Building an Alternative to the Traditional Computer Terminal

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Abstract
For the past year and a half, I have lead a group of researchers in building an alternative to the traditional computer terminal. Instead of building a design workstation complete with keyboard and mouse, we built an animal design playstation complete with fur, feathers, and an irridescent fish tail. We used the tools of puppetry, animation, and computer electronics, to build what is now called *Noobie* (short for "New Beast"). By sitting or standing in the lap of this computer creature, a child can build fantasy or real animals. When one squeezes a part on Noobie, the selected animal part can be seen on the screen in Noobie's stomach, and a sound can be heard.

This paper documents the ideas behind the conception and creation of Noobie, along with how it fits into the short history of the Vivarium research group. This group is a collection of people, ideas, and projects that focus on creating a multi-media environment for children to learn about animal behavior.

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Thesis Advisor: Marvin Minsky
Title: Professor of Electrical Engineering and Computer Science

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"The dream you dream alone is only a dream.
But the dream we dream together, is a reality."

Yoko Ono 1983

Something wonderful happened on the way to finishing my thesis. A lot of people came to help. Joined by a cast of thousands, "I" became "**we**"; and what I had only dreamed about became real. To all those people that built, documented, and supported me intellectually, emotionally, and financially, I can only say, **thank you**.

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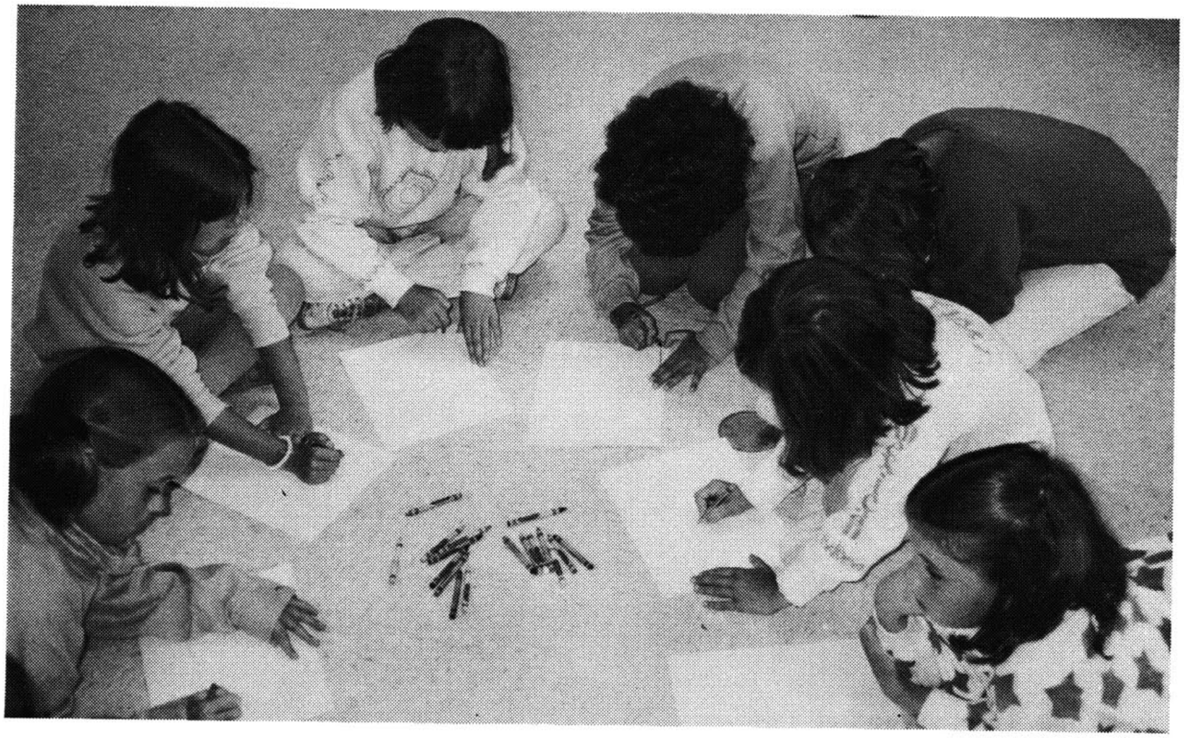
Table Of Contents

(continued)



"The Vivarium should be the crayons, the clay, and the building blocks of another world."

Allison Druin 1985

The Vivarium was originally proposed by Ann Marion, at Atari Inc., as The Aquarium project. She believed that research in advanced animation techniques should be less focused on scripting and more on ambient environments, as is a fishtank. In this way fish behaviors could be analyzed and understood as well as entertain. Eventually the project was revived at Apple Computer and renamed theVivarium. Rather than creating a fish tank to learn from, a life tank could include the study of all animals.

The development of the Vivarium is supervised by Dr. Alan Kay, Senior Apple Fellow. Presently there are two centers of research: one in Los Angeles, California, headed by Ann Marion; and one at MIT's Media Lab in Cambridge, Massachusetts, advised by Professor Marvin Minsky.

The Vivarium took shape at MIT in the Fall of 1985, when a seminar was given at the Media Lab by Alan Kay. From this seminar, students with project ideas came forth. The work fell within the following categories: curriculum design, user interface development, graphics and animation research, and moist models (computational learning models). Alan Kay felt that it was in the combination of these four areas of research that a Vivarium could emerge.

For the past two years, our work has lead us to question what the next generation of computer tools will be. In doing so, we have begun to develop a multi-media environment for children to learn about animal behavior. What this environment will include, how it will be used in the future by students and teachers, and what effect it will have on education in general, remains to be seen. As Jerome Bruner pointed out, "...each generation must define afresh the nature, direction and aims of education...It is in this sense that education is in a constant process of invention." [1]

Therefore, as we see a clearer vision of what Vivaium could be, we begin to more clearly see our questions, rather than our answers. What computer tools do we build? What ideas will we reinforce by building those tools? How will our tools fit in or out of the classroom? According to Cynthia Solomon, "...people believe that the computer can make a significant difference in the learning process. [However] there is no sharply defined image of how this will happen." [2]

What we in the Vivarium can agree upon at this point, is that the computer tools we invent should not take the place of film, television, books, live animals, or people. Children should be exposed to many different ways of presenting ideas. One of the most consistant findings in literature on media in education, is the superiority of multi-media over single-medium presentation. [3] It's been found that each medium, because of its unique representational system and technical capabilities, emphasizes different kinds of information, and therefore offers the child different representations to process. [4]

With this in mind, we continue to experiment, research, and develop new tools for a new type of educational environment. Perhaps with new tools, new kinds of learning can be made more possible. However until we stretch the past into the future we cannot be certain.

It was during the fall of 1985, that I initially proposed the idea of the "fuzzy computer"; an alternative to the traditional computer terminal. I wanted to build a place where you could hug your tools and build your fantasies. I wanted to squeeze my stuffed animals, and have them appear on my computer screen. I wanted to learn about animals, by playing with them.

How did my fantasies became a "furry computer" named Noobie? At times I believe it came from a childhood filled with Muppets, Disney magic, and video-game-mania. At other times I believe it was founded in the words of Alan Kay, back in 1985. At still other times, I believe it grew out of my art school sketchbook of creatures.

Whatever the origins, I began my search for what my part in the Vivarium would be, by making a list. This I called my "Vivarium Should Be List". It consisted of all the things I believed the Vivarium should become.

THE VIVARIUM SHOULD BE...

1) ...the crayons, the clay, and the building blocks of another world.

2) ...a treehouse to build sandcastles in.

3) ...an environment that can direct exploration, or allow exploration to be directed.

4) ...a place to share, or individually explore.

5) ...a Disneyland in which to learn.

I suppose in between those words, I found my goal: to build an animal design playstation; an environment that allows computer animals to be played with and explored much in the same way real animals are; by touching. In doing so, I have created a new place where people and computers meet; a place that is not confined to a hard plastic box, keyboard, or mouse.

"So help me if you can,
I've got to get back to the House of Pooh Corner by one,
You'd be surprised there's so much to be done,
Count all the bees in the hive,
Chase all the clouds from the sky,
Back to the days of Cristopher Robin and Pooh."

Loggins and Messina 1976

"To reach the Magic Kingdom, call your travel agents." [5]

This bit of advice comes by way of Walt Disney World in Florida. However, if you decide that the "Magic Kingdom" is a special place for children to learn, and if you decide that your "travel agents" will be animals, then you might decide to call this world Vivarium.

"But why use animals?", many people have asked. "Why not study human behavior?" "Why not use robots?" Those are hard questions to answer. For as many times as they are asked, there seem to be as many different answers to be heard. This may be because the Vivarium research group is a collection of people, with varying ideas, working on projects in many different areas. Each adds a different perspective to what Vivarium could be. Several views from outside and within the Vivarium, have influenced our research. Four are described below.

Ann Marion: An Aquarium

Ann Marion first saw the project as a way of moving away from scripted animation techniques. She believed that once the viewer knew the animated story, he or she could quickly lose interest. She wanted to create an environment that had changing, on-going relationships, much like an aquarium. So for Ann, animal agents could be used as a way of freeing animation from its beginnings and ends; as a way of making animation open-ended, entertaining, and educational.

Alan Kay: Animals vs. Robots

Alan Kay, on the other hand, sees our use of animals in another light. "Doing animals is a nice control on the child's sense of quality. Whereas doing robots, you could get away with almost anything and say that's what a robot does. The representation has to be finely textured, and move and act believably. We have to generate complex behavior from simple modules." [6]

For Alan Kay, it seems, the use of animal agents is a wonderful way of stretching what we already know about representing animal behaviors, as well as what we know about rendering and animating figures. Therefore, if we are able to give children the tools to explore animal behavior, then we as tool-makers may learn just as much about our tools as about animal behavior.

Marvin Minsky: Artificial Intelligence

Marvin Minsky sees the Vivarium animals as a way to further research in the area of artificial intelligence. Perhaps if one sees each animal agent as having a simple role to play in a more complex society of animals, then one might not only be examining the inter-relationships of animal systems, but of people's minds as well. Marvin defined what he believed to be an agent of the mind in his recently published book, *The Society of Mind*. "[An] agent [is] any part or process of the mind that by itself is simple enough to understand - even though the interaction among groups of such agents may produce phenomena much harder to understand." [7] "Each mental agent by itself can only do some simple thing that needs no mind or thought at all. Yet when we join these agents in societies - in certain very special ways - this leads to true intelligence." [8]

Therefore, if we use animal agents in this context, we may find that the connections between the animals are just as interesting to us as the animals themselves. The societies that we build could serve to be computational models of learning. Complex as it may seem, it is possible that the children, along with the computer tools they use, may exhibit learning behaviors. It is difficult to project how this will affect the way a child acquires knowledge; for the child and the computer may play both the role of student and teacher, as each are learning.

Seymour Papert: Turtle Geometry

Seymour Papert and his "Learning and Epistomology Group" at the MIT Media Lab have also been creating an environment for children using, "...concrete computer models to think about thinking, and learn about learning." [9] They have been developing tools for children, using the computer language LOGO. One such tool, developed in the 60's and 70's, was "Turtle Geometry". In its early days, a robotic turtle was used as a metaphor to teach children geometry while they programmed graphics routines. In doing so, the children acquired a better understanding of mathematics, while they encountered sequential programming techiniques. However, in the larger picture of things, by having the children "teach...the turtle to act or "think", [it] can also lead [them] to reflect on their own actions and thinking." [10]

Today, the LOGO environment is approximately 20 years old. The robotic turtle has become an image on a computer screen. Children along with their teachers, have become accustomed to manipulating the screen turtle as an "object to think with". However, if the Vivarium environment could teach what real snapping-turtles do, while using them as metaphors for mathematical thinking, we could expand upon what is already being used and enjoyed in classrooms today.

For me, the use of computers was an obvious choice when one wants to combine childhood learning with fun. Many of the special things that I can remember from my childhood, were connected in some way with animals. Winney-the-Pooh, the Cat-in-the-Hat, and the Three Bears made storybooks more than just words. Grover, Big Bird, and Oscar-the-Grouch made *Sesame Street* a great TV show to watch (although it was supposed to teach me something). Bambi, Braer Rabbit, and Jiminey Cricket made Disney films better than the popcorn or Raisinettes I was allowed to eat at the movies. Mickey, Donald, and Goofy, made DisneyLand the "Magical Kingdom" it was supposed to be. And the bird house, the pony rides, and the animal crackers made the Bronx Zoo seem as far from New York City as possible.

Storybooks, TV, film, amusement parks, and zoos; they were all filled with animals. In books, they were drawn with words or ink. On TV, they took the furry form of Muppets. On film, they were animated, colorful creatures. In amusement parks, they were large costumed characters. In zoos, they were real. These animal-filled activities sustained my attention, filled my imagination, and piqued my curiosity. If we in the Vivarium can build on this childhood fun, I believe we could create no more powerful a learning environment. As Marvin Minsky once wrote, "Enjoyment, which has been banished to the realm of entertainment sciences, may be the most powerful influence of all on how each person learns." [11]

Why are animals so commonly used in most of the entertainment media? According to Gerald Lesser, Chairman of the Board of Advisors to the Children's Television Workshop, "Most of our observations simply confirmed that preschoolers are attentive to animation, puppets, other young children, and animals..." [12]

Jan Yolen, an author of over 60 children's books, has pointed out that, "Animal tales, in general, are probably the single greatest category in children's books." [13] Why is this? Perhaps it has to do with the artistic freedom an animal representation allows. As one Muppet builder said, "Animal characters are often used to represent ordinary human types common to all classes and countries...The use of unidentifiable creatures or monsters offer a society free from race... It seems to transcend cultural stereotypes." [14]

Disney goes one step further into fantasy when he said, "The duty of the cartoon animal is not to picture or duplicate real action or things that actually happen - but to give a caricature of life and action - to picture on the screen things that have run through the imagination of the audience...to bring to life fantasies that we all have thought of doing during our lives." [15]

Therefore, for children, animals may be travel agents to three different worlds: a true-to-life world which focuses on real animal behavior, a metaphorical world which represents all kinds of people and behaviors, and a fanciful world that catches the dreams that live in imaginations. The use of animals is a multifaceted tool. For children, animals bring together a variety of worlds. For Vivarium research, animals push our work in a variety of ways (i.e. graphic representations, animation, behavioral models...). So it seems, as travel agents, animals may take us far.

Much progress has been made in the area of user interface design, in the way of software. Far less has been explored concerning hardware design. In the commercial mainstream, icons and menus continue to replace the traditional command-line input and keystroke macros, thanks to such labs as Xerox Palo Alto Research Center. However, few hardware interfaces have taken keyboards and mice away from computer monitors encased in hard plastic boxes.

One group that attempted to change the computer hardware and software environment was the Architecture Machine Group at MIT, under the direction of Nicholas Negroponte. In the late 60's and 70's, they experimented with such interfaces as eye-tracking, voice recognition, joystick manipulation, touch-sensitive keypads, and gesture recognition. Led by Dick Bolt and Negroponte, they demonstrated a combination of these interfaces in "the media room", a place where "...the room itself [was] the terminal," and the information retrieval was almost as simple as sitting in a comfortable chair. However, in actuality, it was necessary to wear a bulky headset, and therefore not as comfortable as one would like to think. In retrospect, they did go a long way in demonstrating that computers did not have to look, or be used in just one way. [16]

In the early 1980's, small pockets of people continued to research new kinds of hardware interfaces. One such group, led by Margaret Minsky, was at Atari Cambridge. Hardware input and output devices were built that allowed people "...to communicate with a computer program using touch and force." Research was begun in developing a touch-sensitive screen and a force-feedback joystick. Using the touch screen, one's finger could draw with color in the **x** or **y** coordinates. Large or small areas of color could be made by pressing the screen with large or small amounts of force. On the other hand, the force-feedback joystick could apply force to the user. "By changing the amount and direction of the force, based on how the user moves the stick, one can generate a variety of tactile effects." [17]

Some of the research done at Atari Cambridge, and by the Architecture Machine Group, still continues at the MIT Media Lab today. According to Nicholas Negroponte, director of the lab, "The human interface with computers is the physical, sensory, and intellectual space that lies between computers and ourselves. Like any place, this space can be unfamiliar, cold, and unwelcoming. But it can also be like some other places, those we know and love, those that are familiar, comfortable, warm, and most importantly personal." [18]

Even with words like these and labs like the Media Lab, hard plastic computer boxes still prevail. Let me join in asking with Alan Kay, "What kind of emotional contact can one make with this new stuff, if the physical access seems so remote?" [19] The only answer seems to be in changing the "user interface", "the place where people and computers meet". [20] But people so often forget that people meet computers from the moment they see and touch them; not just from the moment they actually interact with the software. The user interface "...is recognized as being primary because, to novices and professionals alike, what is presented to one's senses *is* one's computer." [21]

Therefore the question remains, how can we build computer environments that do not deprive our senses? I believe this is, and will continue to be, a crucial matter in the development of the Vivarium; for how can we create an environment for children that emphisizes animals that does not consider the way children most often explore animals? They use their fingers. Children like to touch animals. " Studies have been done in settings in which there are both things to observe and things to interact with, such as science museums, field trips, zoos, and aquariums. These studies show a predictable pattern: children are attracted to activities that let them become physically involved. In the zoo, for example, they prefer pigeons and squirrels, with whom they can interact, to the more exotic animals isolated behind bars." [22]

Then how do we keep our computers from merely being animals isolated behind bars? I believe the answer lies with touchable computers; computers that just ask to be felt. This is not to say that visuals and audio are not important to an inviting environment, but children have already encountered video game graphics, flying logos, and *Star Wars* special effects. The Vivarium should include something more.

I think much can be learned from a study done by Harry Harlow, an investigator of animal behavior. "He demonstrated that baby monkeys have a clear preference for a soft environment, regardless of whether food was present. He created two kinds of surrogate mothers. The first, called the 'cloth mother', consisted of a cylinder of wood covered with a sheath of terrycloth. The second, the 'wire mother', was simply a wire cylinder. Within twelve hours after birth, four newborn Rhesus monkeys were placed with the cloth mother, and another four were placed with the wire mother. The cages were constructed so that each monkey had the option of 'visiting' the other surrogate mother...Even when nourishment was provided only by the wire mother, the infants still spent most of the time clinging to the cloth mother." [23]

This is not to say that I believe humans must exhibit the same behavior, or that all computers should be furry surrogate mothers. On the other hand, I do believe that some note should be taken of this study. From my own experience, I have observed that when people interacted with the Noobie software without the furry shell to squeeze, there was less enjoyment and a shorter attention span. However, this may in part be due to the lack of development in the Noobie software itself.

Alan Kay once said, "One feels the clay of computing through the user interface." [24] This may only be true if a feeling of direct manipulation can be created in a computer-simulated environment. Many times there is a separation or gap between the interface and what it stands for. All too often, people take for granted that the user interface merely consists of icons and menus that can be added later. The interface should not be a separate layer, but an integral part of a computer environment. It still may be wishful thinking when Alan Kay assumes that, "The user interface was once the last part of the system to be designed. Now it is the first." [25]

Interfaces should be designed, from input device to output device. If this is not done, no combination of computer tools will ever become a computer environment. Environments are places we live in, learn in, and enjoy. Tools should enhance those places, and help to build new ones. However, if we have a hard time using our tools, we will certainly not want to learn or enjoy anything.

Edward R. Murrow once said, "This instrument can teach, it can illuminate. Yes, and it can even inspire. But it can do it only to the extent that humans are determined to use it to those ends. Otherwise, it is merely lights and wire in a box." [26]

At the time, Murrow was speaking about TV, but the same may be said today of computers. According to Seymour Papert, "What an individual learns and how he learns it, depends on what models he has available." [27] And perhaps those models "...can provide children with new possibilities for learning, thinking, and growing emotionally, as well as cognitively." [28]

How, then, can we create those models that provide new learning possibilities in today's new technology? All too often our teachers begin to use this technology by attempting to fit it into an existing curriculum. This is a mistake. For with this new technology, especially computers, there are advantages and drawbacks not seen before with any one tool previously found in the classroom. These are new tools that should not be expected to conform to the past. Therefore, the question should become: how can our curriculum be changed to take advantage of the new learning approaches made possible by computers? [29]

I would like to take a somewhat unorthodox viewpoint, that the answer may not be found in today's classrooms. I believe it is time that we open up the windows of our classrooms and look outside to a place where children do not have to stand in line, or sit in alphabetical order. It is my opinion that computers have been used, in general, much more effectively outside of the classroom walls, as so-called "play tools". Unfortunately, as children grow older their playtime is replaced with schooltime. One is not "supposed" to play, one is supposed to learn. This narrow view can been seen in the sad words shared by Christopher Robin, with his faithful stuffed animal, Winnie-the-Pooh:

"...what I like doing best is Nothing." said Christopher Robin.
"How do you do nothing?" asked Pooh after he'd wondered for a while.
Well, it's when people call out to you just as you're going off to do it,
'What are you going to do Christopher Robin; '
and you say, 'Oh, Nothing,' and then you go and do it."
"Oh I see, " said Pooh.
"It means just going along listening to all the things you can't hear and not bothering."
"Oh," said Pooh.
..."I'm not going to do Nothing anymore."
"Never again?" asked Pooh.
"Well, not so much. They don't let you," said Christopher Robin. [30]

Perhaps this does not have to be true if we, as tool-makers of the new technology, can find our way back to the days of Chrostopher Robin and Pooh. We should build tools that do not separate fun from learning, because that which is fun may be very similar to that which is educational.

According to Thomas Malone in his 1980 Ph.D. thesis, "There seems to be an important correspondence, rather than contradiction, between most of the features that make environments fun and those that make them educational. Environments that vary in difficulty level increase both challenge and the potential for learning. Intrinsic fantasies not only stimulate interest, they can also provide instructionally useful analogies. Environments that evoke cognitive curiosity and satisfy it, can be both captivating and educational." [31]

Howard Gardner, a psychologist at Harvard University, points out that the most common place to find fun and learning is in a child's playtime. "A child's play has its purposes: greater mastery of the world, more adequate coping with problems and fears, and superior understanding of oneself and one's relationship to the world." [32] He also explains that "[Jerome] Bruner attributes play a crucial role in the development of physical and cognitive skills in young children...Unrestricted by external rules the child is free to experiment, to order and to reorder objects, to try new combinations, to practice, refine and ultimately master his actions." [33]

I believe the best example of mixing play with the power of the computer has been in the development of video games. They are, as Sherry Turkle has said, "...a window onto a new kind of intimacy with machines. They are the first place where the culture as a whole, rather than just the culture of computer programmers can experience how powerful they really are." [34]

This is not to say that our classrooms should be arcades of video games. On the other hand, video games may be a powerful example of how excitement can be brought back into our classrooms. "A study of learning-disabled children found that...children who avoid instruction during reading time were willing to be instructed during computer time. Some children who refused to concentrate on conventional learning tasks concentrated very well on arcade-style games...The children also began to act as teachers of their peers and of adults." [35]

For those people who believe an environment can not be educational unless a list of acquired skills can be identified, Sherry Turkle identifies a few examples: "[Video games] demand skills that are complex and differentiated. Some of them begin to constitute a socialization into the computer culture: you interact with a program, you learn what it can do, you get used to assimilating large amounts of information about structures and strategy, by interacting with a dynamic screen display. And after one game is mastered there is thinking about how to generalize strategies to other games. There is learning how to learn." [36]

Patricia Marks Greenfield, author of *Mind and Media*, uses the game of Pac Man* to exemplify some other skills that may be acquired by playing video games. "In Pac Man, as in other video games, no one tells the player all the rules governing each monster's behavior; these rules must be induced from observation." [38] She goes on to say that, "Pac Man illustrates another cognitive requirement of skillful video game playing: parallel processing...taking information from several different sources simultaneously." [39]

Whether acquired skills must be found or a more generalized experience of growth can be measured, video games remain a good example of what can be done with computers as learning and entertaining tools. Sherry Turkle found from many video game players that, "Video games are something you do, something you do to your head, a world that you enter, and to a certain extent, they are something you *become*...video games are interactive computer microworlds."[40]

This should be something we are looking to build in the Vivarium. If we can create a place that allows children to journey through learning with the tools of fun at their side, then it might not bother them so much that they have to be in a classroom to do it.

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*A game where "...the player uses the control stick (joystick) to guide Pac Man through the maze. As Pac Man encounters each white dot, he eats it and it disappears...The obstacles are not physical barriers, but four monsters or ghosts which chase Pac Man through the maze, and eat him if they catch him." [37]

"Creativity is the art of relating previously unrelated ideas,
And communicating those new relationships,
In ways people can understand."

Vance Johnson (graphic designer) 1986

By bringing animal agents to a place where people and computers meet, it was my hope to create an animal design playstation. To do this, many design problems had to be addressed. The following was my agenda when I began building the first prototype:

(1) exterior design of creature

- what animal parts should be included?
- where should the various parts be positioned?
- what materials should be considered for the exterior?

(2) design of chassis

- what materials will be strong and durable, given that kids will be playng all over it?
- what will keep it from falling over when the child sits in it?
- how large, wide, or thick should the structure be?
- what can be put over the structure to keep it squeezable and soft?

(3) design of squeezable hardware

- what devices will allow the child to communicate the most information possible by squeezing an animal part ?
- how many squeezable input devices can be simultaneous?
- how can they be molded into shapes?

(4) design of electronic hardware

- where will the CPU be located in the chasis?
- how will it be wired to the squeezable input devices?
- where will the air cooling unit and vents be located?
- how can it easily be taken in and out of the furry shell?

(5) design of software

- what will the database of parts consist of?
- will the parts be realistic or non-representational?
- how will the sequence of parts be ordered?
- how will the child give behaviors to their animals once constructed?
- what will the animation entail for the behaviors?

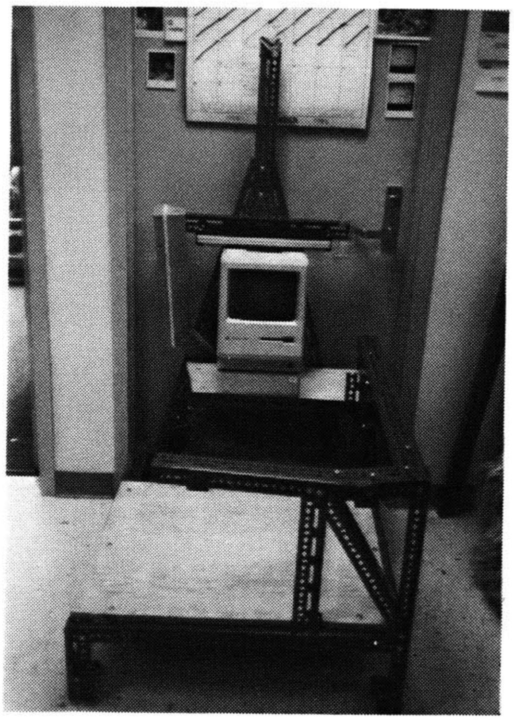
Certain compromises had to be made due to the materials available to us, the funding that could be received, and the time we had to experiment. With some compromises I am more happy than with others, but on the whole I believe we did well for ourselves given the circumstances.

The one thing I regret more than most, is not having had sufficient time to address more software issues, particularly the question of how to give behaviors to animals on the screen. As of now, the Noobie software is in its most early stages. Because of this, it may be difficult to target other apsects of Noobie that have not been addressed. Until the software is more robust, we can not be certain that our approach to the hardware and softsculpture design is correct.

In the sections that follow, descriptions, illustrations and photographs document the creation of Noobie's interior, exterior, electronics, and software.

To move my ideas from paper, to foam, to a computer for children was no small task. The first step in the construction of Noobie was to build the steel skeleton that would support a child comfortably, hold the computer harware in place, and allow for a softsculpture torso. This interior structure was built in collaboration with Doug Milliken, a mechanical design consultant. Doug was instrumental in making sure that Noobie could fit through doors, wouldn't fall over, and was the right size for children.

We began by making a cardboard model, from which we constructed the Dexion-steel structure for the prototype. The demensions that we finally arrived at were 32 inches wide, 36 inches long, and 60 inches high. The structure is shown in the photograph which follows on the next page.



This is the steel skeleton that is housed inside of Noobie. The Mac Plus and hard disk sit on a raised wooden shelf, along with (not pictured) a sythesizer, amplifier, and interface box . The entire interior structure is 8 inches off the ground, with wheels on each leg for mobility.

Creating the exterior of Noobie began long before any piece of foam was ever cut or carved. Since the Fall of 1985, Noobie character renderings had been drawn, redrawn, and drawn again (refer to Appendix 8.1 to see the visual evolution of Noobie). In these sketches, the animal appendages changed, as did the location of the screen, along with the body size of Noobie. Eventually, somewhere in those drawings, we found what our prototype would be.

The next step was to actually construct a softsculpture creature that could surround the steel skeleton. This was made possible with the expertise of Gwen Gordon, a former Muppet builder for Sesame Street. In five months, Gwen adapted the Muppet techniques established at Henson Associates, to build a lightweight, flexible, yet sturdy exterior. The steps that were taken to construct Noobie were as follows*:

(1) Boning (plastic tubing) was applied in such a way that it circled the steel structure. This would be used to support Noobie's softsculpture torso.

(2) Sheet foam was glued and sewn to the boning, as well as selected areas of the steel.

(3) Block foam was carved for most of the appendages. First, a razor blade was used to roughly carve the shape, then small scissors were used to snip the detailed form.

(4) Once the foam structure was in place, snap-action microswitches were embedded in the foam, so that certain areas would be touch-sensitive.

(5) Finally, everything was covered in fabric. Extra dots of fabric were placed over the switches to let people know where to squeeze Noobie.

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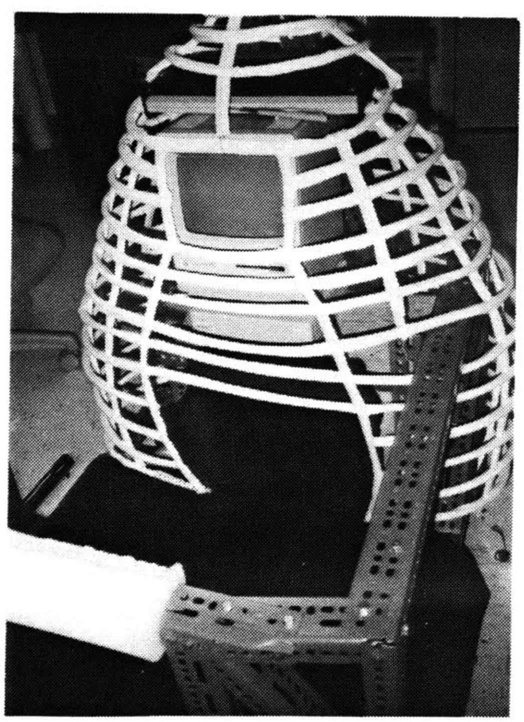
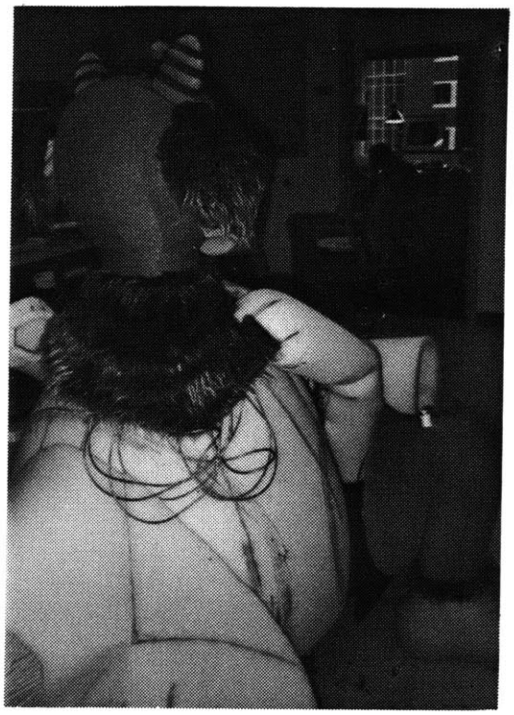
*Illustrations and photos of these steps follow on the next five pages.

This is the final sketch we worked from to build the softsculpture exterior of Noobie:

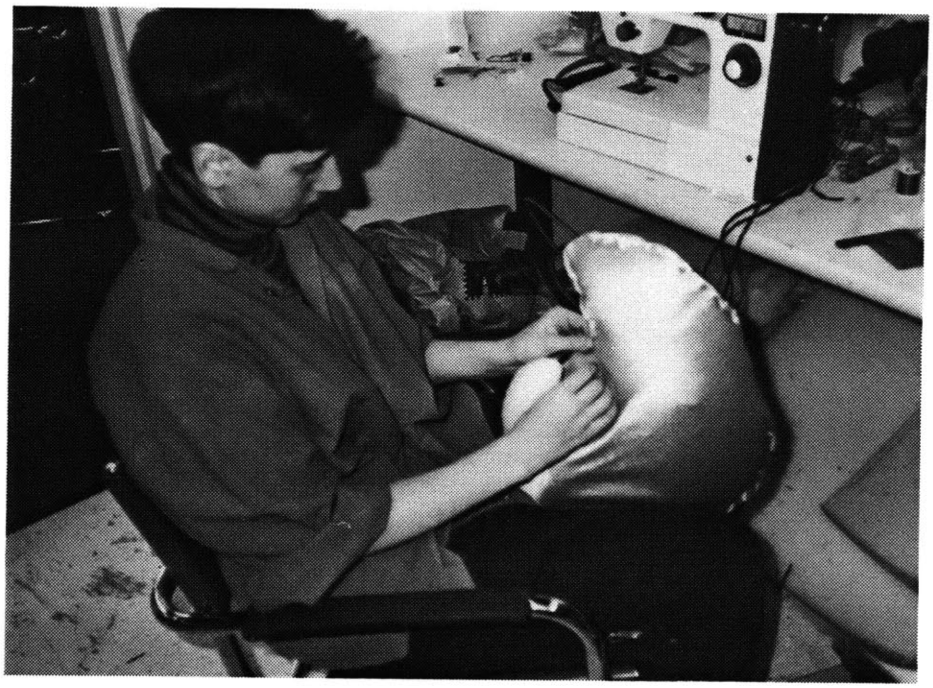


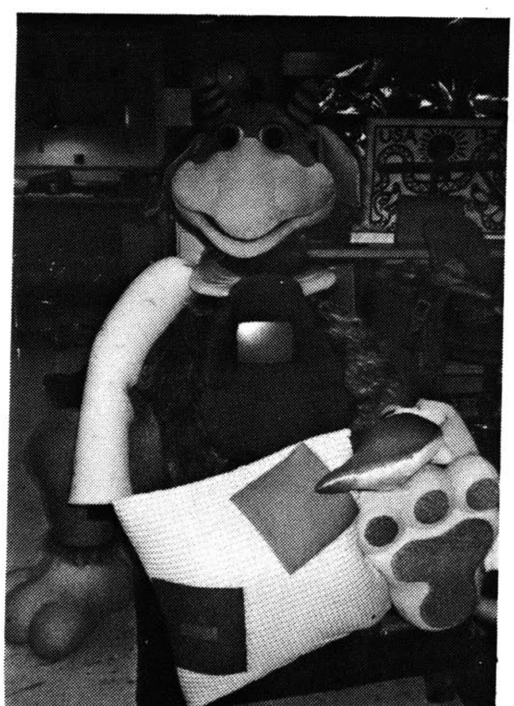
The tools we used to build Noobie were not your typical computer-building-tools. The photo above shows our workbench.

The photo to the left shows the plastic tubing that was placed around the steel skeleton. Sheet foam was sewn and glued to the tubing.



After the foam was applied, the microswitches were embedded into the foam, to allow certain areas on Noobie to be touch sensitive. In the photo to left wires can be seen that connected to the microswitches. They too were soon covered with fabric.





Once the foam was applied, fabric was sewn on. In the photo above Gwen Gordon is applying fabric to the lobster claw.

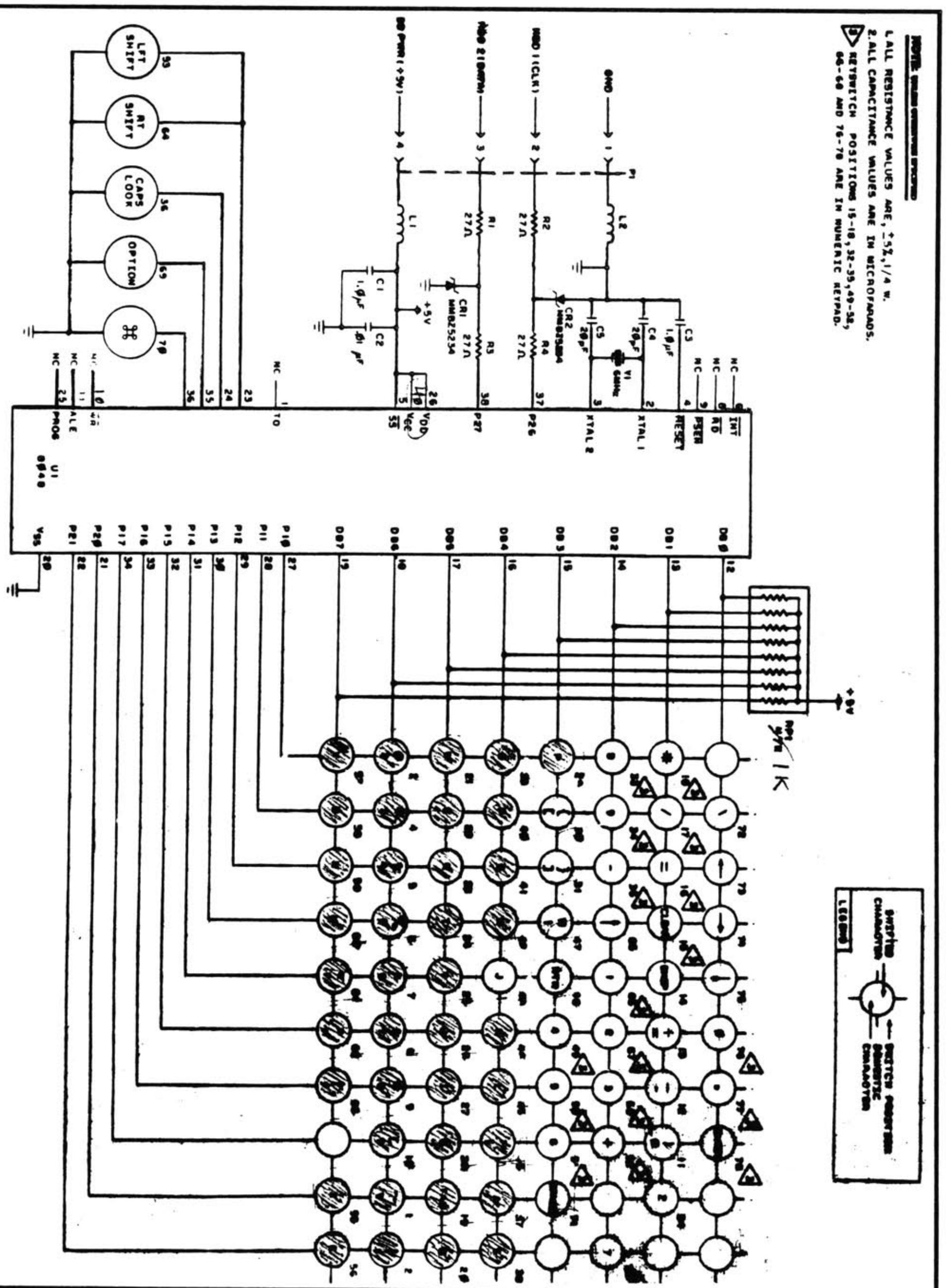
The photo to the left shows what Noobie looked like after a good portion of the fabric was sewn on.

We decided that the simplest way to electronically interface the foam-embedded switches to the computer was to use the existing keyboard circuitry. Thanks to Larry Singer, a MIT grad student in electrical engineering, the keyboard circuitry was removed from its normal encasing and placed in an aluminum chassis. From there, each switch (25 in all) was connected to a point on the keyboard matrix (see schematic on next page).

From this design, each Noobie switch could be thought of as a different key on the keyboard. By pressing a switch, a particular key code signal would be sent to the CPU (note chart on page 40). To debug Noobie, Larry made it possible to bypass the switches and plug in the normal Macintosh keyboard to a special connector.

Also a part of the electronic interface was the movable arm. By disassembling a Kaft joystick that interfaced to the Macintosh, Doug Milliken was able to make a pointing device out of the left arm. Doug placed the potentiometers (pots) from the joystick at each joint of the arm; **x** at the shoulder and **y** at the elbow (refer to diagram on page 40). These two pots are slightly different than most, because they have only 80 degrees (+/- 40 degrees) of electrical travel, instead of the usual 300 degrees. The pots are connected to circuitry in the joystick box that interfaces them to the mouse port in the Macintosh. Along with this, a switch was embedded in the thumb which, when pressed, responds like a mouse button.

Therefore, by modifying traditional electronic interfaces, we were able to give Noobie a set of more touchable interfaces.

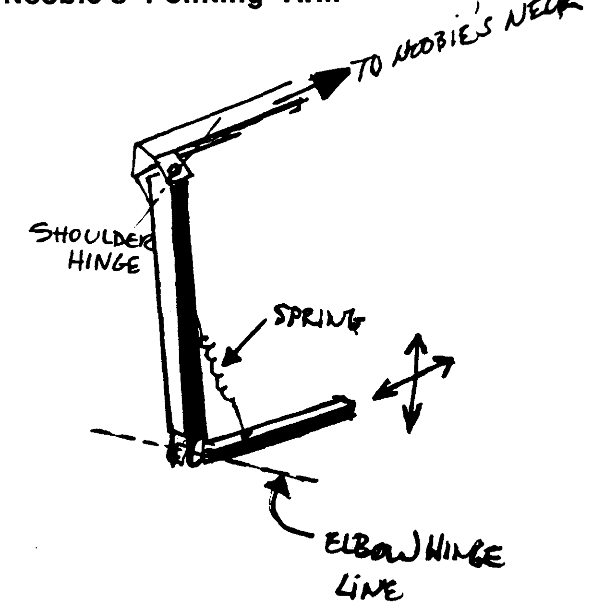


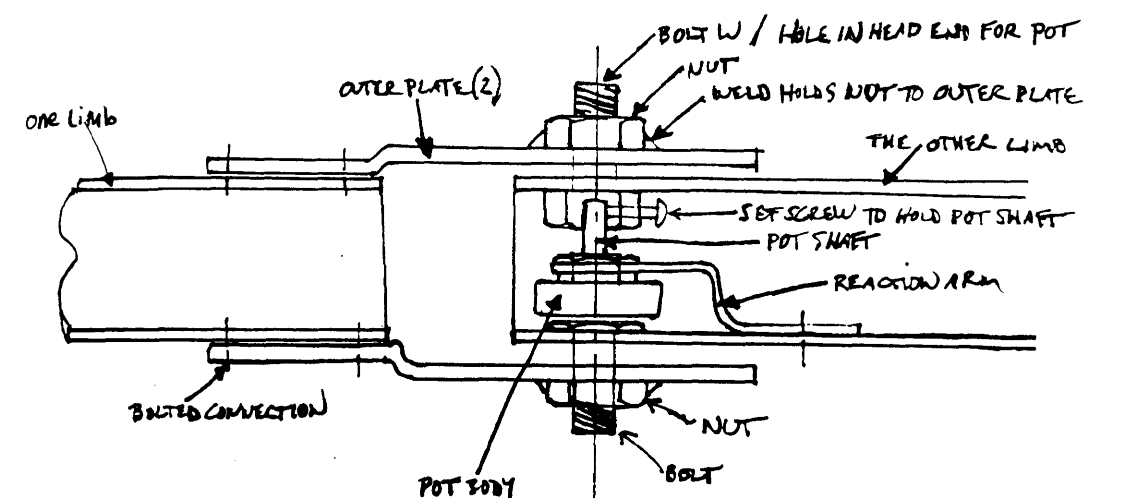
The Modified Keyboard Schematic: shows which points on the matrix were used

The following chart shows the correspondence between the switches in each of Noobie's parts and the keyboard keys and codes:

Noobie Part	Keyboard Key	Code
Hands	d	Ø2
Arm	w	ØD
Arm	2	13
Arm	v	Ø9
Leg/Foot	f	Ø3
Leg/Foot	e	ØE
Leg/Foot	3	14
Leg/Foot	b	ØB
Tail	g	Ø5
Tail	r	ØF
Tail	4	15
Bellybutton	n	2D
Eyes	s	Ø1
Eyes	q	ØC
Ears	1	12
Ears	c	Ø8
Nose	a	ØØ
Antenna	(tab)	30
Horns	`	32
Horns	x	Ø7
Mouth	;	29
Mouth	o	1F
Plus	9	19
Minus	p	23

Noobie's Pointing Arm





Close-Up of Arm Hinge

The Noobie software application, referred to as NoobieSoft, is a very simple representation of what we would eventually like to do. Its state of development, is merely a starting point for further research. How children can use NoobieSoft is explained in the user scenario that follows:

Two children crawl into the lap of Noobie. They sit facing the screen, contained in Noobie's stomach. An adult switches on the Macintosh Plus and hard disk, by reaching behind and inside Noobie's torso. The startup movie begins. With music and animation, it shows the children what kinds of animals they can make with the different animal parts in the database.

After the startup movie is finished, an animal (Noobie Jr.) is left on the screen. Its parts can be changed by pressing a microswitch in the same animal part on Noobie. (Those parts that can change include: eyes, ears, nose, antenna, horns, mouth, arms, hands, legs, feet, and tail) Each time a child squeezes a part, a particular sound is heard, and a new animal part appears on Noobie Jr. There are up to four choices that can be cycled through for each animal part. The children can make animals which include parts from either the same animal database (i.e. all parts belonging to a dog), or from different ones (i.e. a rabbit mouth, fish eyes, dog nose, bird feet, fish tail, etc..) As of now, the selection of animal parts is only a small fraction of what could eventually be created (refer to pictures on pages 43-44).

If one child is to use Noobie, it may be difficult for him or her to see the screen while pressing the parts. Therefore, the movable arm will be useful. By positioning the cursor on the screen over an animal part, that part will change when the thumb button is pressed. In this way, a tail or leg for example, can be changed without having to leave the view of the screen. Another option that can be used, is to see the startup movie again. If a child wants to review the animal combinations available, he or she can do so by pressing the bellybutton, located in Noobie's stomach pocket.

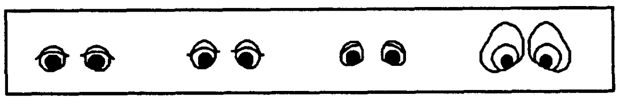
To build the software application that creates this scenario, Hans Peter Brondmo used the VideoWorks animation driver, given to us with special permission from MacroMind Inc. Essentially, NoobieSoft* consists of four programs (noobie.c, nookbd.c, noocreature.c, and noosound.c) written in C, for the Apple Macintosh Plus.

The main program, noobie.c, must be linked with the VideoWorks animation driver. The keyboard information is found in nookbd.c. This maps the Noobie parts to key codes. The procedures that deal with manipulating animal parts on the screen are kept in noocreature.c. Finally, the MIDI animal sounds are accessed from the program noosound.c. This allows for each animal part and type to have a particular sound. These sounds were generated on a Yamaha TX7 synthesizer, by Tom Trobaugh.

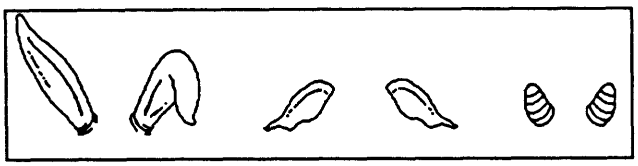
*For a more detailed understanding of the code, one can refer to Hans Peter Brondmo's program, NoobieSoft ©1987.

The following animal parts can be chosen, when using Noobie to build animals.

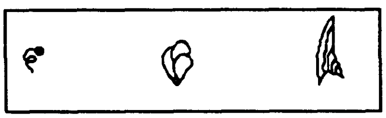
Eyes



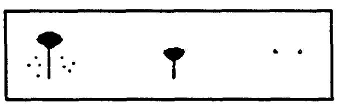
Ears /Horns



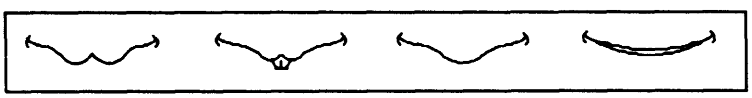
Antenna /Misc.



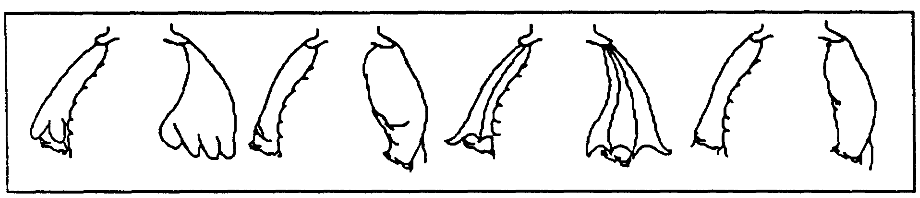
Noses



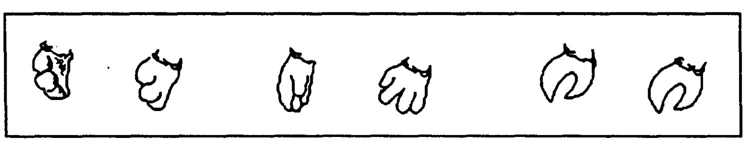
Mouths



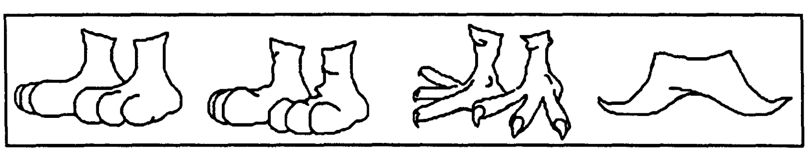
Arms



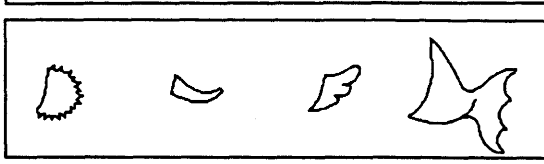
Hands



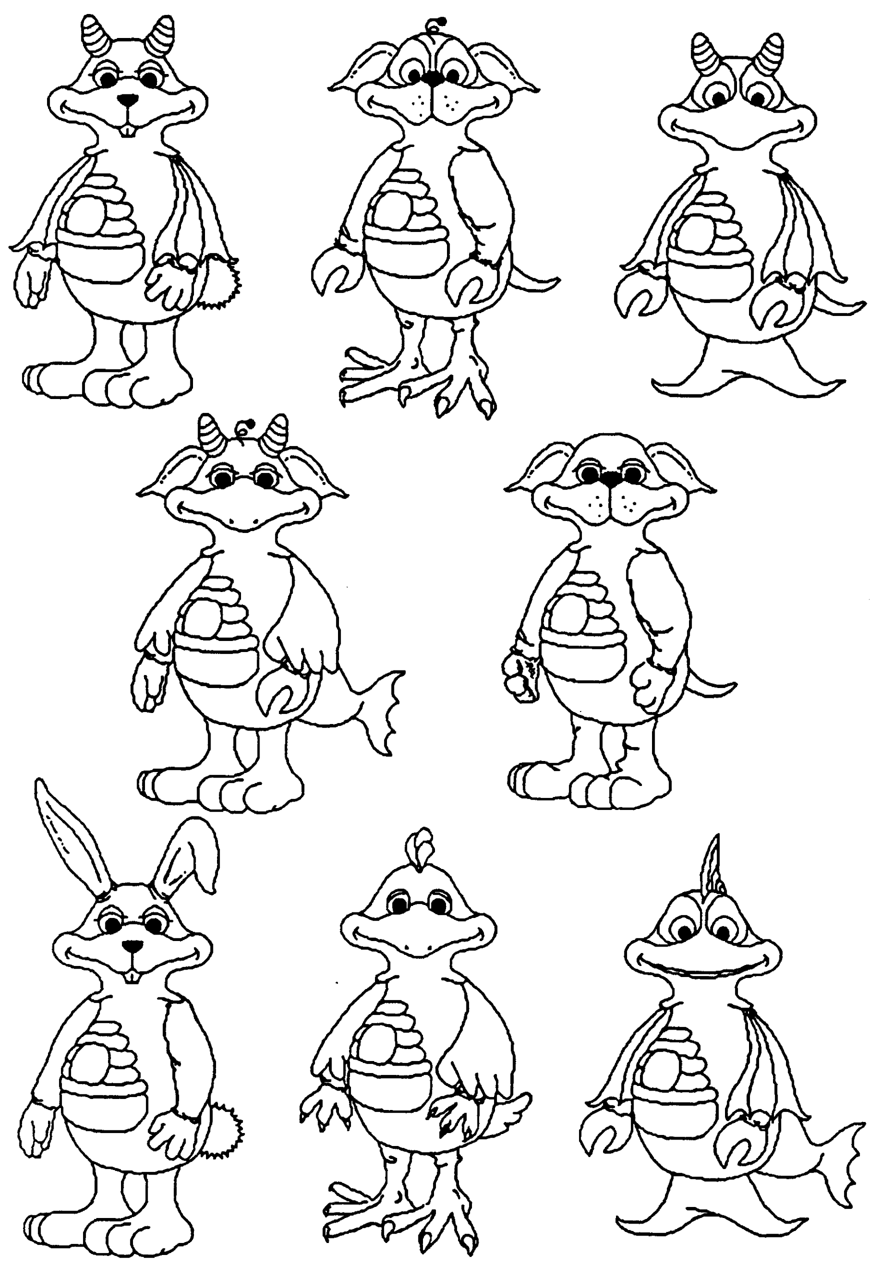
Legs

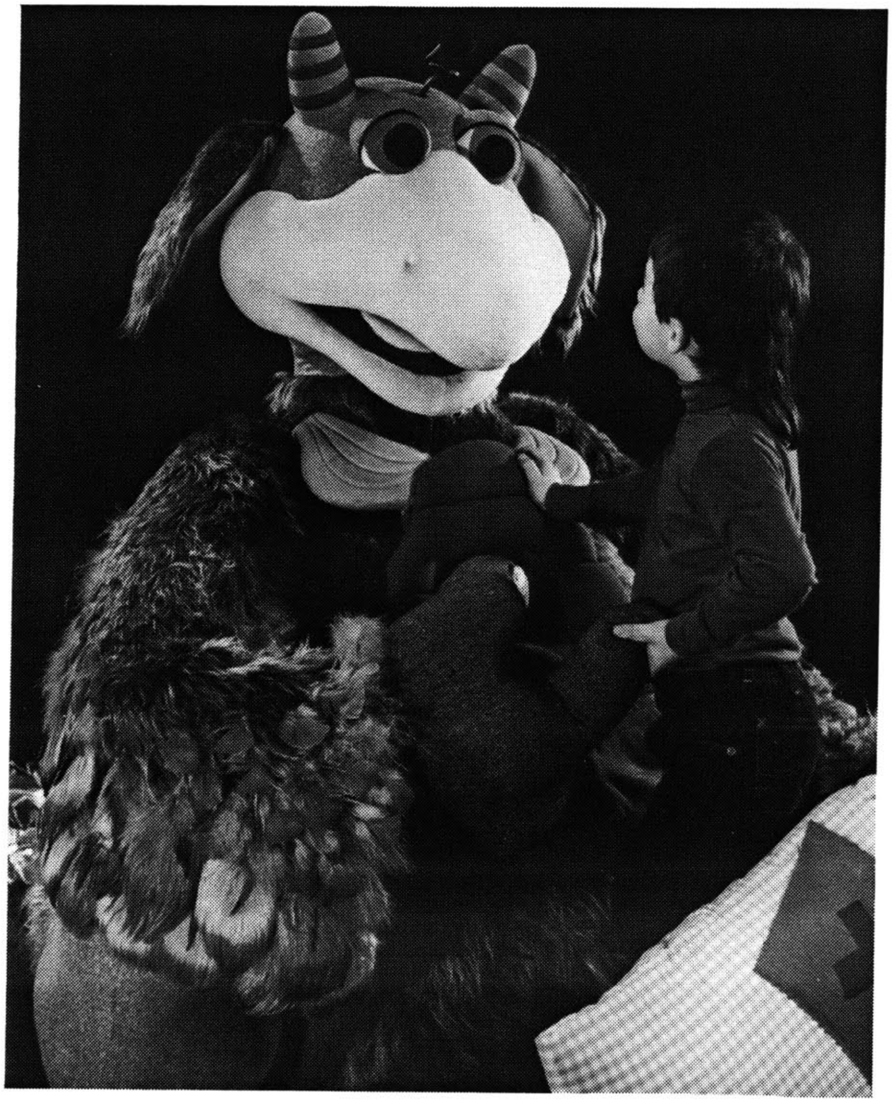


Tails



These are some of the animals that one can make, with the different parts available in Noobie.





"Hey, I'm sitting in a computer!"

Kenneth Bracey (age 6) 1987

In February of 1987, we* began a formative study with Noobie and children from the Fitzgerald After School Program through the Department of Human Services in Cambridge. There were 15 children ranging in ages from 5-8, ranging in grades from kindergarten through 4th grade. The children were broken into groups that contained 2, 3, or 4, children. Some groups mixed the sexes of the children, some groups mixed the ages, and some groups mixed both (see Appendix 8.2 for more group information).

The children were brought in to use Noobie from another room where they played with Lego's and colored. Each group was given no more than 15 minutes to interact with Noobie. In addition to observing the children, these sessions were videotaped. Afterwards each group was interviewed for 15-20 minutes in a room away from Noobie (these results can be seen in Appendix 8.2).

We used these sessions with the children to focus on five main areas that we thought would later help us to evaluate the user interface of Noobie. These five areas included:
(1) *Comprehension:* How much time did it take to figure out what to do with Noobie?
(2) *Ease of Use:* How easy was it to use Noobie for this short period of time?
(3) *Interaction Styles:* How did the kids interact with Noobie and with each other?
(4) *Attention Span:* How much time did it take before they lost interest?
(5) *Expectations:* What did the kids want or expect to do with Noobie?

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*Idit Harel, a Ph.D. canidate in Seymour Papert's group at the MIT Media Lab, and Cynthia Solomon, the past director of Atari Cambridge, were instrumental in laying the groundwork for my research with children.

The answers to our questions were found through observing and interviewing the children while they were with, and were away from Noobie. What follows is a summary of our results:

Comprehension
Regardless of the children's previous knowledge of computers, television, or animation, it took no more than 1-2 minutes for them to understand how they could use Noobie. After seeing the startup movie, generally they all expected to make animals with Noobie, but they were unsure of how to do this. One out of three groups needed an example squeeze before they could figure out what to do. Then all the groups were off and squeezing.

Ease of Use
What every child liked the best about Noobie was how they used it. They visibly enjoyed being able to climb on Noobie, to touch and squeeze the different parts. At times, however, the sensors seemed out of reach and/or hard for them to find because they did not visually stand out. The sounds, on the other hand, were very helpful in letting the children know if they had pressed a sensor. The sounds were also useful in reminding the children what animal part they were changing.

Interaction Styles (children with each other)
Interestingly enough, what we had thought to be drawbacks in Noobie's design were actually instrumental in supporting coopertive behavior among the children. One instance of this was in the location of the screen. Many times when pressing certain sensors, the children were out of view of the screen. Therefore, one child would almost always watch the screen for the animal parts they wanted, while the others would squeeze the different parts.

Another aspect that forced cooperation was the restriction of serial input to Noobie. If the children tried to squeeze different parts at the same time, the computer would simply stack the commands. The children soon realized they had to take turns, or they would loose track of what they had squeezed. In groups of 3 or more, it was quickly obvious that unless one child took a leadership role, the group's interaction was purely chaotic.

Interaction Styles (children with Noobie)

One of the first things we noticed when the children encountered Noobie was that they did not wonder where the keyboard or mouse was. Only one child even looked for the computer hardware. To the rest of them, Noobie was a new kind of creature. This observation was supported by the fact that all of the children, except 3, talked to Noobie. They said "hello" to Noobie, "good-bye", and one group even kissed Noobie. On the other hand, 7 children believed that Noobie was talking to them when sounds were coming out of the synthesizer in the softsculpture belly.

In terms of the children's interaction with the software application, NoobieSoft, they noticeably enjoyed changing the animal parts on the screen. Near the beginning of the sessions, they were asked to let us know when they were finished making their animals. In all cases, there was not one group that let us know they were done. Most likely, this was due in part to how easy it was to continue squeezing parts and changing them. No group became attached to any of the animals they had made on the screen.

Attention Span

We never did find out how long it took before boredom became apparent. In each case, after the 15 minutes were up, all the children wanted to continue to use Noobie. On a later occasion, we were able to work with a few children for 45 minute sessions. Each time they did not want to leave. A more accurate examination of attention spans should be done in the future, perhaps by leaving Noobie in one particular place (e.g., in a classroom, hospital, or museum) for an extended period of time.

Expectations

After seeing the startup movie, all of the groups expected to make animals with Noobie. It was interesting to note that the one group who did not see the startup movie had no idea what Noobie could do. In terms of the software, all the groups ageed that it would be "...great...fun...the best", if their animals on the screen could be animated. Even 8 out of the 15 expected the softsculpture exterior to move as well. Overall, the children did not expect to do anything more than we ourselves had envisioned for future research.

In March of 1987, two teachers came to use Noobie. Ruth Hosien had 4 years of teaching behind her, and Margaret Schmacher had 3 years. For an hour and a half, the two interacted with, and talked about, Noobie.

For 10-15 minutes the teachers used Noobie, after which a 45 minute discussion took place about how they saw using Noobie which children. During that time, Idit Harel and I asked a series of questions which were the basis of discussion.

In the areas of *comprehension, ease of use, interaction styles,* and even *attention span* , the teachers mirrored what we had learned from the children. However, in terms of *expectations,* the teachers gave us much more in the way of feedback.

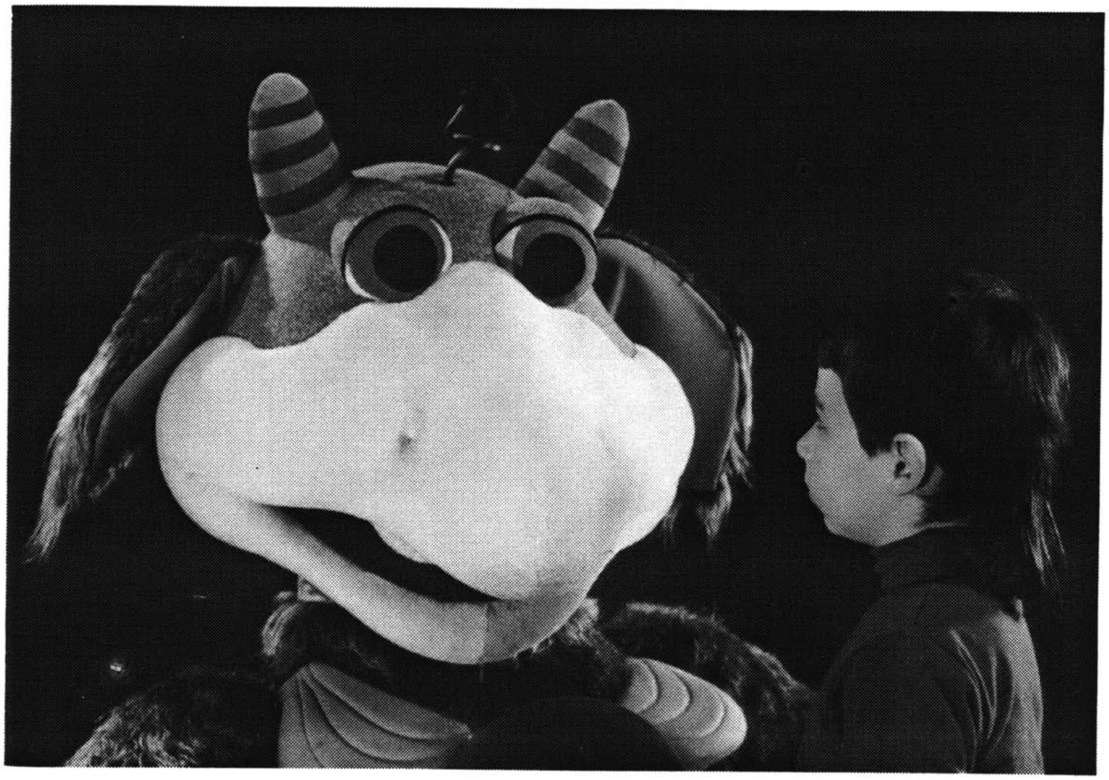
Their first reaction was that Noobie could be used as an effective catalyst for story-telling. After the children made animals, creative writing assignments could range from what this animal might do, to why this animal has dog and bird parts. Another activity that was suggested dealt with the animal parts being objects to learn with. Such activities as learning to count the parts, and remembering the order of how the parts were changed could help math and memory skills. They also suggested activities that would concentrate on identifying different animal characteristics, such as footprints, or texture differences between feathers, fur,or shells.

Other suggestions included adding environments to the screen animals, to see how the animals would behave in different weather and land conditions. Along with this, suggestions were made concerning activities that dealt with sound. Such problems as how to create animals by only hearing the sound, and hearing a number of sounds and repeating that sequence, were suggested.

It was interesting to take note of how these teachers might use Noobie in a classroom. Unfortunately, I believe these teachers were falling into the trap of trying to fit Noobie into an already existing curriculum. I had hoped that they might think of things that Noobie could teach that weren't already being concentrated on in their classrooms. However, when asked to draw on one's own experiences to create new things, it is hard not to fall back on what is already familiar territory.

From these sessions with children and teachers, revisions and/or additions were suggested to us. From observations or direct interviews, their comments and reactions were recorded. The following chart shows a summary of our results.

Revisions Suggested	By Children	By Teachers
StartUp Movie	•show how to make animals by pressing part	(same)
Switches	•should be easier to get at •should be easier to see	 (same)
Screen	•should be easier to see	•should be larger
Sounds	(nothing)	•should correspond to an animal, regardless of part
Software	•screen animals should move •change backgrounds for screen animals •have Noobie talk to users	(same) (same) (same) •have information to read about the animals •parts should shrink and grow when pressing the + and - switches on pillow



"We're searching here,
Trying to get away from the cut and dried handling of things, all the way through,
Everything-- and the only way to do it,
Is to leave things open until we have completely explored every bit."

Walt Disney

Aside from the suggestions we received from the children and teachers that used Noobie, I believe there are many more areas to research and explore. Let me begin by examining that part of Noobie which we built first, the interior structure.

First off, the materials used to create the interior skeleton could be radically changed. Something besides steel should be considered, due to amount of weight the steel adds, and the amount of flexibility it takes away. The use of thermal-plastics should be experimented with, because of their lightweight, yet sturdy, qualities. Glass- or mineral-filled polyester, or nylon, could be melted and shaped to our specifications.

The dimensions of Noobie's interior should also be modified. More room is desperately needed in the torso to hold the computer hardware. Additional space is also needed in the child's sitting area, so that more than one person can sit in Noobie's lap. However, reducing the height of Noobie would allow children to access Noobie's facial parts more easily. If those dimensions were to be adjusted, the size of doorways should again be taken into account. Perhaps a modular structure should be considered to allow Noobie to be more easily moved. With pieces that hook together and come apart, Noobie could be transported without the 3 or 4 person road crew now needed.

In terms of the exterior design, the*dimensions, appearance*, and *materials* all should be re-examined.

Dimensions

Noobie's size should most certainly be experimented with. By making Noobie much smaller or larger, new kinds of environments could emerge, and new types of information could be conveyed. On the smaller side, a hand-held animal could be developed that would be somewhat puppet-like in nature. Instead of sitting in Noobie, a child could hold it, and squeeze the different animal parts just as he or she does now. On the larger side, a rocking-horse metaphor could be adapted to develop another prototype. With the screen located in the head, the child could straddle the animal and squeeze the different parts. Still larger, a room size environment could be developed. The ceiling, floor and walls could contain softsculpture creatures growing from them. The screen could be located on the floor, modeled after a large lake, or on the ceiling, modeled after the sky.

Appearance

There is so much more fun waiting to be found in Noobie's appearance. Thumbnail sketches and models should be used to explore the various possibilities. The question of what animal parts should be included is very important. For instance, each new Noobie could include only the parts of one family of animals. One could have a fish-Noobie, an insect-Noobie, a bird-Noobie, etc. More than one structure might not be necessary, if the exterior softsculpture could easily zip off, and another be put on. For that matter, if one were zipping open Noobie, perhaps children could zip open the chest and find the heart, kidneys, etc. In this way children could learn about the insides, as well as the outsides, of animals.

Another possibility is to have Noobie-parts in a toy chest: no screen, but parts that could be put together in any number of ways to build 3-dimensional animals. The twist would be that each part would have the computer knowledge of how to move, so when any combination of parts is put together, a moving playful animal is made. Still another possibilty would be to create a Noobie terminal that doesn't look like an animal at all. It could be a free-formed, non-representational environment, where a child sits and creates animals with a small hand-held input device, much like the one previously mentioned.

Materials

New kinds of glues, foams, and fabrics should also be explored. First and foremost, the Barge Cement should be replaced. Though it is the most durable of all contact cements, it is also the most hazardous to one's health. Perhaps if the sheet foam were replaced with another squeezable material, like molded latex, the Barge Cement would not be necessary. New types of fabrics should also be considered and tested for durability. As it stands, the fabrics used in the existing Noobie prototype will not last more than another year before refurbishing will be necessary.

The sensors used to make Noobie's parts touch-sensitive also need our further attention. It is important that we find input devices that convey the most amount of information between the user and the computer. Strain gauges or pressure transducers should be tested to see how much information we can learn from a simple squeeze. By measuring pressure, another dimension of information could be used to distinguish different types of input. The sensors should also be explored in conjuction with voice input, and/or a touch screen, which could allow Noobie to be a more flexible tool. As it stands now, the microswitches we used in the first prototype can only give us on/off signals.

Another aspect that we should consider is where to place the sensors, and how to camouflage them. From our studies with children, we've found that they should be lower and more highly recognizable, by sight or by touch. The sensors, on the other hand, should not be so accessible that they are easily leaned against.

The most unexplored part of Noobie is the sofware design. Color and animation are areas that need to be experimented with. The visual database of animal parts and animal movements are relatively unexplored. What animals should be included, if one is concerned with teaching children? What behaviors should this database of animals be able to do? How do we translate these behaviors to animation? Even the relationship of an animal's environment to its behavior should be questioned.

More questions arise in the area of sounds. How do we create sounds so that even blind children can build animals? How can these sounds be audible to the partially deaf? How can the children create their own database of sounds? How important is sound as a feedback mechanism?

The amount of background information describing animals should also be examined. Is it possible to describe the animals in words, as well as with pictures and sounds? Perhaps a database of text could be stored and called up after the children are done choosing their animal parts. Stored video disk images could be used to show real animal behaviors.

These ideas are only a few of what I believe Noobie could include. However, until further research is allowed to happen, we will not find out what other Noobies wait to be created. As Marvin Minsky wrote, "...we ought to recognize that we're still in an early era of machines with virtually no idea of what may they become. What if some visitor from Mars had come a billion years ago to judge the fate of early life from watching clumps of cells that haven't even learned to crawl? In the same way, we cannot grasp the range of what machines may do in the future, from seeing what is on view right now." [41]

[1]Jerome S. Bruner, Toward a Theory of Instruction (Cambridge, MA: Harvard University Press,1966), p. 1.

[2]Cynthia Solomon, Computer Environments for Children (Cambridge, MA: MIT Press,1986), p. 135.

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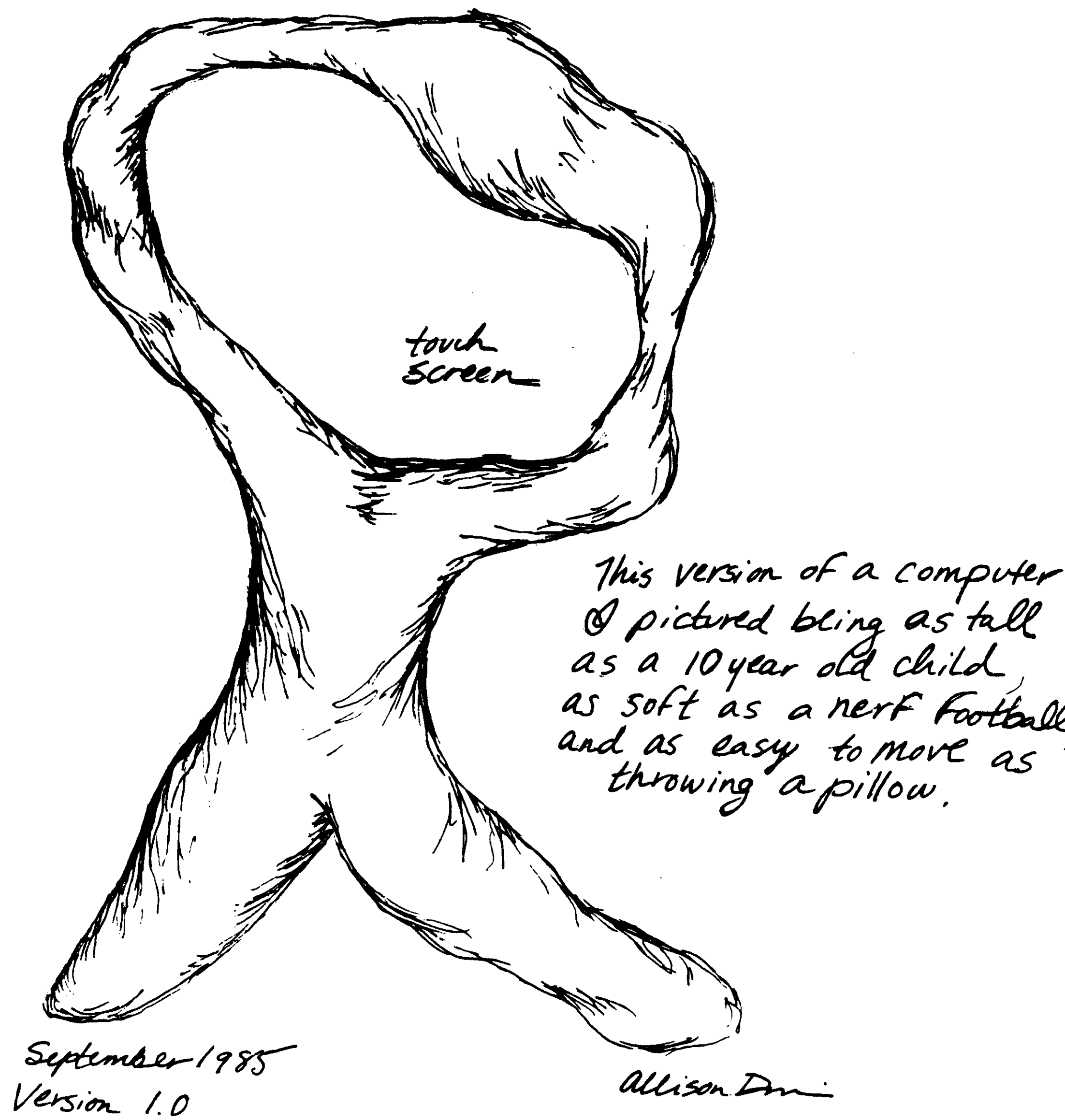
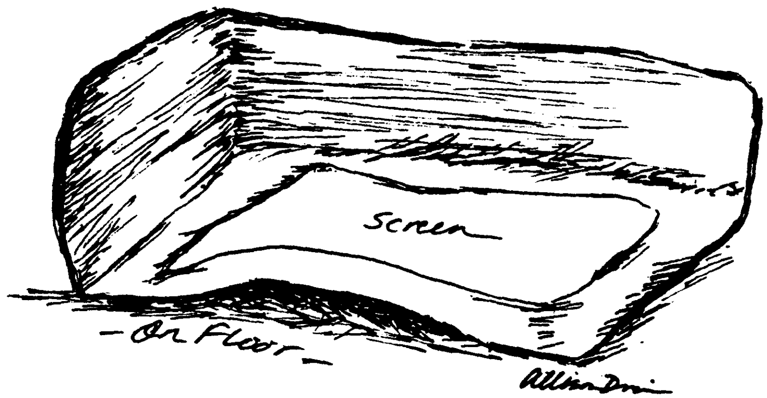
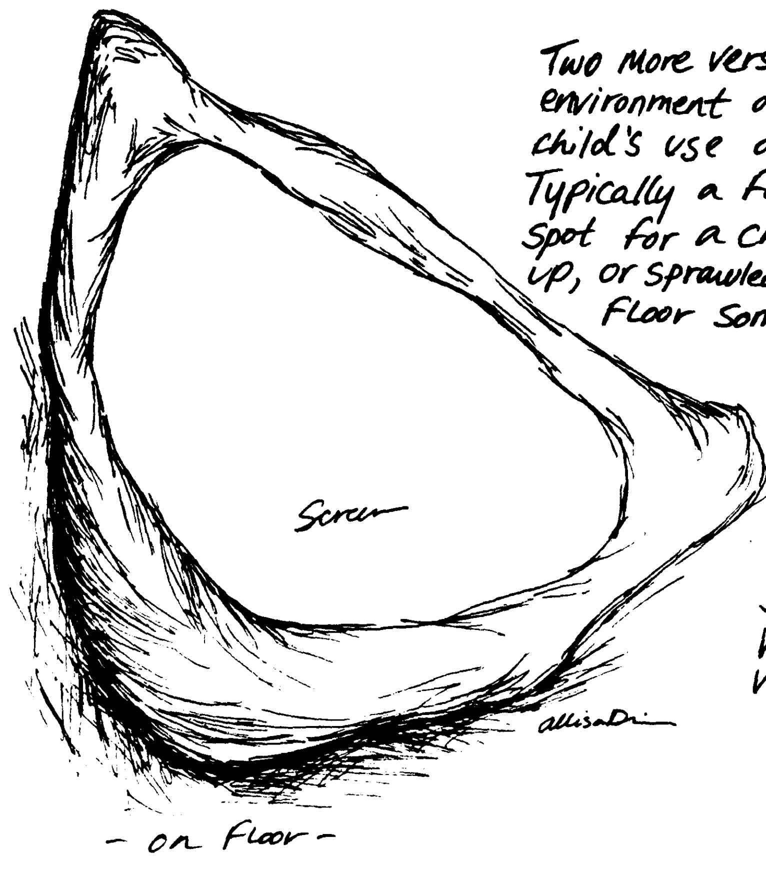
The next nine pages contain sketches that represent the transition Noobie went through from the Fall of 1985, to the Spring of 1987. The later illustrations were drawn in collaboration with Marc Baldo, a freelance illustrator and animator, and Gwen Gordon, our softsculpture designer.

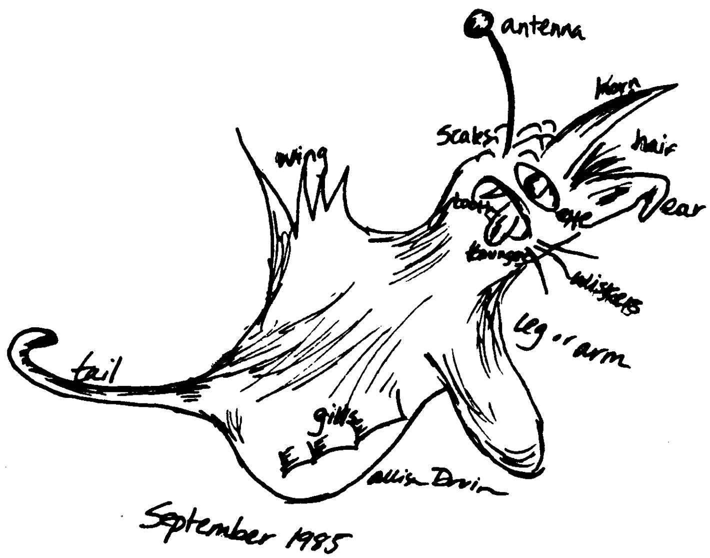






Two more versions of this environment deal with a child's use of the Floor. Typically a favorite play spot for a child is curled up, or sprawled out on a Floor some where.

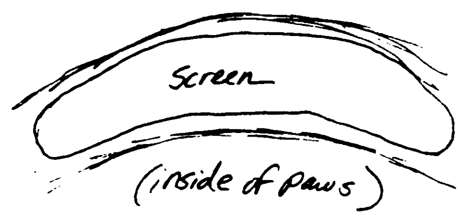
September 1985
Version 1.1
Version 1.2



Input Device for Environments
squeeze part on body -
that part will pop up
on the screen in
front of them

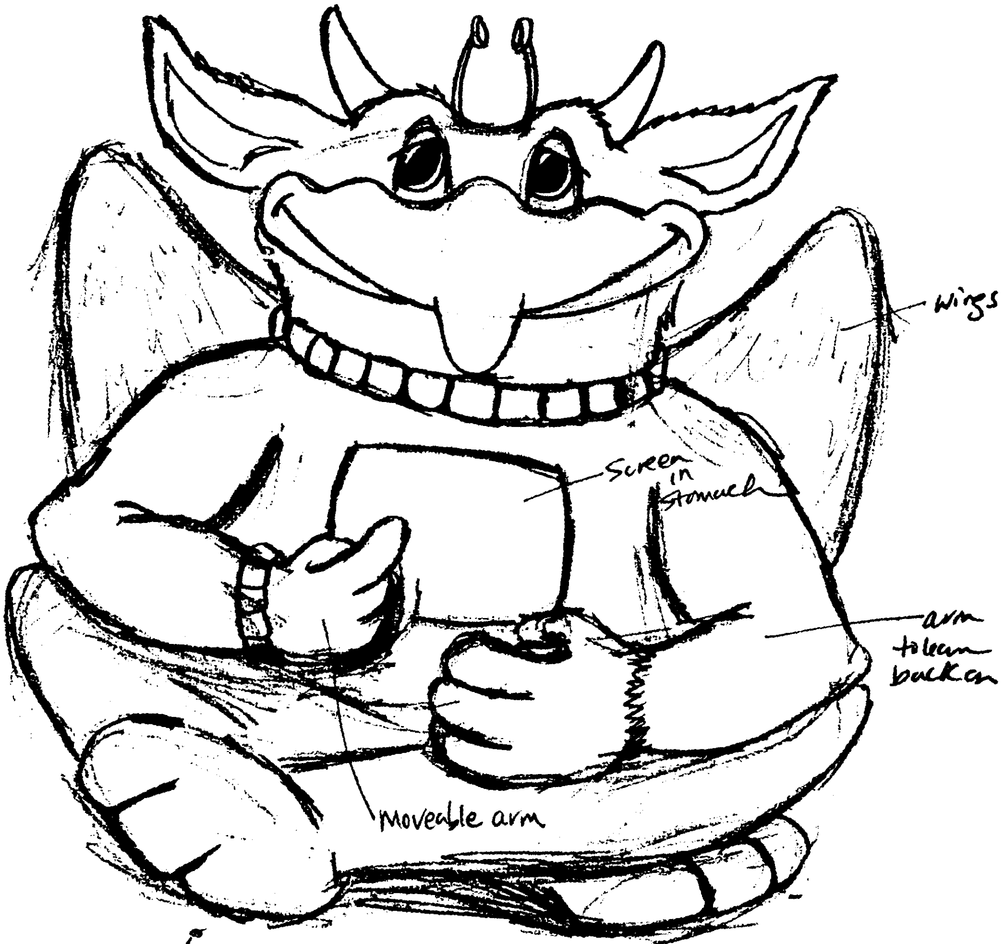
Children sit in the lap of the computer creature. the Screen would be in the palms of the paws. To create animal forms, children squeeze animal parts on the computer.

- play Station for children
- a place to share or individually explore
- gives multiple points of view
- viewing, abstracting, constructing, instructing
- allows child to take a hold of the world



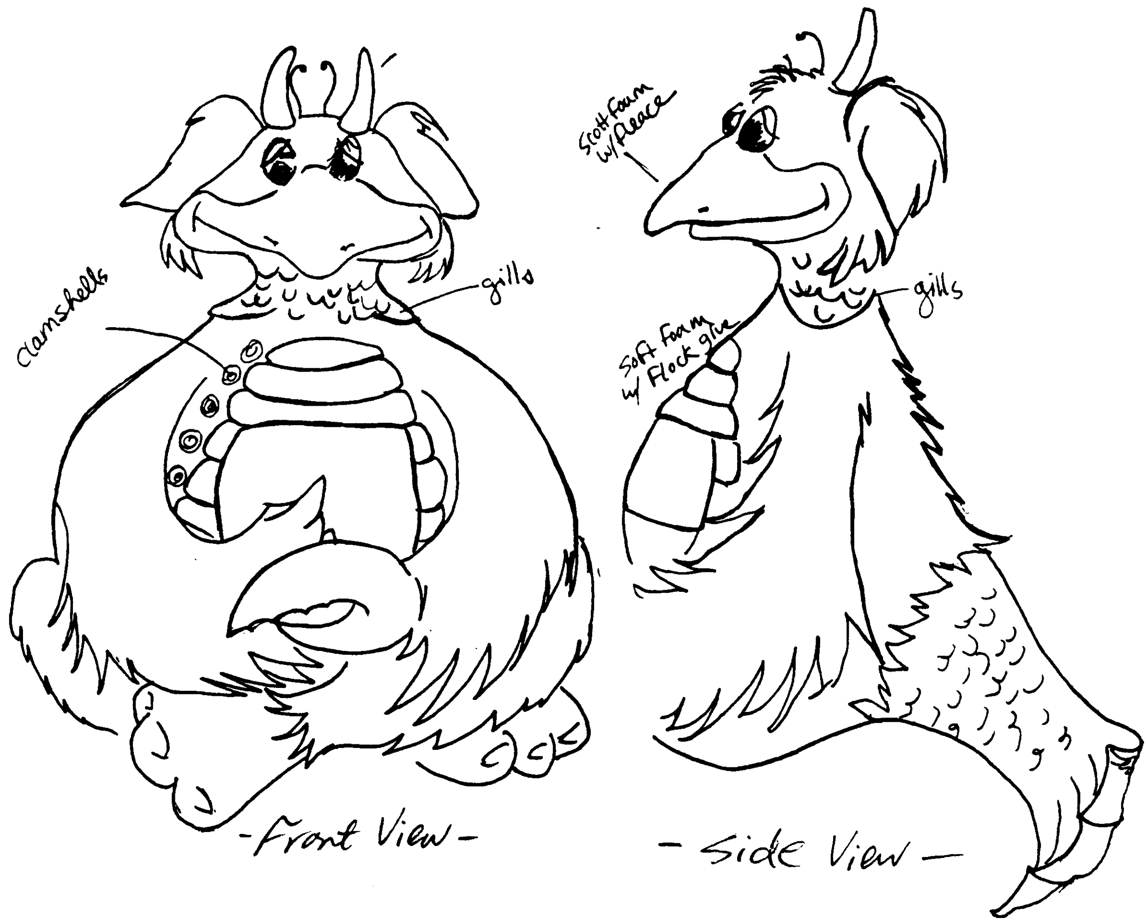
(character re-design) July 1986

(character re-design)
July 1986



(Character re-design - Full body)
July 1986

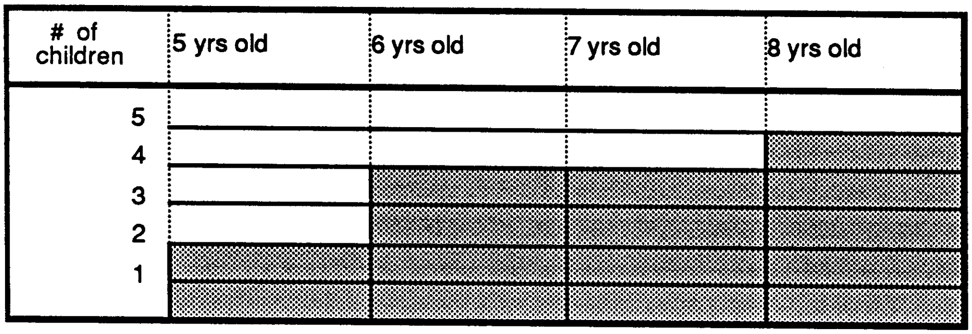
Character Redesign July 1986



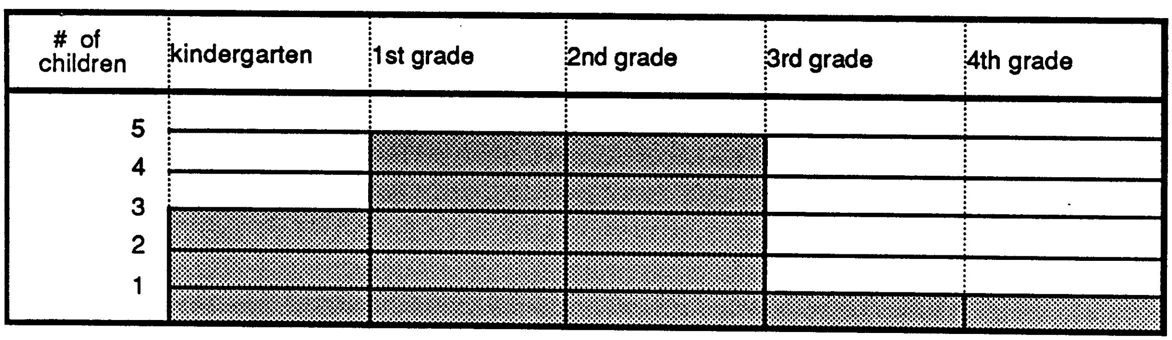
Final Noobie Sketches - Sept. 1986

In our study, the children's ages and grades varried.

Children's Age

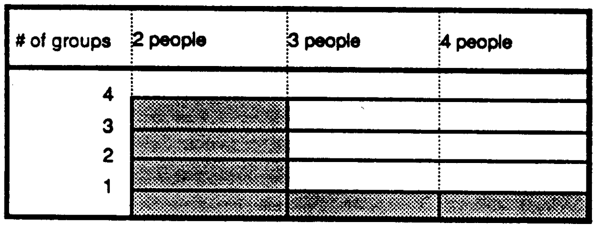


Children's Grade Level

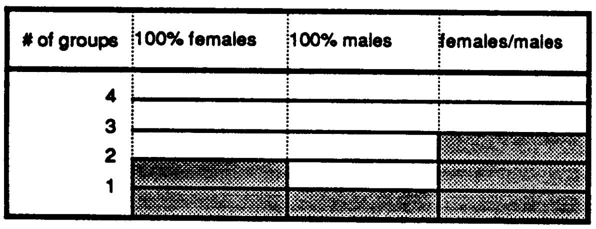


The next group of charts show the groups' size and makeup.

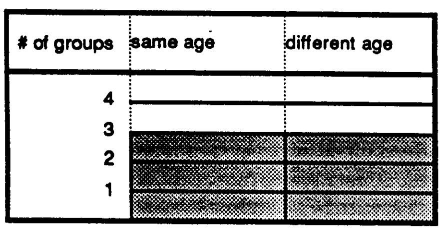
Group Size



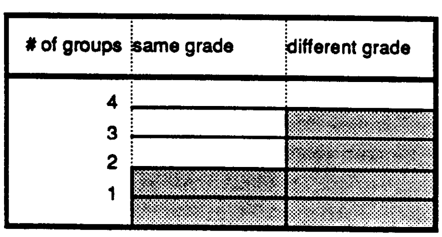
Group Makeup -Sex



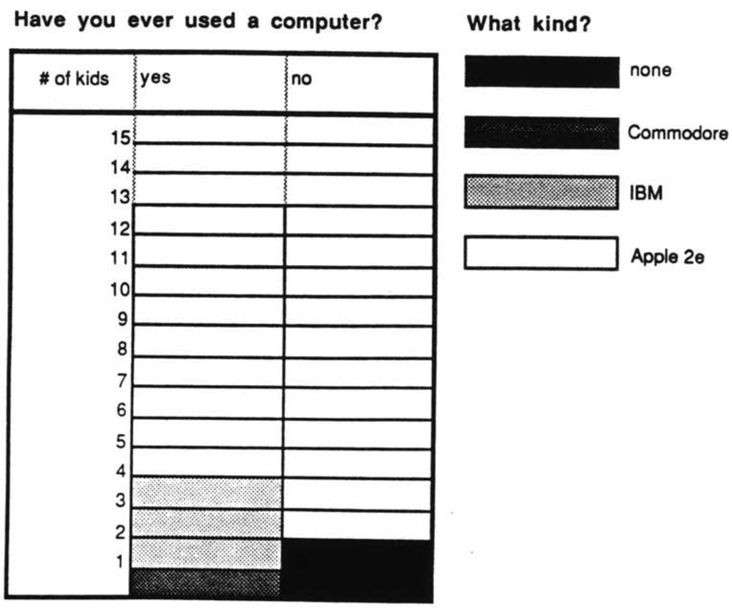
Group Makeup -Age

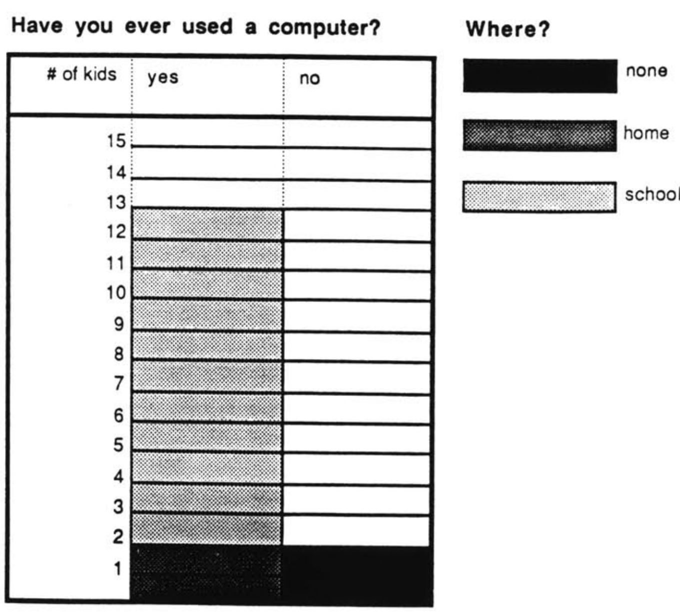


Group Makeup -Grade



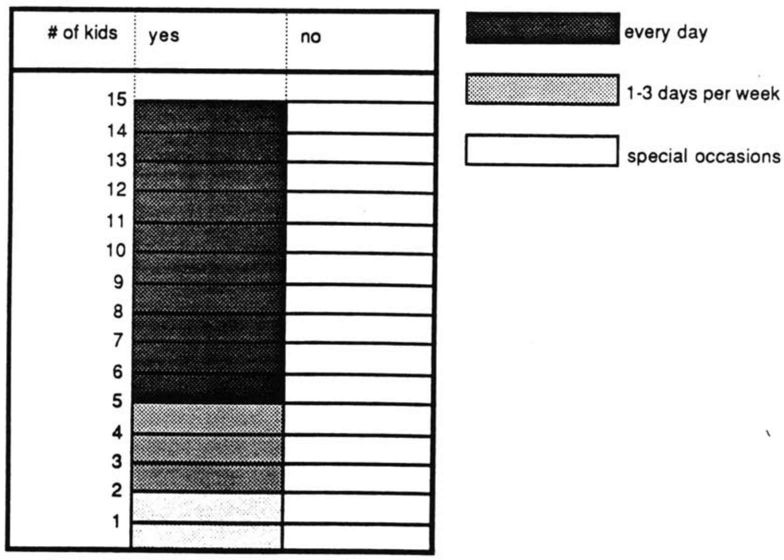
The next five pages contain questions that were asked of the children after their sessions with Noobie.



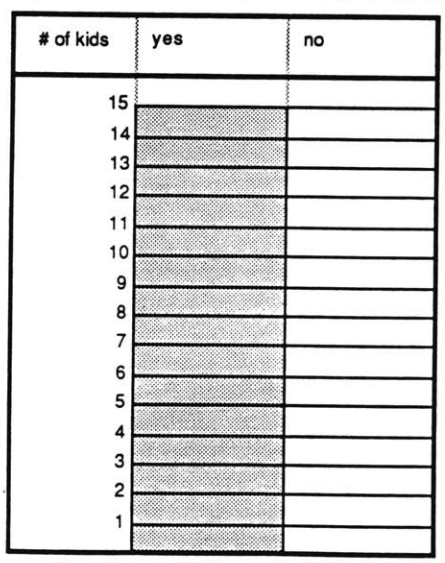


Do you watch TV?

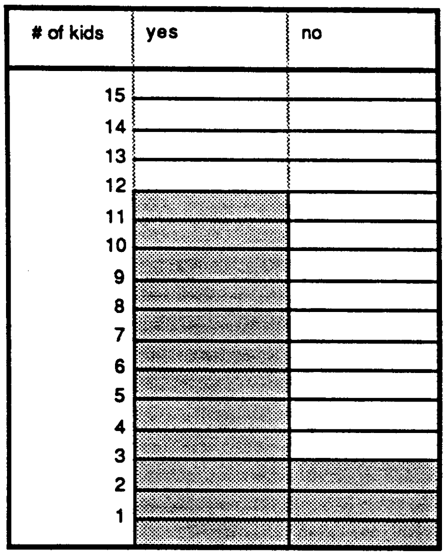
How often?



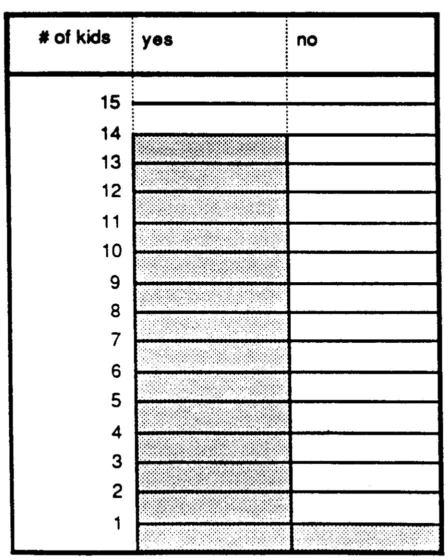
Do you watch Saturday morning cartoons?



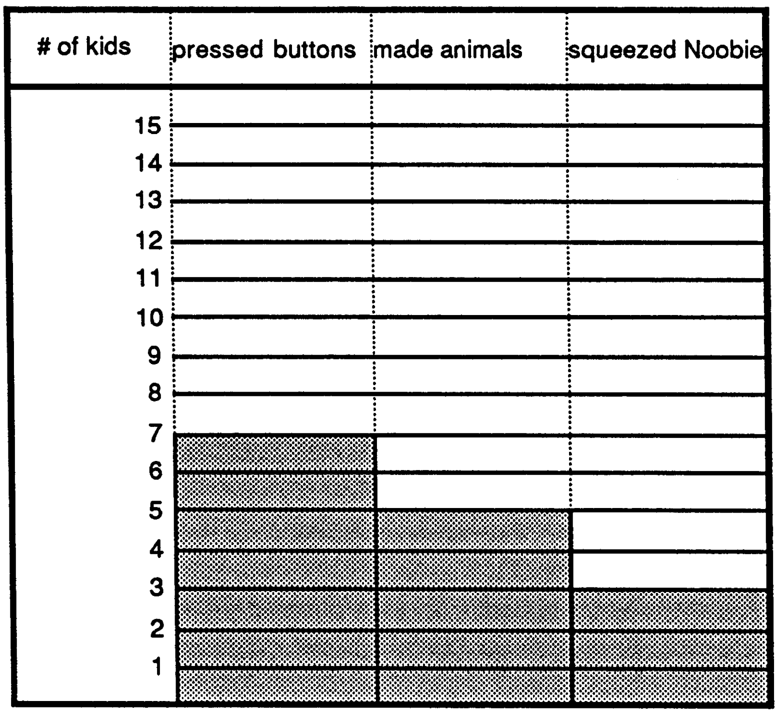
Have you watched the Disney Channel?



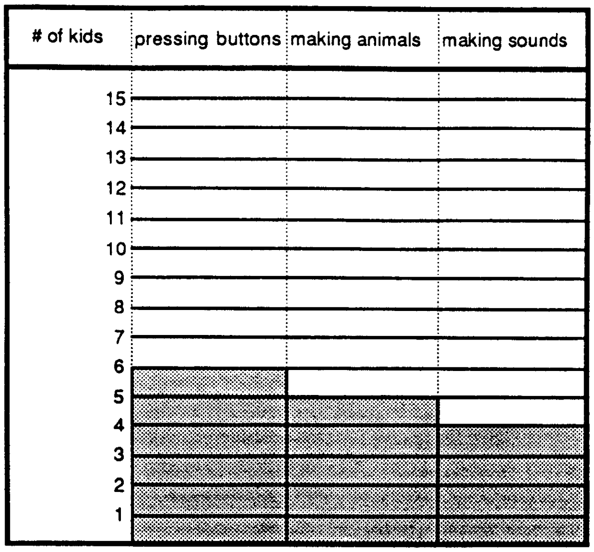
Have you ever seen the Muppets?



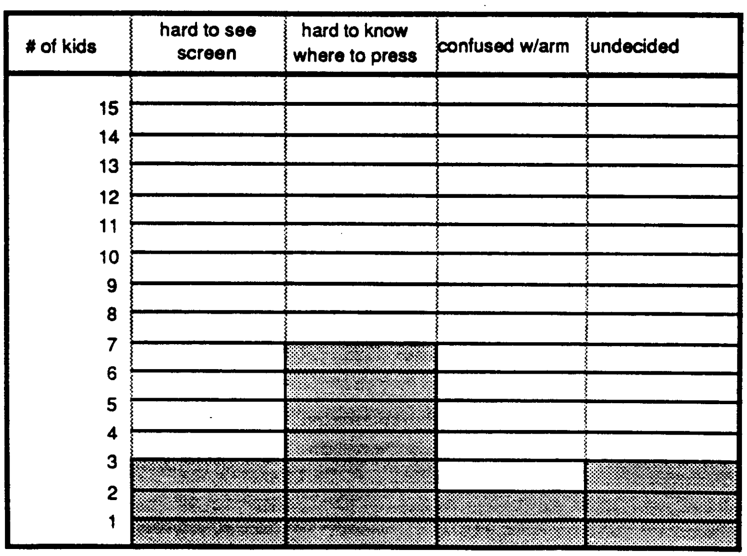
How would you describe what you just did?



What was the best thing you did with Noobie?



What was the worst thing about Noobie?



No photographs were to be taken. No video cameras or tape recorders were to be allowed. The press was to be turned away. These were the rules we were to abide by, if Noobie was to be taken to the Hospital for Sick Children, in Toronto, Canada.

For four days, we had demonstrated Noobie in Toronto at SIGCHI + GI '87 (a conference that focused on "Human Factors in Computing Systems and Graphic Interfaces"). Bill Buxton, the conference co-chairman, had suggested that we take an extra day and bring Noobie to a children's hospital in town. Not knowing what to expect, we did.

Some children were in wheelchairs; some dragged intravenous (IV) bottles wherever they went; some rolled in by way of hospital beds; and some of the lucky ones had to use crutches. No one ever told us why any of these children were there. Though, from the looks of things, it seemed a fair number were living through chemotherapy, a good portion had had major surgery on some appendage, and a few had hands or feet that had developed abnormally. These were the 20 or so children who used Noobie that day in the hospital.

I have no written notes recording the children's reactions to Noobie, and I have no pictures documenting even our presence. What I do have are some vivid feelings about what I saw that day. My most overwhelming one was that of surprise. With crutches, IV's, wheelchairs and the rest, these children reacted and used Noobie no differently than did the 15 children that could freely crawl all over. Though less mobile in their attempts to squeeze all the parts, they were able to use Noobie. This we never counted on, for in fact we never thought about handicapped access to the switches. The children confined to wheelchairs rolled around Noobie, and grabbed at what they could. The children with IV's wiggled their way into Noobie's lap (IV cord and all). The two children who were wheeled in on hospital beds found they could even press the claw or the tail. Noobie was poked at, squeezed, and pushed with everything from hands, to feet, to crutches, to noses.

What I did find most amazing about these children was their extraordinary patience to cooperate with each other. At one point, there were 7 different children pressing the different parts of Noobie. Curiously enough, they all weren't pressing at the same time. Each waited until the other had his or her turn. We did not find this to be the case in our previous study with children. There was a child in a hospital bed at the claw, and another at the fish tail. There was child with an IV taking care of the ears, and another sitting in Noobie's lap. There was a child in a wheel chair at the arm, and a child with crutches at the eyes and nose. There was also a little boy that was lifted by a nurse, so that he could squeeze the antenna.

Together they built animals. The child in Noobie's lap would call out the part to be changed, and that person at the part would do the squeezing, while the person in Noobie's lap would call out what was happening on the screen. This pattern of interaction continued for near half an hour, until the next group of children were rotated in by the attending nurses. For the hour and a half that we stayed in the hospital, Noobie was the center of their giggles and excitement, and cooperation.

When it was time to leave, one child that called herself Mam asked me, "Can Noobie stay?"
I said, "I really don't think so."
After some thought, Mam asked, "Would it be OK if I taught my bunny to be Noobie?"
I replied, "Sure, but how would you do that?"
She said, "I'll hug my bunny all over, and I'll make believe he can be any animal I want him to be."

What did I learn from Mam and all the rest? Basically, that I need at least a million more hours to spend with all kinds of children. The ideas that surrounded the building of Noobie, prepared me very little for the vast number of questions that I would encounter when using Noobie with children. We need more time, more children, and more research, before we can truly realize what we have built, and what we can build in the future.