not more so than their formal expression. He helps them to learn discourse styles that are appropriate to different situations.

Another aspect of African American cultural norms that is evident in teacher-student interactions at Paige is direct and unambiguous communication to students about their behavior. Lisa Delpit points out that cultural differences about the way adults talk to children about their behavior can affect students' coming to understand the culture of power (Delpit, 1995) At Paige, Bro. Joe tells children directly what he expects them to do or stop doing. "Stop playing with that while we are trying to tape. I've asked you not to get in the way of this once and you need to stop." This kind of direct request has been shown to be useful to avoid difficulties that African American and working-class children can have interpreting "indirect requests for adherence to an unstated set of rules" in situations where teachers tend to convey commands through indirect statements (Heath, 1983, cited in Delpit, 1995).

Bro. Joe encourages children's natural tendencies to question authority as long as they are respectful. They know that they can question any assignment he gives or make alternative suggestions to any activity he proposes as long as their suggestions are serious. Negotiation with students is a normal

occurrence in the school as a part of children being full participants in the community and contributing to emergent curriculum. Students know and respect Bro. Joe's authority in decision-making while Bro. Joe respects them for being who they are.

Watching Bro. Joe with the children, I have seen that engaging with ideas is a glue for their relationship. Communicating and working together to make something is the reason for their connection. For instance, the point of his interactions with children when he teaches spelling is not to learn to spell by privileging the notion of spelling in the abstract, independent of the purpose and meaning of the words. The point is to work together to help the child bring some new words and spellings into his or her experience. His manner with the children conveys that he completely respects who they are and is going to work with them to learn something new.

My conversations with Bro. Joe about his views of learning and teaching reflected his pedagogical style. He said, "I try to hear what they are thinking from their interests."[19] He always expects children to express their interests, likes, and dislikes. If he began teaching a lesson and the children said, "We don't want to do that today." He may say, "We are going to work on this today because I feel it is something that you need to get into." Or he might say, "OK, tell me why you don't want to do this and maybe we can think about doing something else." But he always bases his response on the acceptance and respect of students' self-expression and who they are. He never tries to make students invisible, even when he is making the decisions about what they are going to do and how a class will be run.

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[19] From transcript of discussion with Bro. Joe on June 13, 1994.

3.1.3 Conclusion: Aspects of the school culture at Paige Academy nurtured Keanna's constructionist learning.

What can be learned about children's learning in a school where their learning experiences are culturally relevant and a lot of successful learning is happening? I chose Paige Academy as the site for my research because teaching there makes children's cultural identities, expressions and contexts an integral part of the learning culture. The learning culture at Paige Academy provides a rich environment for children's learning because the culturally explicit nature of teaching and learning there helps to reveal how culture indeed plays a role in children's learning. At Paige, children are taught in ways that assume that culture plays a role in their learning.

In this section, I have described and discussed characteristics of Paige as a child-centered, alternative, African-centered school. The history, philosophical grounding, class structures, schedules and physical environment all contribute in significant ways to the community members sustaining Paige as a culturally relevant school. Images of Bro. Joe's teaching convey his efforts to make learning in school fun and authentic for his students. He includes children's interests in developing curricula, and attends to ideas that each student needs to know in his instructional process. Overall he facilitates children's learning in ways that are consistent with the visions of his science workshop as a boy by working to help children at Paige feel comfortable being who they are and being strong learners.

The exploration of Keanna's project construction in Chapter 2 revealed that the exploration of her cultural identity and her active involvement with cultural practices were intertwined with her coming to understand computational ideas in the process of her project construction: for instance,

the thread throughout her projects of thinking about herself as a programmer, led to finally reconstructing her image of who could be a programmer to include herself. Given the description of the culture of Paige, it is possible to make connections between the involvement of cultural identity and environment in her learning and the attentiveness to cultural identity and practice in the context of her school. At Paige, Keanna could explore her identity and be who she is because the fabric of the school environment is designed to nurture her as who she is, an African American girl who needs to learn how to survive and thrive in the world.

3.2 Logo: a constructionist technological media for learning conducive to cultural expression

Keanna and her classmates constructed their projects within the programming environment of Logo.[20] The visions of learning embedded within Logo and the particular characteristics of Logo environments supported Keanna's ability to develop technological fluency that was connected to exploring her cultural identity and experience. In this section, I 1) discuss the historical and philosophical foundations of Logo as a programming environment designed to support learners' engagement with learning; 2) describe the computational objects and ideas that are major components of Logo programming environments which were used with Group 3; and 3) discuss the ways that these computational objects and ideas afforded the development of long-term, personally expressive, intellectually and culturally meaningful projects by Keanna and her classmates.

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[20] I use Logo as a general term for several different programming environments which share fundamental features and intentions of the original Logo programming environment. When I am referring to features which are particular to certain versions of Logo, I name those versions, i.e. LogoWriter and MicroWorlds.

3.2.1 Logo: Technology facilitating new visions of learning and teaching

When Seymour Papert began to use computer technologies for easier access to mathematical ideas, he began by imagining what children could do if they were given powerful computational technologies to explore certain facets of the world. The pivotal characteristic of his new mathematical explorations was that the computer made mathematical ideas that had traditionally been accessible only as "abstractions" more concrete. Papert pioneered the notion that computers would be able to provide children with materials that allowed them to learn mathematical ideas in ways that were as naturally engaging as the ways that young children learn to speak (Papert, 1993). As Papert and his colleagues created ways that computers could be used to make mathematical ideas more accessible they developed the programming language Logo.

Logo is designed as a conceptual construction set or microworld[21] for learning about and learning with computational objects and ideas. Papert describes a microworld as use of computers in which children pursue mathematical activity because the things they are drawn to do in the world shaped by the computer environment requires that they develop particular mathematical ideas (Papert, 1993) All versions of Logo and Logo-like environments such as Lego/Logo (Resnick, Ocko, and Papert, 1988) and StarLogo (Resnick, 1994) share the quality of providing children with computational ideas they can use as materials to build artifacts in the world. These environments are based on the belief that, as children construct projects with these programming environments, they engage with

[21]A mircoworld is described by Papert as "an incubator for powerful ideas." Mircoworlds give children materials that encourage them to invent children their own ideas about a particular subject matter (Papert, 1980, pp. 126-127).

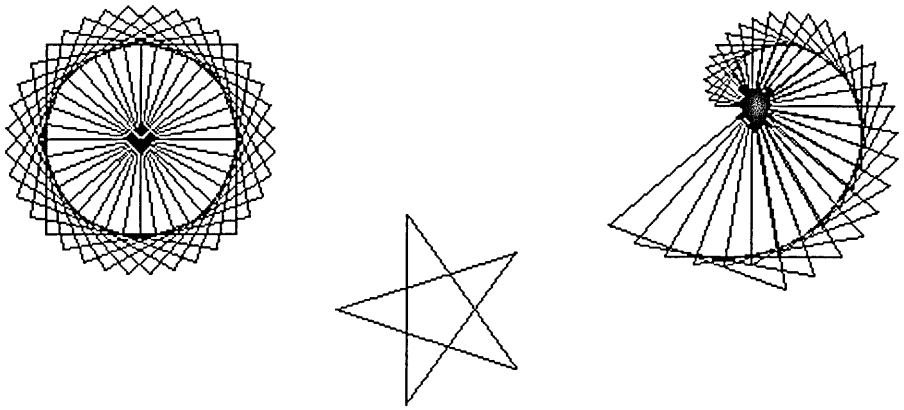
mathematical ideas either that in the past were either inaccessible to them or that they encountered only in contexts of formal learning in school. Papert has articulated this position about learning into the theory of constructionism which states that the process through which children come to understand new ideas in the context of making new projects is a particularly good way for them to learn (Papert, 1993) (discussed further in Chapter 4).

TURTLE GRAPHICS WITHIN EARLY LOGO PROGRAMMING ENVIRONMENTS OFFERED NEW WAYS OF THINKING ABOUT GEOMETRY

Geometry is not there for being learned. It is there for being used. (Papert,1993)

Turtle graphics was the first Logo microworld that gained a broad base of use in schools. Papert described turtle graphics in this early work as conveying new ways of engaging with geometry that would help to usher new ways of learning and teaching into schools. Common to all versions of turtle graphics is an icon on a computer screen called a turtle. It is a computational object with properties of size, shape, heading, position, color, pen size, and drawing. The turtle can be instructed to move around, draw a line when it moves, and take on different shapes when the user enters instructions into Logo. Users can use the turtle to draw a huge variety of designs and pictures including shapes such as squares, stars, and spirals or pictures such as apartment buildings, maps, and rainbows. In the process of creating instructions to have the turtle draw, the user needs to think about how the movement of the turtle can be directed through the path that draws the desired picture The process of thinking about how to move the turtle is the foundation of turtle graphics providing new ways of exploring geometric thinking. The turtle was used as a computational object. Programming instructions for moving the turtle functioned like thinking about moving

yourself. This resonance between personal motion and controlling the turtle's motion was used to make interesting and satisfying pictures. This way of thinking about geometry ideas was not widely used in schools (Papert, 1980).



Typical student designs in early versions of Logo.

3.2.2 Microworlds Logo: A construction kit of computational ideas and objects which children can use to explore the world

MicroWorlds Logo[22] is designed to extend Logo beyond the turtle graphics microworld by adding computational objects to the programming environment offering access to computational ideas that encourage the exploration of content areas other than geometry. In MicroWorlds Logo children can use computational objects such as turtles, colors, buttons, music,

[22]MicroWorlds Logo is the latest version of Logo in the family of versions designed by Logo Computer Systems Inc. (LCSI, 1996) This version is in wide use in elementary schools across the country.

video clips, sounds, and textboxes as their construction materials. The colors are programmable objects that can be used to give added control on the screen. The turtle is more versatile than the other objects because it is possible to create many turtles and assign different procedures to them easily. Turtles can also be assigned variables that can give them attributes such as age or likes and dislikes. MicroWorlds also contains computational objects that allow students to create multimedia projects. Audio and video clips can be incorporated into projects, adding to the possibilities for the kinds of projects that can be created.

A MicroWorlds Logo project starts with a blank project page containing one turtle. The programming environment provides several features for creating projects and managing objects. Instructions for a project can be typed into the Command Center for immediate execution. A Drawing Center allows children to draw onto the background with drawing tools to set the turtle's color and pen size, and to program colors. A Shape Center provides students with set of shapes from which they can select a shape for the turtle and an editor and a drawing palette which they can use to create their own shapes for the turtle. A tool bar provides access to tools for creating and manipulating objects. There is a tool for hatching turtles, creating textboxes, composing melodies, recording sounds, making buttons, generating sliders, importing Quicktime movies, and selecting clips from audio compact discs. (LCSI, 1996)

These objects allow Microworlds Logo to provide for children all of the computational ideas that previous Logos are known for, allowing procedural abstraction, recursion, iteration, data abstraction, and turtle geometry. But in addition, they allow more complex computational ideas to be accessible to

children's creativity. Parallelism, feedback, and basic levels of object-orientation allow children to create more realistic experiences. Keanna and her classmates used MicroWorlds as a construction kit to make a greater variety of projects than they could with turtle graphics alone including animations, video games, and adventure games.

PURPOSE FOR PROCEDURES

When the MicroWorlds environment was first developed, there were arguments about whether some features in MicroWorlds would dilute children's learning of powerful computational ideas. The biggest debate was whether the ability to draw with a drawing palette rather than the turtle would impede children's learning of procedural abstraction and geometry ideas which are the mainstays of the turtle graphics microworld. This was the wrong debate. The point of turtle geometry was not just "geometry in use" but to facilitate learning of compputational ideas through creating graphical images. Papert (1980) considered the specifics of learning geometry this way to generalize an example of a good way of learning. He called this idea "knowledge in use."

My experiences with children at Paige have revealed that children do not resist or ignore using procedures in any way different from when they used LogoWriter. In LogoWriter, it was sometimes hard to get them to write procedures rather than draw shapes in the shape editor. Although writing procedures is difficult, every time a child was invested in the real purpose for writing a procedure, they completed the task of writing procedures successfully. When a child had a reason to write a procedure, she would write the procedure and ask for help when she needed it. The reasons for

writing procedures in MicroWorlds are to a large extent different than those in older versions of Logo. In MicroWorlds projects at Paige children usually wrote procedures in order to create action for the characters they had created on a background they had drawn with the drawing tool. The drawing tool allowed students to make their scenery and their shapes more detailed than with turtle graphics alone. Turtle graphics commands are still used to move the characters through a scene. For example, children learned how to use the commands FD, BK, RT, LT, and REPEAT in order to make a horse run back and forth across a screen that contains their drawing of a prairie, rather than draw a geometric figure. The MicroWorlds environment provides a richer context for learning the same ideas about procedures and geometry that are embedded in earlier versions of Logo.

Purpose for Turtle Graphics

Once children have had some exposure to the kinds of designs that can be made if they use the turtle to draw, they sometimes choose to use turtle graphics for drawing. Children learn what objects are best drawn with the drawing tool and what objects are best created through writing turtle graphics procedures. For instance, if a child wants to create several of the same geometric figures, it is easy to show them that writing a procedure which instructs the turtle to draw a triangle or an octagon is a much more effective way to make their picture than making a shape in the shape editor or drawing shapes with the drawing tool. They notice that the advantage to writing a turtle graphics procedure is not only that they get the equilateral shapes they had in mind but also that they can easily draw the shape again by putting the turtle in a different position and running the procedure for that shape.

As mentioned earlier, MicroWorlds adds capabilities to Logo of creating projects using ideas of parallelism, feedback, and some aspects of object-orientation that children can use to make projects like Keanna's.

PARALLELISM AND REALISTIC NARRATIVES

Children often ask how they can make things happen at the same time in their projects as soon as they see that they can make their projects somewhat like the real world. Children expect the computer to be able to make things happen at the same time if they can make things that are "like the real world." "How can I make all of the horses run at the same time?" "How can I make my man walk across the street and try to avoid several cars that are going by?" "How can I make my music play in the background while my project is going?"

In the previous generation of Logo, it was possible to simulate parallel processing with embedded REPEAT statements. This process was very tedious and difficult for many children to manage comfortably. MicroWorlds makes it possible for processes to be launched so that they can (as far as children are concerned) happen at the same time. For instance, a child might ask "How can I make a dog run across the screen and a bee fly at the same time?" In a fairly short period of time, it is possible to explain how to write procedures with instructions that talk to each turtle and launch those procedures so that they will run at the same time.

There are several ways to implement parallelism in MicroWorlds by running different processes at the same time. Some of these are: clicking on several buttons to get their procedures running concurrently; selecting several turtles that have commands in their instruction boxes and clicking on

them; and using the command LAUNCH inside a procedure will start a process and immediately go to execute the next process. Exploring parallelism is for the students a way to make something that they want to make and to explore their interests in representing the "real world." Learning to add parallelism to their projects in MicroWorlds becomes a task of furthering their understandings of processes and how they can be executed in parallel or sequentially.

OBJECT-ORIENTATION AND UNDERSTANDING WHAT TURTLES CAN DO IN PROJECTS

One aspect of object-orientation is manifested in children using turtles as objects to perform different functions in their projects. Children learn the kinds of things that a turtle can do. These are the turtles' properties or attributes: move, change size, change shape, have position, have heading, have color, draw, have instructions that will run when you click on them, and have their own variables. These are the attributes of the turtle as a computational object which the children talk about as "the kinds of things the turtle can do." Two levels of true object-orientation are implemented in MicroWorlds. On one level, the instruction box associated with each turtle evaluates instructions when the turtle is clicked on. On another level, variables can be defined for each turtle. The next step towards full object-orientation would be to give each turtle a procedures page.

Children sometimes ask if things are possible that are characteristics of a totally object-oriented environment. They express intuition or informal understanding of ideas that form the paradigm of object-orientation. When Rafael made his video games he usually had two characters that punch or hit each other. He wrote a procedure to make one hit and then wondered if there

was a way to use the same procedure to make the other one hit. This is not possible in MicroWorlds as it stands because the hitting motions are created by separate shapes for each turtle because they are facing different directions. Rafael's sense of possibility was hinting at an idea that it should be possible to write a hitting procedure that could be connected to the turtles. This procedure could use the appropriate turtle shapes in the execution of the procedure. This could be an informal understanding of the relationship between the process, the data, and the computational object.

Programming Objects Gives Feedback and Represents Behavior

MicroWorlds provides children with tools they can use to control how and when processes are executed. Turtles can detect how close they are to one another. They can also be programmed to act based on what color is underneath them. Colors can be programmed to execute instructions when turtles or a mouse click touches them. Children can use these tools to use feedback as a way to control action in their projects. Children begin recognizing sensing or feedback as a way to control processes they envision for their projects and simulate reality. Turtles in the shape of fish, horses, cars or anything they create can be set up to race across the screen until one of them reaches a red line. A procedure to make all the turtles stop when they touch the color red can be put inside the instruction box for the color red. When any turtle touches red, the race will be over (LCSI, 1996). Turtles can be given shapes so that the scenery can cause different things to happen. A turtle in the shape of a boy can walk along the scene of a street with buildings. If the buildings are turtles that are programmed to detect if another turtle is touching it, then it is easy to have the building open doors when the boy comes up to them.

This simple control mechanism for an action-reaction kind of process can become a tool that children eagerly engage in programming because it allows them to make their projects more real. They engage in thinking about programming real behaviors like doors opening when you touch them and people starting to swim when they touch the water in a pond. Similar to other kinds of programming ideas, feedback control or sensing (or simple cybernetics ideas) are explored by children in MicroWorlds because children can use them to make their projects more "real."

3.2.3 Conclusions: Students used Logo as a culturally expressive computational environment.

The design of MicroWorlds Logo supported Keanna and her classmates in creating the kinds of projects they wanted to make. The projects that children can make in MicroWorlds Logo can contain a much greater degree of complexity and expressiveness than in previous versions of Logo. The flexibility and variety within these computational materials accommodated individual and cultural expression and ways of thought.

Keanna used Logo to explore her identity and cultural experience. The flexibility and variety of current versions of Logo accommodated both the individual and cultural expression that Keanna's work exemplifies. The children incorporated Logo as a cultural tool because it allowed them to use it in ways that were resonant with their learning culture. For instance, MicroWorlds tools were used by the girls to design characters and do what they referred to as "spice things up." Changes that "spiced things up" were often expressions of their children's cultural identities. And the need to add their aesthetic style in order to feel like a project was complete was consistent with their cultural experiences. At Paige, *creativity* is valued and

MicroWorlds is an environment where it is easy to be creative. At Paige, *collaboration* is valued and MicroWorlds is an environment where children can make collaborative projects easily. At Paige *cultural identity is expressed through design sensibilities.*

3.3 The teaching perspective: Using Alternative Epistemologies to explore ways of knowing that include issues of cultural identity and children's experiences

Keanna's learning occurred within a teaching context. My exploration of ways of understanding knowing were integral to recognizing who children are as a part of their learning during their project construction. This recognition informed the teaching context. My work in the Epistemology and Learning Group at MIT exposed me to thinking about epistemological pluralism. Early observations of children learning to program identified gender differences in styles of programming. I brought to my work at Paige an investigation of alternative epistemologies as ways of knowing from the standpoint of gender and racial experience. Alternative epistemological perspectives informed a lens I used to view my work at Paige and to understand ways that Keanna's work could be recognized as culturally connected. Issues of gender and culture are the basis for alternative epistemological perspectives. I investigated these perspectives for what they could offer to understanding how culture was involved in the learning I observed and facilitated at Paige. Alternative epistemologies provide ways of understanding the intertwined nature of Keanna and her classmates ways of investigating their own issues of identity and constructing new computational ideas.

3.3.1 Alternative epistemological perspectives

> *Representation of the world, like the world itself, is the work of men; they describe it from their own point of view, which they confuse with absolute truth.*
> *(de Beauvoir, 1972)*

There are many different ways of knowing represented in the various cultures and belief systems in the world. There are spiritual ways of knowing the world by which people believe that whatever happens in the past and in the present is a direct result of "divine intervention." Others believe that the world can be understood through instinct, as in the common sense notion of trusting your instincts (called, "mother wit" in some folk cultures). Many people hold that the world can be understood only through directly sensed experience. Still others believe that truth can be found in something because an authority figure declared it. Others make sense out of the world from rules of formal logic, and take stock in the scientific method as a worldview for explaining the truth of nature and social relations.

Just as people will adopt the tonal inflection and dialect of the communities and regions in which they live, people's ways of knowing will be influenced by their experiences in their communities. Some ways of knowing are common among people that share particular *standpoints*. These shared ways of knowing have come to be identified as ways of knowing that are characteristic of that particular group.

> *Although there are other ways to justify what we think we know (for example, divine revelation), the combination of rationalism (which often takes the form of logic) and empiricism in modern science captures the dominant trends in Western thinking. (Nielsen, 1990)*

Rationalism, positivism, and empiricism dominate Western thought. Empiricism is a view of the world emerging from direct observation of the world. Positivism is the assumption that the world can be objectively understood in terms of facts that can be "posited" or laid down. Rationalism is defined by developing truth and determining validity based on logic and pure reason.

> *Traditional canons within Western society have made marginal and silenced out groups whose ways of knowing are unacknowledged and often unseen.*
> *(Harding, 1991)*

Obviously, scientific inquiry is important and yet, even in the West, such stifling traditions as empiricism or positivism should be overcome. Harding's comment exemplifies trends within women's studies and African American studies acknowledging that the voice of those who have been marginalized is instrumental in allowing this progress.

This section is an investigation into ways of knowing that exist outside of the dominant paradigm of Western thought. I have approached teaching with the belief that bringing these alternatives into view within an effort to teach and learn about learning, contributes to extending developmental theories and their application to pedagogy. I present three epistemological perspectives: feminist, afrocentric, and afrocentric feminist, with examples of how theorists within each group tend to develop their sense of truth and to validate their ideas and beliefs.

3.3.2 Listening to alternative epistemologies: three perspectives

This section describes key notions that form the basis of feminist, Afrocentric, and Afrocentric feminist epistemological perspectives. These

notions have been used to rethink theory and practice in natural and social sciences, and also in literature and the arts. These perspectives were central to my approach to teaching at Paige.

FEMINIST EPISTEMOLOGY

A central question in the area of feminist epistemology is: What does it mean to think of scientific knowledge as developing from the lives of women?

> *... conventionally what it means to be scientific is to be dispassionate, disinterested, impartial, concerned with abstract principles and rules; but what it means to be a woman is to be emotional, interested in and partial to the welfare of family and friends, concerned with concrete practices and contextual relations.*
> *(Harding, 1991)*

Since the 1970's much work has been done to articulate feminist theories of knowledge (Harding, 1991 p. 105) Underlying all of the orientations is the notion that "knowledge always involves an awareness of one's social location and this location's relation to lived experience" (Harding, 1990). Many feminist theorists claim that, for women, the nature of knowledge, learning and truth are imbued with a sense of connectedness and situatedness. This connection is possible through including intuitions and feelings in determining the truth of an idea and serve to create a way of knowing that puts the knower in context with the known rather than seeking to separate knowledge from the knower (Belenky et. al., 1986).

CONTRIBUTIONS TO FEMINIST STANDPOINT THEORY

Evelyn Fox Keller has focused specifically on the question of gender and science. She has made a significant contribution to thinking about feminist epistemologies through her examination of the work of the Nobel Prize

winning biologist Barbara McClintock. Her contribution was in redefining the notion of autonomy, to allow subjectivity in the scientific enterprise, and to show that connectedness is indeed a valid way of gaining deeper understanding (Keller, 1985).

Mary Belenky and her colleagues describe what they call "women's ways of knowing" from extensive discussions with women about their lives. Their research characterizes a "concern for context" that permeates women's thinking. The authors define five categories of women's ways of knowing: *silence*, in which women feel unable to voice their own thoughts and see valid ideas as coming only from external authority; *received knowledge*, in which women see themselves as capable of receiving knowledge from external authorities and even of reproducing that knowledge but not capable of creating knowledge on their own; *subjective knowledge*, in which women perceive truth and knowledge as personal, private, and subjectively known or intuited; *procedural knowledge*, in which women adopt objective procedures for obtaining and communicating knowledge; *constructed knowledge*, "a position in which women view all knowledge as contextual, experience themselves as creators of knowledge, and value both subjective and objective strategies for knowing." (Belenky et. al., 1986, pg. 15) These categories offer helpful ways to view characteristics of a woman thinking during the course of growing out of silence to develop her voice.

Collins and Harding both focus on "the advantage of being outsiders managing the outside and inside allowing the creation of a new perspective." (Collins, 1989, cited in Harding 1991) This aspect of the discussion suggests that women can expose the limitations of knowledge production rooted in dominant positions within those fields because they are able to see from a

distance the positivist philosophies and behaviors forming the inside of these fields.

> *A reliable picture of women's worlds of social relations between the sexes often requires alternative approaches to inquiry that challenge traditional research habits. It is not only that the underlying general principles of scientific method are not powerful enough to detect culture-wide sexist and andocentric bias but also that the particular methods and norms of the special sciences are themselves sexist and andocentric." (Harding, 1991)*

Carol Gilligan identifies forms of moral reasoning used by women that are different from dominant ethics formed from studying only men's reasoning. Gilligan claims that relationship is a key influence on how women think in general and on how their moral reasoning develops in particular. Gilligan also makes the point that women tend to reconstruct an ethical standpoint for each individual case of moral dilemma, instead of "applying" general rules of moral conduct to particular instances.

In summary, a major contribution of efforts to articulate a feminist epistemology is to bring back to the center of discussions about teaching and learning the ideas that: to know is to relate; we are engaged in our object of inquiry; connectedness is a means for gaining deeper understanding; and situated knowledge is as relevant as abstract knowledge. Bringing these ideas back to schools and valuing them can help many girls to grow and become confident in their abilities to learn.

AFROCENTRIC EPISTEMOLOGY

African-centered epistemology is an articulation of aspects of world views from the African American experience.

> *In contrast to Western, either/or dichotomous thought, the traditional African worldview is holistic and seeks harmony. 'One must understand that to become human, to realize the promise of becoming human, is the only important task of the person,' posits Asante (1987, p. 185). People become more human and empowered only in the context of a community, and only when they 'become seekers of the type of connections, interaction, and meetings that lead to harmony.' (p. 185). The power of the word generally (Jahn, 1961), and dialogues specifically, allows this to happen.* (Collins, 1990, p. 212)

There is a fundamental idea in discussions of African-centered epistemology regarding how knowledge is formed from a place that *values harmony rather than individualism.* Ideas have meanings based on how they offer a person's individual creativity, talents, and efforts to promote harmony among the group.[23] Many African Americans are faced with situations that emphasize individualism and profit over community connection. But the values that define our culture suggest that this kind of focus was not designed for us, but for the dominant cultural group of European Americans in the United States. As groups outside of the culture of power, these values are not designed to benefit us. This is another case of "the master's tools never being able to dismantle the master's house." (Lorde, 1984)

The main assertions of Afrocentrism have emerged as fuel for critiques of ideologies and practices within several fields, including science, math, and education. Molefi Asante describes the primary assertion that African-centered thought is a way of knowing which is derived from African roots formed through an African American experience (Asante, 1987). To him, the ways in which ideas are given form and meaning are intimately connected with the media and styles of communication. How we express ourselves is as important as what we say. In other words, the meaning of what is said is

[23]The term "group", in this case can refer to family, church, community, or African Americans as a cultural group.

affected by the way it is said. Asante refers to the idea of the power of the word as the concept of *nommo*. Nommo expands forms of speaking to include expression through music, dance and art as well as conventional oratory styles. For instance, truth can be expressed in jazz in a unique way. And, rap exemplifies a contemporary form of musical storytelling.

The way we use language is an important characteristic of our experience. Asante describes how our knowledge is linked to our oral tradition, and our oral tradition to our resistance to oppression. This speaks to what we learn through stories and how we share things through discussions. Developing knowledge in an oral tradition doesn't require a written representation to validate it. Asante gives many examples of famous black orators. These orators, like Nat Turner and Marcus Garvey, conveyed provocative knowledge about the circumstances of African American people and how to resist oppression and choose freedom. The power of their words came through how they delivered their speeches as well as the activism in their lives. Their written words made an impact too but mostly because their spoken words provoked people to consider new ideas.

The harmony that Asante describes as a part of afrocentric thought rings true to me from personal experience. I can describe many events I've experienced where knowing in isolation from others has not been useful. An example of knowing in community that is connected to oral tradition comes from going to church and experiencing the spontaneous participation that happens throughout the service; vocal "calling out" is heard whenever people are moved to speak. There is an understanding that what you experience as an individual is enhanced by, and is intended to be a part of, participating in a community. In practices after a death, the family is usually

broadened and supported by members of the community. The message conveyed by an African American minister that is commonly conveyed through the cultural practices in Black churches is "White people say 'I think therefore I am'; while Black people say, 'I am because we are.'"

In summary, a major contribution of articulating African-centered epistemology is to bring back to the center of discussions about learning and teaching the importance of harmony, the roots of understanding in experience (or authenticity), oral tradition, and the meanings communicated through forms of expression.

AFROCENTRIC FEMINIST EPISTEMOLOGY

As we come more into touch with our ancient, non-European consciousness of living as a situation to be experienced and interacted with, we learn more and more to cherish our feelings, and to respect those hidden sources of our power from where true knowledge and, therefore, lasting action comes.
(Lorde 1984)

African-centered feminist epistemology is an epistemological alternative derived from the experiences of African American women, our particular struggles, and the particular ways we learn to survive and thrive. African American women's ways of knowing are distinct from the dominant paradigm in that they include an interplay between emotion and intellect as a way to understand an idea. There is a connection between what is felt about something that helps to understand it. There is also a sense that what you know about a person affects whether you believe what they say. The use of dialogue is a characteristic within the African American Diaspora that carries on a definitive role in black feminist thought.

Patricia Hill Collins is a black feminist theorist who offers a formulation of contours of an African-centered feminist epistemology. The key experiences

she draws from are "alternative sites such as music, literature, daily conversations, and everyday behavior." She uses authenticity as the core of the definition of black feminist thought. Her claim is that for African American women, talking from experience feels more authentic than "patching" from other people's thinking. Collins proposes a theory of African-centered feminist epistemology that has four key elements. These elements relate to how meaning is constructed through concrete experience, using dialogue, an ethic of caring, and an ethic of personal accountability.

One dimension of African-centered feminist epistemology is how meaning emerges from concrete experience. The way you know something is through the concrete experience of connecting with it. The idea of ridiculing or being skeptical about "educated folks" because "they have 'book learning' but no 'mother wit'" is an illustration of this dimension (Smitherman, 1977, cited in Collins, 1990). "Book learning" means that you may know a lot in academically defined areas, but if this "knowledge" is not connected to life experience, it is not as valid as the wisdom growing out of being reflective and expressive about your personal experience.

Dialogue, speaking and listening to others, plays a predominant role in how we build new knowledge. The *call-and-response mode of discourse,* which can be found in many aspects of African American culture from churches to storytelling, is an example of how dialogue is used to make sense. There have also been linguistic analyses of Black English which illustrate thinking in terms of dialogue:

> *There is no passive voice constructions possible in Black English. For example, you cannot say, ' Black English is being eliminated.' You must say, instead, 'White people eliminating Black English ... every sentence assumes the living and active participation of at least two human beings, the speaker and the listener.*
> *(Jordan, 1985, pg. 129 in Collins)*

Collins describes the making meaning with an ethic of caring as a dimension of black feminist thought composed of three values all rooted in the idea of "talking with your heart." One value is placed on *individual uniqueness and expressiveness.* Quilt patterns are a beautiful example of this value: Each piece of a quilt made by African American women may be visually unique and representative of different life experiences but the individual pieces are incorporated into a coherent and often strikingly artistic whole.

The second value within Collins' ethic of caring is the *appropriateness of emotions.* You are "expected to say what you think in the way that you feel it." The meaning of your speech is conveyed not only by the words but also by the emotions. A vivid example of this perspective is presented as Aretha Franklin (1967) cries for R-E-S-P-E-C-T . If it wasn't a soulful cry, it would not mean the same thing. The final piece of the ethic of caring is the *capacity for empathy.* This is a capacity which involves caring about other people's ability to feel your emotions. The growth of this empathy is key to an ethic of caring.

Collins' shaping of an alternative epistemology is completed by the idea of an ethic of personal accountability. This means that "what you personally believe is important" and the fact that you believe it influences the understanding of what you convey. The salient feature in validating meaning here is that *what you say has got to be associated with who you are.* You have to connect yourself to what you are saying and take responsibility for it.

An epistemology from the lives of African American women helps to refocus discussions of learning and teaching to notice concrete experience, dialogue, an ethic of caring, and an ethic of personal accountability as central elements in creating inclusive learning environments for African American girls and women.

The discussion of afrocentric feminist epistemology also highlights the fact that this section presents the alternative epistemological perspectives provided by feminism, Afrocentrism, and African-centered feminism as fairly separate constructs, yet they are of course more connected than it seems in this presentation. The threads of experiences of lives of people belonging to the representative groups makes these connections. The lives of African American women include elements of each of these perspectives. Women and men belonging to various groups by background and location can adopt values reflected in these epistemologies for several different reasons. As mentioned in the introduction, it is a matter of which perspective has the greatest influence on the epistemology that each person forms at different times in his or her life. It is important to be able to discuss differences to support recognizing the need to include them in discussions of education as well as critiques of other fields where voices from these perspectives are not heard.

3.3.3 Conclusion

So far I have described how scholars have postulated that the way one comes to look at the world is influenced by the particular standpoint one has as a member of a cultural group. Feminist theorists have described how they see women's views of the world as different than those of men through an

emphasis on connection rather than separation. Ideas of African-centeredism describe ways of viewing the world that are predominant in African American cultures rooted in harmony and meaning through expressiveness. An attempt has been made to delineate an African-centered feminist epistemology that characterizes the ways that African American women evaluate truth and are most comfortable developing new knowledge for themselves and for others.

There is a common thread through these perspectives that favors a relationship between knowledge and the knowers; a connectedness in the process of learning; and a productive interaction between subjectivity and objectivity. These commonalties form an alternative to the emphasis on separation between subject and object, distance between the knower and the known, and the goal of learning as an abstract understanding that characterize canonical paradigms. How did these perspectives inform my teaching at Paige Academy?

I take the position that scientific ideas can be situated and grow from children pursuing their own interests: for example, in baking bread, watching a disk float, or drawing a picture on the computer. The ways in which learners elaborate on ideas and twist and turn through the experiences they choose reflect their particular epistemology. Educational institutions, from teachers to superintendents, need to be aware that children's learning and development is not just a matter of motivation or special needs, it is also a matter of epistemological orientation. With this awareness, steps can be taken to rethink and redesign learning activities and environments to address epistemological influences.

At Paige I tried to create engaging learning environments that supported the construction of knowledge, the empowerment and the self-esteem of the teachers and students. I came to realize the complexity of this goal. In the past, I thought that taking a constructivist view of teaching and learning was the "answer." This perspective led me into conceptualizing a theory of learning and activities for learning that focused on people as the builders of their own cognitive tools. I have come to see that while a theory of the learning process that views children as constructing their own knowledge is essential to creating engaging and empowering learning environments, it is not sufficient to support change in the reality of schools and society. Part of the reason why purely constructivist theories of learning are insufficient is that they do not address aspects of students' relationships to knowledge that are connected to gender and culture.

The ways that schooling is traditionally designed and implemented are formed from dominant sociocultural positions and perspectives. The fact that I, as an African American woman, think about thinking in an inclusive rather than competitive way contradicts the dominant paradigm.

> *We have to be explicitly recognized as who we are in order to feel comfortable and not have to struggle ridiculously in order to survive.*
> *(Lorde, 1984)*

Paige Academy–through its characteristics as an alternative afrocentric school–exemplifies a learning environment that is, in my view, inclusive. It is inclusive because the students know that they can express their opinions about their learning. They know that they are supported in finding a "hook" into learning. Learning is both a community and individual activity, and there are a tremendous variety of forms of expression available to children.

Many current reform movements in education are driven by the application of Piaget's theory of children's cognitive development Aspects of his theory that focus on children as builders of their own cognitive tools has created a powerful drive in mathematics and science educational research and practice. His stage theory of development is considered problematic because some people have interpreted it to support a view that all learners develop the same ideas in basically the same ways. From this interpretation of stage theory, it is possible to view constructivism as a position that is not inclusive of alternative epistemologies. Even though Piaget's theory is rooted in observing children's thinking in a variety of situations with a variety of children, the notion that development is a march towards formal, abstract thinking (as though all other thinking is subordinate) is evidence of the roots of Piagetian theory in the dominant positivist paradigm (which privileges abstract thought and scientific method).

It is obviously important to know that infants are understanding the world in a way that is intimately connected to what they can see and touch (often with their mouths). It is incredibly important to know that a six-year-old's understanding of the number six is intertwined with knowing that if she had six cookies, she could share with more friends than if she had two cookies. Piaget's theory is good at helping to recognize that the six-year-old's idea of more is connected to her experiences.

Given the roots of Piaget's actual view in learning from experience, he would not consider a standardized test to be a viable learning experience. However, Piaget's theory has been used to support, for example, the position that a thirteen year old who scores low on a paper-and-pencil standardized test is developmentally delayed in his ability to think abstractly. This kind of

"application" of Piaget's stage theory is problematic if utilized to determine that a culture which relies on concrete representations of math (and for instance, does not apparently have a calculus) is intellectually inferior to Western cultures. This intellectual superiority is based on the fact that Western cultures focus the goals of their mathematics on highly abstract thought and symbol manipulation.

According to the alternative epistemologies as standpoints of human experience, it is possible to consider Piaget as a white male scientist and psychologist who viewed the definition of truth to be controlled by what he could prove logically through strictly designed experimental methods and reasoning. Some people who hold alternative perspectives might question whether he would accept a theory that recognized a constant interplay between concrete and abstract thinking.

3.4 Computer Class: a place for learning to make your own computer projects

Keanna's creation of "computer projects" occurred in the context of concert a computer culture at Paige that grew within a Computer Class. Computer Class was held during all four years of her project work. Rather than organize this description of the class chronologically, I have arranged it according to four of the most salient shifts in the class. Before describing and elaborating on these four shifts, let me briefly describe the setup and logistics of Computer Class.

3.4.1 Setup of Computer Class

I was very much both a facilitator and a participant in Computer Class. As a teacher, I was in constant search for ways to help Computer Class be more like what I began to understand as ideal for learning at Paige. I wanted to create sessions in which children would work to create projects and in the process think about computational ideas because they cared to understand and express themselves with them. What were some of the different ways that students worked during Computer Class? What were some of the different approaches to teaching during Computer Class?

Computer Class consisted of several different kinds of activities and interactions. The structure of the class sessions changed over time as children became more technologically fluent and in response to particular situations in the class environment, such as the mood of the class, preparing projects for demostrations or contest entry, or constraints of time. Class sessions were predominantly focused on work with individual students and small groups on their projects in a workshop or studio fashion. Class experiences also typically included the following activities that were supportive of project work. Some of these elements are explained in more detail below:

- Explorations
- Idea Projects
- Students' sharing of what they have done in their projects and plans for next steps
- Working with students individually on options for how to think about solving problems in constructing their projects
- Sharing projects with peers, younger students, parents, or visitors
- Sharing projects outside of class at Media Lab Open Houses and Demo Fairs or CompuFest Awards presentations of MacWorld

- Visits to the Computer Clubhouse or the Media Lab for work with other media technologies

Elements and Logistics of Computer Class

My approach to teaching Computer Class was formed by several goals. I wanted to help children develop a sense of what was possible for them to do with Logo. I tried to encourage them to challenge themselves. I worked with children more individually and in small groups than as a whole class, aiming to understand the ways they thought about ideas the involved in their projects.

Over the years of Computer Class, we used several versions of Logo and several generations of Apple computers. The first year of Computer Class, 1991/92, we worked on Apple IIgs computers running LogoWriter 2.0. During the second year we made a transition, starting in January 1993, to using both LogoWriter and MicroWorlds Logo on Macintosh computers. In the fall of 1995, we switched from using MicroWorlds 1.02 to using MicroWorlds 2.0. We never had less than four, or more than seven, computers to use.

During my first two years of working with students at Paige, I taught Computer Class regularly to all of the children in the elementary school. As I began to shape the focus of this research towards following children's thinking as they became more expressive in their programming, I changed to teaching Computer Class regularly only to Group 3. Since the oldest children were in Group 3, most of them developed enough experience working with Logo to begin to create their own programming projects. Students in this

class ranged from ages 7 - 12 and were developmentally more prepared to create extensive programming projects. I also became interested in this class because the daily life of this group seemed to represent many of the expressed goals of the school and ideals discussed within the community. Keanna's assertiveness in learning to make computer projects, her role as a leader in the class and her development in thoughts about herself in connection to her accomplishment in understanding programming ideas led me to choose to develop her case study as the foundation of this dissertation.

Computer Class was held anywhere from once to three times per week over the duration of this study. Sessions lasted different lengths of time ranging from 45 minutes to 3 hours. The length of time was dependent on the schedules of other classes and the kinds of work that needed to be done. Computer Class also sometimes meant field trips to the Computer Clubhouse or the Media Lab to work on computers with different capabilities, new software, or demostrations of new media technology research.

The students describe me as the "Computer Teacher" but other people often helped the class either regularly. Bro. Joe often taught with me and sometimes held class when I wasn't there. Several undergraduates who worked with me came to Paige as "computer teachers" once or twice per week.[24] Many visitors came to the class and were soon helping children in any way they could, consistent with the practice of the school that anyone who sits in a class for any period of time is called on to work and not just observe.

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[24] The undergraduates who worked with me through the Undergraduate Research Opportunity Program at MIT included: Shawniqua, Rosalie, Jennifer, Berenice, and Isaac.

I usually brought the group together in the beginning of class sessions. During this time we would focus on new explorations or Idea projects, listening to each student share plans for what they intended to accomplish that day, or discuss plans that would affect the whole class, such as arrangements for entering Compufest or going to a demo fair at MIT. After the class discussion, the bulk of class time was spent in a design studio or workshop format where children worked freely on their projects and teachers worked closely with students to figure out how to create aspects of their projects. Teachers were often called by students to help them with programming. It was also common for teachers to help students plan their projects with ideas they could realistically accomplish given the time and complexity constraints. Class usually ended in a staggered fashion with each child leaving class once they checked in with a teacher about what they had accomplished that day and planned to do next. Occasionally class would end with a group discussion about what was accomplished or arrangements for special events.

3.4.2 Four Lines of Development in Computer Class

There were four shifts that developed in the class over time and contributed to Keanna's work. First there was a shift from Computer Class being more *teacher-centered to more child-centered.* There were several factors that contributed to this shift, including children's growth of understanding programming in Logo and the development and access to technologies with features that progressively improved possibilities for independent exploration. Intertwined with the progression towards a more child-centered environment was the shift from students working on *projects that were suggested by a teacher to projects that were initiated by students.*

Early work in computer class primarily took the form of the teacher providing structured activity sheets, which I called "Explorations," for students to work through in one or two classes. In contrast, during the last year of this research students were resistant to the teacher's suggestions for their projects. Students considered the purpose of Computer Class to be helping them design and create their own projects. As time moved on, there was *an increase in the appropriation of computational ideas.* As students developed greater understanding of computational ideas the desire to understand and utilize computational knowledge became a part of the classroom culture. One indication of this development was the students' appropriation of the idea of procedure. The idea of "procedure" became a part of the process of creating projects. Students talked about procedures and asked teachers to help them write procedures. Younger children talked about writing procedures as an idea they looked forward to learning when they began to "take Computer Class."

The *shift in attitudes about programming* also constitutes a prominent line of change of Computer Class. Keanna's shift in this regard was echoed in a general attitude among the students. In the early years, students resisted describing what they were doing as programming. Their attitude towards programming changed once they started to work on and accomplish projects. The association with using a programming language became located within their own environment rather than within an imagined stereotypical computer programmer.

DEVELOPMENT FROM A TEACHER-CENTERED TO STUDENT-CENTERED CLASSROOM

The overall character of the learning culture changed during the first two years of the project from being largely teacher-centered to a predominantly child-centered class. Its child-centered nature is reflected in the fact that for the last three years, children viewed Computer Class as an environment that was centered around them working on their own projects. They saw my role primarily as helping them to create their projects. If I wanted to show them something new, I had to negotiate with them for an understanding that it would be fun and/or have a purpose that would benefit their project work.

The fact that the children had taken ownership over Computer Class was a reflection of the culturally relevant nature of the school. As mentioned earlier in discussing the culture of Paige, children learned to assert themselves as learners. They expected teachers to offer them valuable things to think about and they resisted when they didn't think an experience was fun or engaging their interests. One aspect of making it fun and interesting involved how well it supported their connections with other people. Their actions were driven by the following questions: Was it something they wanted to make? Was it something they would be able to share? Was it something they could work with each other to do? Was it something that was helpful to someone else?

When children asked me how to make something and I wanted them to recognize that there were many ways to create the process they needed, I usually described two options that I thought they could use and asked them to choose the one they wanted to use. For instance, on February 1, 1994, Shanay was trying to make all of the characters in the *Wacky World* project go into a door and have the door shut behind them. One strategy for creating this

action was a straight forward counting of steps and the other strategy involved learning how to program the door to sense the last turtle going in. Shanay listened carefully to each option and chose to do the second one. I tried to use situations like this to value children's thinking by allowing them to choose the way they wanted to solve their problem. I wanted to encourage them to know that there were choices in how to create the actions they envisioned and to assert their own ways of thinking about programming.

DEVELOPMENT FROM ASSIGNMENTS TO PROJECTS

During the first year of the projects, school year 1991-1992, the class focused on turtlegraphics projects that I designed for students every week. My goal was to help them to become familiar enough with turtle graphics commands and writing turtle graphics procedures to create designs that they would begin to want to create their own projects. I remember a tension in those early classes when the students sometimes didn't want to do what I planned for them, yet when I suggested that they make their own projects, they shied away from taking initiative.

I prepared what I called "Explorations" for the students each session. The explorations used turtle graphics commands to make designs like a bug, glasses, or a train made out of squares. The usual structure of a session was to introduce the exploration, have students work through the exploration and then make their own additions and modifications to the picture they created.

The students seemed to respond well to this kind of structure. At this point, they had a tendency to become distracted when I gave them time to create what they wanted to create without an "assignment." Once they became more comfortable with writing their own procedures they began to make

progress in creating their own projects. There were several moments for most of the children where they seemed to take a leap in independence and expressiveness when they made a project with procedures of their own initiative. Keanna's *Apartment Building* project is an example of one such project. (see Chapter 2) Seeds for developing the notion of project seemed to start to grow as the students became more comfortable with making their own procedures. By the time we began to get Macintosh computers and MicroWorlds in the fall of 1993, the expectation of making their own projects in Computer Class started to become more prominent than expecting me to give them an exploration.

The second year of research in Computer Class, school year 1993-1994, was a year of transition in many ways. We began the year continuing to work on the IIgs's with LogoWriter and ended the year working primarily with MicroWorlds Logo on Macintoshes. Students began the year with some of the apprehension and resistance to creating their own projects they had held the year before. By the end of the year Computer Class for Group 3 had become driven mostly by the goals that each child had for creating his or her own project. I didn't have to spend much time creating assignments or explorations to help them to become engaged in creating something. They often came up with their own ideas for projects and my discussion with them became more of helping them to think about their projects in ways that they could actually accomplish.

At first the tone of class was rooted in my telling the children what they needed to do in Computer Class. By the end of the year, a shift had occurred. Students in Group 3 became much more independent about what they needed to accomplish in Computer Class. This independence seemed driven

by a more comfortable notion of creating their own "Projects." Through the stories that follow, it seems that they also gained independence in their work from gaining fluency in programming (Papert, 1991).

The *Elephantbird Project*

In late fall of 1993, The *Elephantbird Project* was the first watershed experience for the notion of project taking hold in the class. In this project, each child created her or his own animation for an Elephantbird along with scenery to accompany the bird. The idea for this project came from one of the students reading a book about "two feature creatures" and Bro. Joe developing a thread of discussion he heard among the children about whether or not there could really be an Elephantbird. This class developed spontaneously with Joe asking each child to draw, with paper and pencil, their ideas of an Elephantbird and explain their theories of why an Elephantbird would look like their drawing. Bro. Joe and I then modeled what we imagined we could make this creature look like in the LogoWriter shapes editor and we modeled an animation of the bird flying with wings flapping. We developed and acted out and wrote the following procedure for the class to model:

```
TO FLY
REPEAT 10 [SETSH "WING1 FD 3 SETSH "WING2 FD 3 SETSH "WING3 FD 3]
END
```

The class assignment became, "Create your own flying Elephantbird in Logo and create a scene in which the Elephantbird is flying. You can also make your own thing to make fly or move in your own kind of animation."

This project captured the students' interests and each child became invested in creating her own version of the project. Several elements seemed to converge in this project that helped the class to internalize and begin to exhibit a stronger sense of project. Everyone collaborated on creating the idea of the project. Everyone thought together about programming the animation.

> When the program became an assignment for everyone to try, it was structured around making the animation and a background scene but was also open-ended so that students could develop their own ideas for the action and the animation.

The idea of creating an animated story that was planted in the culture of the class during the *Elephantbird Project* began to grow when we began to use Macintosh computers and MicroWorlds Logo. The goal of making projects in Computer Class was facilitated by two MircoWorld's features: 1) the ability to create scenery with the drawing tool and 2) the ability to create more sophisticated shapes for the turtles. These tools seemed to advance the sense of project primarily because they made it easier to create projects that told stories.

By the Spring months, students began to move ahead with their own ideas for projects and I began to design and develop (with the assistance of undergraduates who worked with me) what I called *Idea Projects* in order to support rather than frame students' work. I felt that once students' own projects became the focus of the class, my way of teaching needed to become responsive, presenting them with options for projects they could make and ideas that would help them learn more programming and support their work on their projects. *Idea Projects* provided examples of pieces of programming or features of the MicroWorlds programming environment that I wanted students to work with, figure out, and incorporate into their own projects. One example of a project inspired in part by an *Idea Project* was the programming of growing and shrinking in the Wacky World project made by Keanna, Shanay, and Shamia. They were exposed to the use of `SETSIZE` and

SIZE in an Idea Project with buttons that made a dog and a bee grow or shrink.[25]

During the school year 1994-1995, the notion of creating computer projects began to mean drawing backgrounds and writing procedures. Even though the types of projects were varied, i.e. animations, interactive stories, and games, each project shared a process of moving back and forth between primarily working on drawing or primarily programming. Even the youngest students in the school were picking up on the project culture of Computer Class. Several times I came into the school and faced several of the Kdg. and First graders in Group 1 asking me, "Are we going to have Computer Class today?" and "When can we learn how to make a procedure?" These questions from the youngest students were an indication that the idea of writing procedures had developed some degree of shared meaning among the students. Procedures as an important part of making projects had become a shared idea in the school's computer culture.

Asia, one of the younger students in Group 2 (there were only two groups that year) said to me during the Spring of 1996 "Sis. Paula, what do you have for us today?" Her question made me think that *Idea Projects* had become part of the culture. It was an indication that the students expected me to create them. But these projects had a more complex role than they had when we first began making them. In previous years, my goal was to make examples in order to help students understand new ideas and generate new possibilities for their projects. During this year, we created *Idea Projects* in response to requests children had for figuring out parts of their projects. I wrote about some of these issues in my notes:

---

[25] This Idea Project was designed by Jennifer and me and constructed by Jennifer.

Writing procedures and projects to help students think about what they want to do has become clearer to me. But, these issues raise another set of issues about how I organize giving new idea or practice projects? Should they be for each child, every time? Or, should they be created for children that seem to need it most each time and sometimes for the whole group.

For the younger students, we created projects to help them think about programming colors and turtles because I thought that they would enjoy thinking about controlling their projects in new ways. The older students were taking clear initiative in creating their own projects, so they prescribed the kinds of *Idea Projects* they wanted to help them with their own projects. For instance, Keanna and Shamia asked for an *Idea Project* that would help them to create a clothes changing project (refer to the learning story *A Different Keanna* in Chapter 2). Rafael was interested in keeping track of depleting energy for characters in his video game, so we designed a project where a character was going shopping and to the movies with an amount of money that was depleted when he entered each store. The *Idea Projects* for the older students were suggestions of ways for them to create what they wanted to create. They were purposely created in different contexts and with some differences in the programming so that the student would be able to take the idea, modify it and make it her own. Often students had an idea of what they needed their code to do and what was possible but the specific code was too complex for them to figure out on their own and within the bounds of their patience. *Idea Projects* then served as objects for them to think with about constructing their projects (Papert, 1980).

Appropriation of Computational Ideas

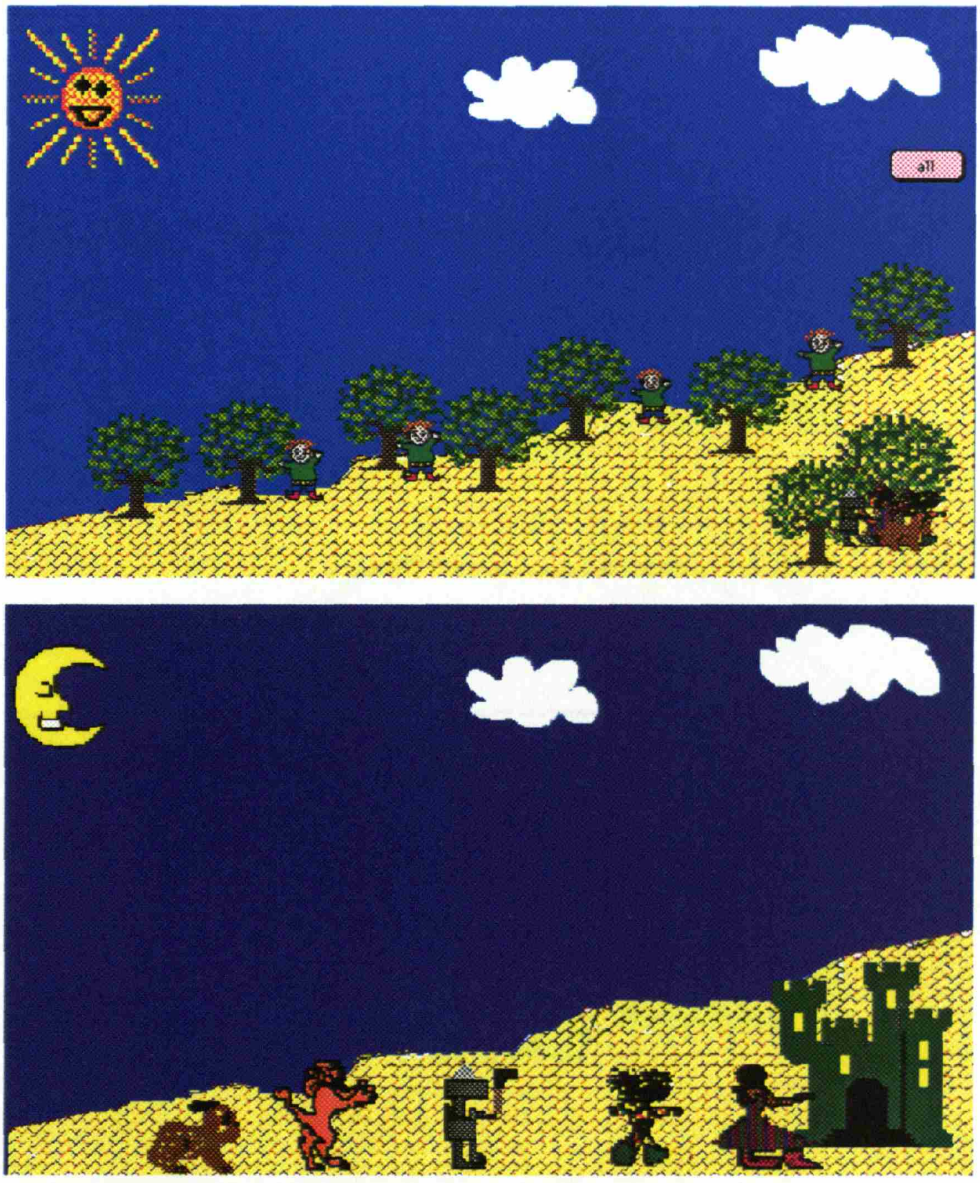
When children began to write their own procedures, they began to follow their interests more, they began to express their cultural identity more, and

they began to ask to learn new programming ideas for the purpose of creating their projects. For instance, when Shamia began to create her rainbow for the background of her Elephantbird project, she became engaged, with help from Bro. Joe and me, in creating a procedure that made arcs of different sizes. This was one of the first times during the class when I noticed a student becoming intensely invested in thinking about a complex computational idea because of the purpose of creating her own project. Her project became creating a procedure that would draw her design. He goal became a personal goal that happened within the boundaries of Computer Class but it was not something she wanted to do for the class, it was something that she wanted to do for herself.

As Shamia made her rainbow, I also began to notice more instances of students helping each other and praising each other for their work on the computer. One exciting example of this situation was when Maisha said, "You go girl!" praising Shamia as she created the arcs for her rainbow. Maisha's praise was an acknowledgment of Shamia's intellectual engagement in figuring out the computation and programming for her rainbow. Prior to this, I had noticed children praising each other this way only in situations outside of class, such as in choreographing dances during lunch time.

Programming ideas were becoming a valued medium for children's expression. Programming ideas were becoming part of the learning culture for these children. Children began to see programming ideas as a way to make what they wanted to make rather than something that I planned to teach them.

The line of developing narrative projects grew in sophistication and investment when Antonio came up with the idea to make his own version of a movie, *The Wiz.* He called his project, "The Wiz 3"and worked steadily on creating a scenario that could show the story. He created two pages; on the first, munchkins stood on a hill above the yellow brick road and could wave when clicked on. Then he created shapes for all the major Wiz characters Dorothy, The Tin Man, The Lion, The Scarecrow, and Toto. He wrote a procedure for the turtles wearing these shapes to walk down the yellow brick road until Dorothy touched the brown of a tree trunk drawn at the edge of the screen. Then the screen switched to another page with a night scene where the sun set, the moon rose, and they continued down the road to the Emerald City. Once at the Emerald City, they each appeared to go inside by disappearing when they touched the color black on the door.



Pictures from *The Wiz3*

Several characteristics of MicroWorlds made this project not only easier to create than in LogoWriter but more possible to envision. These characteristics include: drawing shapes with different colors, creating several pages for one project, programming instructions inside of the turtles, and programming the colors. The procedure for this project held a different kind of sophistication than projects that Antonio had taken some independence with in LogoWriter i.e., the exploration of stars with different numbers of

points that he was quite invested in for a few sessions during Spring 1992. These procedures involved problems such as: setting the heading for the turtles to walk down the yellow brick road in the right direction; figuring out how many times and what length to repeat their steps forward so that they would make it across the whole screen at a reasonable rate; learning to use the colors to control making the turtles disappear; and page turning. The programming changed when we began to use MicroWorlds but the programming also became more a part of the students owned culture when making their own versions of movies became a trend in the class.

The third year of Computer Class was when Keanna and her friends created several extended projects: *Magic Circus, A Town Called Spookton,* and *The Fairy Tale Project.* There was a trend among other students to make not only interactive narratives but video games and educational games. One key common aspect to the sense of project that became clear during this year is that students wrote procedures for purposes that needed procedures and they used other features of the MicroWorlds environment whenever they could. For instance, the boys tended to spend a lot of time drawing shapes for their animations. But when they needed to create the interactivity for their games, they engaged in learning programming techniques for single-keystrokes and detecting turtles' positions on the screen. Keanna's group used procedures for very specific purposes in *A Town Called Spookton* because the main flow of interaction was based on clicking turtles that were parts of the scenery.

I began to notice, when children began to frame and execute their own projects, their use of the words "program" or "programming" seemed to disappear from the class. Students talked about figuring out how to make their projects. I consciously avoided using the terms "writing programs" in favor of "making projects" or "writing procedures" because I felt that if used these terms as the teacher, there was a risk that they would think about programming as something other than just a way to get the computer to do what they wanted it to do. There were also times during these early classes where the students, particularly Keanna, Shamia, and Shanay would talk about programmers as "geeks," "nerds," or describe images of white men with glasses, white coats, and pens in their pockets. I was personally hoping that their views would change from experiences with Bro. Joe and me working with them. I also invited undergrads who are people of color to work with us in the classroom.

I did not want to support their stereotypical images becoming entrenched barriers to their sense of themselves doing their projects or even envisioning themselves as programmers. Years later, Keanna's work particularly showed that not reinforcing those stereotypes, and allowing them to think of their work in Logo as their work creating their projects rather than "programming," paid off. (refer to Keanna's case study in Chapter 2)

3.4.3 Broader notions about Project, Child-centered Classroom and Constructionist medium emerge from developments in Computer Class

The shifts that occurred as Computer Class "grew up" within the culture of Paige offer new nuances of meaning to the stages of development of ideas

of project, child-centered classroom, and constructionist materials for learning.

PROJECT

During late winter of 1995, right after we had sent in entries to the Compufest95, Bro. Joe suggested that we design a project for the students that would help them to learn about parts-of-speech. We designed a project that involved each child in writing procedures to generate sentences by combining random lists of words. This project became known as the *Sentence Generation* project. Students worked on the project for about three weeks and created several variations on the procedures that we designed and first gave to them. By the time that we began this project, it had become common for students to spend most of their time in Computer Class working on their own projects. Often time was spent in the beginning of class working with new *Idea Projects* or solving a programming problem that one student had that seemed to offer important knowledge to all children.

Given the fact that students working on their own projects had become the norm in class, it is not surprising that when students overheard Bro. Joe and me planning for the *Sentence Generation* project during lunch one day before class was about to start, they had a particularly adamant reaction against it. They made statements like: "We don't want to work on that." I asked them why they didn't to do what we were planning for them. They said, "Computer Class is not for us to do projects that teachers tell us to do." "Oh," I said, "What is Computer Class for?" The students replied, "Computer Class is for students to do their own projects and teachers to help us do them."

This was a pivotal moment for me because I realized that over the span of about two years the notion of project for these students had gone from something that they resisted doing because they felt they didn't know how to do to something that they owned to the extent that they would resist not doing it. Outside of Computer Class several different notions of "project" existed. One example of project was described in the *Fish Pond* story (see section 3.1.2). In this situation, several students were involved in the project of building a pond because Bro. Joe asked them to do it. This project was a way for them to help someone they cared about. They knew that he cared about having a pond in the backyard to beautify the grounds of the school and that he cared about them thinking through solving the problems involved in the construction of the pond.

Several aspects of the idea of project are brought out by a contrast between the *Fish Pond* project and the notion of project that grew to be the norm in Computer Class. Both notions of project have a sense of authenticity that is different than completely teacher-defined projects that are common within traditional school situations. In traditional classrooms it is a common notion for a teacher to assign a project that means creating an object that addresses some curricular requirement in a way that is not just an exercise. Students may have different levels of input into the content and process of creating the project but the project is framed by the curricular goals, time frame and expectations of the teacher.

With Bro. Joe, the *Fish Pond* project was not defined in terms of a curricular goal but with the goal of personal connection to him and connection to shared interests in the goal of beautifying the school. The involvement with mathematical ideas was an artifact of working on the pond

that Bro. Joe had in mind as one of many good things about the project. This kind of objective for project work represents an epistemological contrast to common notions of project in traditional classroom situations.

The goal of using project to achieve certain curricular objectives within a given time frame reflects a more positivist view of the world than prevailing notions of project at Paige. Because it is an important experience to share addresses a connection with someone you care about and situating knowledge within a meaningful goal are reasons for working on a project that resonate with alternative epistemologies such as those of feminist and African-centered feminist epistemological perspectives (see section 3.3).

CHILD-CENTERED TO CHILD-OWNED

The prevailing notion of project in Computer Class also helps to conceptualize a new sense of child-centered teaching. When the students insisted that Computer Class was intended to have teachers helping them do what they want to do rather than students doing what teachers wanted them to do they were asserting their definition for the focus of teaching. They envisioned more than the class being child-centered by teachers designing the flow of classes in response to their interests and ideas. They were asserting a sense of ownership over what they class would be and the teacher's role in relation to them. Students like Keanna, who had experienced Computer Class since it began and had been a part of its development in this direction, seemed to particularly express the position that since the teachers had helped Computer Class to become a place where the focus was their projects, they could not, in effect, retract that direction once it was in place.

Ultimately, an understanding was reached where students knew that sometimes teachers would assert agendas that they felt were important. It was necessary to negotiate the issue that if a class is completely child-owned, the teacher finds it difficult to exercise their responsibility to guide children's learning. Teachers have a responsibility to help children learn ideas that they need to negotiate the world. In its most noble sense, the purpose of curriculum is to help to frame these ideas for teachers and students. It is likely that it was easier for Computer Class to become more framed in children taking control of their work because the curriculum was defined only by ideas that I felt would help them develop greater technological fluency and connect to whatever subject-matter seemed relevant. I knew that students creating their own movies would help them deal with ideas of narrative but I didn't feel a responsibility to connect their Computer Projects to Reading or Language Arts curriculum.

CONSTRUCTIONIST MEDIUM

The work of Computer Class gave new meaning to constructionist medium by highlighting the development of children's ownership of the computational ideas and the definition of what it means for them to program. Prevailing ideas of constructionism point to media that children can use to make their own projects. The increase in children's technological fluency and appropriation of computational ideas in Computer Class was accompanied by the class developing its own meanings for these activities. For instance, children knew that they needed to learn how to make procedures in order to make projects but the class developed a sense for the kind of procedures that were needed for creating particular kinds situations in projects. The class developed its own meanings for why and how procedures

needed to be used in projects. Procedures were needed in order to "make action happen." Procedures were needed to check and see if certain conditions were met, i.e. a key was pressed or a turtle reached a particular place. Computational ideas became not just tools used to make projects but materials that everybody learned how to use, share, and carry in their personal repertoire of ways to make projects.

Constructionist tools were also a part of the shift in attitudes about programming. When children were using computational ideas as ways to make their projects, it became less important to distinguish that they were learning to program and then using programming to do their projects. They were just doing their projects.

3.4.4 Conclusion: Support within Computer Class for themes within Keanna's work and learning

In conclusion, I observed four salient types of transformation during my participant observation in Computer Class: a progression of the class from a teacher-centered to student-centered focus, an emergent notion of project from a focus on assignments, an increase in appropriation of computational ideas; and a development of positive attitudes about programming. There are several points of consistency between these lines of development and Keanna's constructionist learning over the years. The process of Keanna creating her own projects was a part of her process of exploring her cultural identity and experience. Her actions in many cases supported the changes that happened in the class. Her need and motivation to explore cultural identity and context was the fuel for taking on many of her projects and embracing student-centered learning activities. In the next chapter, I explore

theoretical ramifications for Keanna's learning and the intertwined contexts that supported it.

Chapter 4

Towards a Cultural Constructionist perspective

In this chapter, I situate Keanna's learning as she constructed her programming projects over a four-year period within the cultural context of Paige Academy in a theoretical perspective. This will lead me to formulate a perspective on learning that I have come to call *cultural constructionism.* In its briefest description, it is an extension of constructionism to the view that children learn particularly well through creating objects in the world that express their cultural identity and have shared meaning within their home cultures.

Cultural constructionism is a theoretical perspective grounded in observations of Keanna and her classmates as they created projects by constructing their own ideas in culturally-relevant ways. To make sense of her work I draw on ideas about alternative epistemologies which emphasize understanding the world through collaboration, creative expression, and community support rather than through purely logical and empirical categories. In the end, I argue for the potential of this perspective to contribute to the development of technology rich learning environments that will support high achievement of African American and other students who are marginalized within traditional school environments in this country.

I have shown how Keanna and her classmates at Paige invented computational ideas for themselves through the process of creating their

projects. They created their own understandings of computational ideas such as modularity, parallelism, and evaluation. Their active engagement in making sense of what the computer could do and what they could do with the computer is consistent with the constructivist theory of learning that is rooted in the work of Jean Piaget. However my work goes beyond Piaget's constructivist perspective in two respects.

The first of these is in line with the theoretical perspective that led to the formulation of constructionism. Piaget defined himself as a structuralist, interested in the forms of intelligence that emerge from the developmental process rather than in the specifics of the process of getting there.

He also defined himself as an epistemologist as opposed to being a psychologist. Unlike the more modern idea of multiple epistemologies, this meant a focus on the universal aspects of thinking, what was common to thinking as such, leaving to "psychology" concerns about differences. Thus the second respect in which I differ strongly from him is my attention to issues of cultural identity and environment in understanding children's learning.

My overall perspective on the evolution of the view I'm calling cultural constructionism recognizes three layers:
Constructivism captures the idea that children construct their own knowledge. *Constructionism* adds that they do this particularly well in the course of constructing things in the world. Finally, learning stories depicting Keanna's work on programming projects reveal constructionist learning that occurred particularly well in the context of concurrent exploration of her

cultural identity and context and this leads to the extension of constructionism to *cultural constructionism*.

I begin the chapter by fleshing out this development and then proceed to a discussion of the bearing of the theoretical perspective of cultural constructionism on school learning, for example, via the notion of culturally relevant teaching (Ladson-Billings, 1994). The three layers do not represent contradictory theories, rather they progressively refine one another. From a cultural constructionist perspective, constructivism is true as a very general theory and constructionist theories are more specific in how they characterize the learning process.

After this discussion of the theoretical grounding of cultural constructionism in Keanna's work I conclude the chapter with a consideration of implications for methodologies of teaching with technology suggested by a cultural constructionist perspective and indicate some issues for further research.

4.1 From Constructivism to Constructionism

Constructivism is a theory that characterizes the nature of children's learning as the creation of their own ideas about the world through making sense of their experiences. This section is an examination of the defining principles of constructivism and the extension of constructivism to constructionism. Constructionism extends traditional constructivism to focus on the benefits of learning through creating artifacts in the world. Constructivist theory and its extension to constructionism can explain some but not all of the experiences that formed Keanna's learning process.

4.1.1 Piaget's constructivism

...to understand is to invent.
- Piaget

Constructivist approaches can be criticized as positing a universalist or essentialist view of cognition across classifications except age...
(Confrey, 1994)

Constructivist theory is rooted in the work of Jean Piaget. Piaget's aim was to develop a theory of mind based on similarities in thought that he found across many different children. Constructivism, as he formed it, was not intended to address differences between children other than age. He analyzed children's thought during experiences that he shaped to embody particular intellectual constructs. For instance, he created situations to elicit children's thoughts about volume, mass, or geometry. Given the understandings that children expressed of these ideas over time, he articulated epistemologies for children's notions of these ideas.

After the early work with his own infants, Piaget was not concerned with the personal experiences that may have informed children's notions. He did not address personal meanings that children might associate with the experience of the ideas. These general principles of constructivism leave open the investigation of the nature of children's learning in particular contexts such as contexts of building artifacts or contexts where there is concern for the personal nature of the experiences.

Piaget pursued the goal of developing a completely general overarching theory of mind that would characterize both the common set of cognitive structures created by all people and what is in the processes by which they are

constructed. He was not concerned with *which* personal experiences contributed to the construction of knowledge but with experience *as such* as a source of the perturbations that instigate children's learning. When he did consider the thoughts that children expressed about particular concepts which he was investigating, it was only as a way of getting at what was common to all children.

Piaget's work was vitally important in its opposition to behaviorist theories which assume that children's minds are blank slates that can be filled by passively receiving knowledge from adults (as possessors of greater knowledge). For the behaviorist, just as anything can be written on a slate, anything and any combination of things can be written in the child's mind. The child is just a neutral receiver. But Piaget's observations of children led him to see the child as an autonomous agent rather than a blank slate. This leads to a far more respectful view of the child.

With Inhelder, he conducted experiments to observe the thinking of children at every age between infancy and adolescence. Their experiments involved a process of listening to the thoughts of, for instance, adolescents engaged in figuring out a combination of chemicals that will produce a certain reaction. When he listened to children he heard them making their own sense of the situations. Whether or not their assessment of the situations were correct, he valued the ideas that children generated themselves and recognized the coherence of ideas the children expressed.

> *Children don't conceive number, they make it. And they don't make it all at once or out of nothing. There is a long process of building intellectual structures that change and interact and combine.*
> *(Papert, 1988, pg. 4.)*

He characterized the process of building new intellectual structures as children using ideas they have as cognitive tools to address new experiences. They are able to build on their current thoughts to construct new thoughts when faced with situations in which their current thoughts don't resolve their experiences.

Thus the constructivist perspective views children's learning as a developmental process with its own internal regularities and constraints. He believes in a constant interaction between the evolving intelligence of the child and the environment of which the child is trying to make sense. But there is little in the theory to guide us about what kinds of environment will most facilitate this evolution. This is where constructionism enters the story.

4.1.2 Extending constructivism to Papert's constructionism

> *Constructionism–the N word as opposed to the V word–shares constructivism's connotation of learning as 'building knowledge structures' irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitiously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe." (Papert 1991, p. 1)*

Seymour Papert developed constructionism as an extension of constructivism to the view that building projects is a particularly good context for building ideas. He initiated the investigation of children's learning with particular uses of technology that helped him to establish constructionism. Papert's work has highlighted Logo programming environments as providing children with good materials to use to engage with computational knowledge. Papert intends for constructionist learning to support a new view of education where learning without explicit teaching is considered viable in

schools because project construction carries children into engaging with new knowledge for authentic purposes.

4.1.3 Constructionism and Logo research

Constructionist research using Logo and Logo-like environments has supported and helped to develop the constructionist perspective in several ways. Research with a focus on children's learning of Logo programming itself has examined the development of programming skills, the reflexivity of understanding programming, and ways in which learning programming influences other kinds of learning. For instance, learning programming can influence understanding knowledge in other domains and knowledge about self.

Other lines of research have put their focus not on the learning of Logo in itself but on what can be done by children who have learned Logo. Many studies have pursued the idea that mastery of Logo can put students in a position to develop richer projects on almost any topic and thereby enhance learning within that topic. Yet other studies have used Logo-based work as a prism with which to study different styles of thinking. In the case of Mitchel Resnick, a whole new version of Logo was developed to allow what he calls "decentralized thinking" to develop and manifest itself (Resnick, 1995).

My work has something in common with all these lines of research. It has been influenced by them and it adds to their goals. To spell out all the connections would be a larger task than is needed for my purposes here. Instead, I confine my attempt to place my work in the context of earlier Logo research to *one* thread of a more complex story. The essence of the thread is the trend towards research on situations that permit progressively deeper

levels of expressivity and personal involvement. But even this thread has several dimensions because different conditions contribute to expressivity and quality of involvement.

One of these is sheer time. Some of the earliest research on Logo looked for interesting happenings when children spent as little as ten or fifteen hours with Logo and Logo-based activities. A tradition of research conducted at the Hennigan School in Boston, MA by Idit Harel (1988; 1990; 1991), Yasmin Kafai (1993; 1995) and Michele Evard (1996; 1998) developed a style of project in which students would typically work for three or four hours a week over a school year. These projects showed clearly that many important developments only come about when the student has lived with a project for periods of time longer than those found in most Logo research, indeed in most research paradigms used by educational psychologists in all fields of their inquiry.

My research takes the time dimension a qualitative step further and provides the strongest evidence for the conclusion that important developmental processes take more time than is usually allowed in research projects. Time was the necessary condition that allowed students to develop personal involvement as deep as I see in my subjects. But time alone is not a sufficient condition.

I focus here on two other factors that affect involvement: the content of the work and the social environment in which it is done. In both of these respects Logo-based work with children has gradually evolved to become more effective and in both cases, though especially the latter, I can present my work as taking a qualitative step beyond any other.

In the earliest Logo research, children carried out simple geometric projects that allowed very little room for deep personal expression. Partly this was due to the limitations of the early computers and early versions of Logo confined to run on these machines. Projects such as Keanna's more advanced ones would have been inconceivable even if there had been enough time. But, in addition to the limitations of technology, there were limitations due to the less developed state of the constructionist theoretical framework which indeed had not even been explicitly formulated when some of the best known Logo research was carried out.

I myself had participated in some of the earliest Logo research on the educational psychologist paradigm. After doing my Masters work on one such project, I worked for several years as an elementary school teacher[26]. When I came back to a research environment as a doctoral student at the MIT Media Lab, I found that many of the above mentioned developments were coming about. My own work naturally fell into the on-going lines of development and I think that it has contributed to all of them. But there is one line of development where my approach took a qualitatively new turn.

Some earlier research had brought out the fact that different children showed different personal styles in their work with Logo. But all of the observations on which this research was based were made in the context of schools that did not favor any particular personal style and in fact did not very deeply favor personal styles at all. My research is the first in which the variable "style" is applied not only to the individual child but to the entire

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[26] I participated in teaching and testing groups of first and third graders who were learning to use an early version of Logo in studies of young children's cognition, metacognition, achievement, and creativity conducted by Douglas Clements (1986, 1987) at Kent State University.

learning environment. I worked in a learning environment that itself had a strong style different from those regularly found in public schools. Thus I was able to see children developing over time in an environment that strongly supported a style that was in an important sense theirs.

I used the word "style" in the previous paragraph to bring out a continuity with earlier thinking about Logo research. But in reality, I see what I did as deepening the issue by looking at something with deeper social presence than the merely "cognitive styles" that had been studied for example by Turkle and Papert (1990). The *culture* that figures in my research includes the attributes of style but also very much more, including a large degree of conscious, deliberate reinforcement both at home and in the school. It involves deep feelings and strong personal attachments shared within school community and across home and school experiences.

In this perspective I feel that I can make the claim not only that constructionist ideas and technologies have supported culturally coherent learning but also that it is in a context of culturally coherent learning that constructionism has its greatest power. For if children learn best through meaningful construction, it is in such contexts that meanings go deepest and that constructions have the most connection.

4.2 Relationship to Current Trends in Educational Thinking.

I define cultural constructionism as an extension of constructionism to the view that children learn particularly well through creating objects in the world that: 1) express their cultural identity and have shared meaning within their home cultures, and 2) are constructed in culturally relevant ways that reflect alternative epistemologies, i.e. understanding the world through

collaboration, creative expression, and community support that have significant cultural meaning. This theoretical perspective is grounded in observations of Keanna's work where I found a pattern of thoughts related to cultural identity and participation connected to *her* thoughts about computational ideas. This theoretical perspective is related to current trends in education that describe both the need to develop constructivist theories and the need to critique approaches to multicultural education.

4.2.1 Links with the development of constructivist theory.

The need for giving constructivism a bigger cultural connection has been recognized. For example:

> *Constructivism has resulted in the documentation of diversity in student method, but little or no discussion exists in the literature to explain systematic difference among classifications of student participants according to culture, race, and gender. One possible explanation lies in the tendency for the constructivist program to assert heavy dependence on the autonomy of the individual... Constructivism needs to be able to account for difference in performance, behavior, or opportunity in relationship to group membership.*
> *(Confrey, 1994, pg 6)*

Cultural Constructionism shows a way to deal with Confrey's concerns. Whether it is the only way I cannot say; but it is certainly the only example, that I am aware of, that has been elaborated and given at least some empirical support. The evidence I found that Keanna's learning was supported by her participation in the Paige community is one way to discuss differences that are affecting children's learning in connection to their group membership. Keanna's group memberships were acknowledged and utilized in supporting her learning. A dissonant relationship between children's group experiences inside and outside of school could explain struggles they face in learning.

4.2.2 Links with Multicultural teaching.

Equal is not the same. (Nieto, 1992)

Culturally relevant teaching supports African American children in cultural participation and identity along with academic achievement. (Ladson-Billings, 1995)

The idea of cultural constructionism is linked to multicultural education through the view that children who learn successfully in school do so because their school environment recognizes and values their cultural identities. The field of multicultural education includes awareness of culture playing an essential role in children's learning. It is considered valuable to address children's cultural backgrounds and experience in order to help them learn in school.

Culturally relevant pedagogy is one of the specific threads within multicultural education that creates conditions for learning that reflect an acknowledgment of the role of culture in children's learning. Gloria Ladson-Billings defines culturally relevant teaching as a pedagogy that empowers students, intellectually socially, and politically by using cultural referents to impart knowledge, skills, and attitudes. The aim of culturally relevant teaching is for students to choose academic excellence yet still identify with culture (Ladson-Billings, 1995).

But it raises what might be a deep issue about the idea of multicultural teaching. What I have presented at Paige is not multi-culturalism. Paige has *one* coherent culture. Multiculturalists appeal for schools to do for the *many* sub-cultures of our society what Paige does for one of them. Making school culture visible, and explicitly attentive to creating a resonance between home

and school cultures, is a fundamental principle within the field of multicultural education for improving teaching for children of color. (Banks, 1995; Gay 1994, 1995; Hollins, 1996; Shade, 1994).

The issue with which I leave my readers and future researchers is whether one school can be culturally resonant with all homes.

Appendix

Keanna's Aladdin procedures

```
to start
forever [fight]
page1
st
t1,
setpos [-315  -106]
repeat 5 [fd 35 setsh 52 wait 5
fd 35 setsh 53 wait 5 fd 35 setsh
54 wait 5]
seth 0
fd 40
WAIT 5
seth 90
fd 30
WAIT 5
seth 0
fd 35
seth 90
fd 20
ht
page2
t1,
wait 5
hidetext
setpos [-16 -111]
seth 85
repeat 8 [fd 30 wait 1]
t3,
setsh 15 wait 1 setsh 14
t1,
setsh 56
seth 273
repeat  15 [fd 30 wait 2]
t2,
setsh 15
wait 1
setsh 14
t1,
setsh 54
seth 80
repeat  13 [fd 30 wait 2]
t7,
setsh 15
wait 3
setsh 14
t1,
setsh 56
seth 275
repeat 9 [fd 40 wait 3]
t4,
setsh 15
t1,
wait  3
setsh 14
setsh 54
seth 80
repeat 7 [fd 45 wait 1]wait 1
setsh 14
t1,
setsh 56
seth 270
repeat 9 [fd 30 wait 1]
t9,
setsh 15
wait 1
t6,
setsh  15
setsh 14
t1,
setsh 54
seth 80
repeat 7 [fd 30 wait 1]
t5,
setsh  15
wait 1
setsh 14
t1,
SETSH  56
seth 286
repeat  6 [fd 30 wait 2]
t8,
setsh 42
t1,
setsh 57
wait 10
ht
page3
wait 90
t2,
setsh 60
WAIT 20
seth 0
fd 40 ht
wait 1
page4
wait 5
t2,
seth 270
t3,
setsh 39
t2,
repeat 4  [fd 20 setsh 47 fd 20
setsh 48 fd 20]
wait 5
t2,
seth 270
t3,
setsh 39
wait 5
launch  [t1, seth 270  repeat 5l
[fd15  wait 1 setsh 56 fd 15 wait
1 setsh 58 wait 2]]
launch  [t2, repeat 5 [fd 15  wait
10 setsh 47 fd 15 wait 10 ]]
wait 50
page5
t3,
seth 270
fd 40
wait 10
fd 40
wait 10
fd 20
wait 5
fd 10
text3,
showtext
seth  45
setsh 23
wait 50
text3,
hidetext
repeat 8 [fd 40 wait  5]
text2,
showtext
t1,
seth  270
fd  60
t2,
seth 270
fd 40
t3,
setsh  34
wait 30
text2,
hidetext
launch [t1, repeat 11  [seth 250
fd 40 wait 5]]
launch [t2, repeat 11  [seth 250
fd 40 wait 5]]
launch [t3, repeat 11  [seth 250
fd 40 wait 5]]
wait 50
page6
t2,
repeat 5 [fd 30 wait 2]
```

```
t1,
repeat 5 [fd 20 wait 2]
text1,
showtext
text2,
showtext
wait 40
text1,
hidetext
wait 40
text2,
hidetext
launch [t1, repeat 10  [setsh 20
wait 4  setsh 18]]
launch [t2, repeat 10  [setsh 25
wait 4  setsh 24]]
wait 20
t1,
setsh 21
t3,
setsh 28
seth 270
fd 90
t2,
setsh 24
wait 4
setsh 25
t1,
ht
t4,
setsh 29
wait 2
seth 270
fd 90
wait 1
fd 90
wait 1
fd 90
page7
wait 50 page8
wait 50
end
to setup,
page2
showtext
t1,
setsh 53
st
seth 0
setpos [4  -110]
t8,  setsh 14
page4
t2,
setsh 46
setpos [168 -108]
t1,
setsh 58
setpos [-119 -112]
t3,
setsh 37
page3
t2,
st
setpos [104 -132]
setsh 58
page5
t3,
setpos  [43 -120]
setsh 34
TEXT3,
HIDETEXT
TEXT2,
HIDETEXT
T2,
SETPOS [246 145]
T1,
SETPOS [273 145]
PAGE6
T3,
SETSH 27
SETPOS [79 -49]
T4,
ST
SETSH 30
SETPOS [226 -88]
TEXT1,
HIDETEXT
TEXT2,
HIDETEXT
T2,
SETSH 25
SETPOS [-320 -71]
T1,
ST
SETSH 20
SETPOS [-10 -62]
PAGE0
end
```

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