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ABSTRACT

This study describes preschoolers' computer-generated graphics. Of specific interest were three questions: (1) What is the nature of children's computer-generated drawings in terms of the developmental stages of art? (2) How do the stages evident in children's computer-generated drawings compare with those in drawings produced with traditional art materials? (3) What evidence is there to indicate that children use the computer as a means of symbolic representation? The primary sources of data were computer-generated graphics produced by four middle-class children with no prior exposure to Apple computers or the mouse attachment. Equipment used to produce the computer graphics included an Apple IIGS computer with color monitor using a PaintWorks Plus software program and a black and white Macintosh SE with MacPaint. Video and audio data were collected in eight 1.5 hour sessions. Findings revealed that computer-generated graphics exhibited the traditional three broad developmental stages of art. Stages evident in computer art were consistent with stages in works produced with traditional art materials. Children used the computer as a medium for creating expressive and symbolic representations that reflected stages of representational development. A bibliography provides 21 citations. (RH)

A Study of Children's Computer Generated Graphics

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(WORKING DRAFT)

A Study of Children's Computer-generated Graphics

The introduction of microcomputers into early childhood classrooms generated considerable interest about the contributions that microcomputers might make to young children and how computers might be used to ensure the best possible results. Speculations about computer effects range from positive to negative and pertain to all domains of development. Some critics question the appropriateness of exposing children to computers at an age when children are constructing their knowledge about the world from concrete experiences. Computer activities that limit children to manipulation of two-dimensional abstractions of objects instead of the real objects themselves are seen as potentially harmful (Cuffaro, 1984; Zajonc, 1984). Proponents of computer usage do not agree with the interpretations of the computer as a basically nonconcrete tool that may negatively affect children's ways of thinking. On the contrary, some see computers not only as providing children the opportunity to acquire programming skills but also as a means of promoting problem solving, creative thinking, and the ability to engage in symbolic representation (Goodwin, Goodwin, & Garel, 1986). Further, when children create graphics on the screen, they are manipulating spatial variables, or concreteness; how the material is used rather than the material itself defines real from symbolic materials (Church & Wright, 1986; Silvern & McCary, 1986). Some researchers take a more cautious view and focus on maturational levels and skills that preoperational children need in order to benefit from computer usage. Among these are level of representation or degree of abstraction, spatial knowledge, and ability to see part-wh relationships (Brady & Hill, 1986; Strand, 1986). One study found that preschoolers who benefited from microcomputers were more mature, had a higher level of representational competence, and tended to engage in single-minded, sequential, and abstract play; it was suggested that children who lacked this representational ability needed further experience with concrete materials (Johnson, 1985).

The ability to create symbols to represent meaning is a function associated with cognition; thus the use of computers during the early years, a period of rapid growth of symbolization, is of prime importance. While the benefits of traditional art activities to symbolic representation have long been recognized, the availability of computer software programs for drawing and even coloring could provide the same benefits: promoting children's capacity to understand and create meaning through use of symbols for representation (Smith 1982). Some supporters of computer usage for young children believe that the computer's capacity to translate symbols rapidly can provide an opportunity for developing symbolic competence (Dickson, 1985; Hofmann, 1986; Kull 1986). While there has been conflicting evidence, such claims are given support by some research. One study using drawing programs found that children moved from experimenting with the machine's responses to carefully planned symbolic representations followed by explanations of the procedures (Church & Wright, 1986). Others have reported that experiences on the computer and conceptualizations on paper affected each other (Vaidya & McKeeby, 1983) and that computers enhanced other expanding symbolic systems such as language, pretend play and counting (Beaty & Tucker, 1987).

It is often assumed that the direct, active involvement of using traditional art materials such as crayons is absent with computers. However, computers can offer children other different symbol systems and activities that allow for greater child control and creativity. Some software programs provide the equivalent of paint and brush activities, allowing children to create pictures and designs from scratch and to use computers for symbolization much as they do other art media (Sheingold, 1986). A small number of studies related to children's use of computer graphics indicate that children can master the computer, use it as a powerful tool for aesthetic expression, and become active directors of their creations. Reports show that computers also impacted children's use of traditional art materials by helping them attempt new things on paper; thus computers became an extension of the available art materials and affected conceptualizations on paper (Alexander,

1983; Church & Wright, 1986; Sheingold,1984; Vaidya & McKeeby, 1983).

While preliminary studies confirm the appropriateness of computer drawing activities for young children, little research has addressed the computer's impact on children's art abilities or stages of art development. However, given the symbolic nature of art and the symbol manipulation capacity of computers, the possibility exists for computers to aid artistic development in children as well as symbolic representational ability. Therefore, the purpose of this study was to describe the computer-generated graphics produced by preschool children in terms of developmental stages of art and symbolic representional evidence; theories from these two areas provide the bases for the investigation.

Theoretical Bases

How computers may affect children's thinking and their symbolic representational abilities is an area of major consequence because the emergence of symbolic representation is an important part of an individuals' ability to know their world; the ability to create symbols allows humans to become familiar with their environment and to communicate their knowledge (Werner & Kaplan 1963). Symbols convey meaning by refering to a thing, idea or feeling, and thus are the means by which humans express mental representations and images. In children, the emergence of symbolic representation is an important step in the development of cognition, since it becomes not only an avenue by which children can show what they know about their world but also a means of integrating new experiences. The development of representation in children is described as evolving in stages from: contemplation (knowing an object exists even when it is not present) to denotation of objects (pointing to or naming objects), to depiction (recreating objects pictorially or with a construction), to advanced phases of denotation (writing, metaphor, non-representational symbols) (Werner & Kaplan, 1963). Thus, the use of materials such as dolls, blocks, and concrete art materials helps children develop a greater and more accurate understanding of their environment by allowing them to

reproduce the realities of their experiences (Maxim, 1985; Riefel, 1982).

In the process of developmental art stages, definite characteristics become evident in the natural unfolding of pictorial symbolization that emerges in qualitatively different stages. The art products indicate the level or stage at which the child is operating. Initially, the process is perceptual and motoric in nature; as children explore and experiment with the properties of any materials, they are primarily focused on the kinesthetic sensations experienced. Lacking the necessary concepts of physical and visual properties to give them direction, they move their hands in reflexlike motoric rhythms and produce art works characterized by random marks, lines, and scribbles (Random Scribble Stage). As their visual-motor and perceptual-conceptual aspects of coordination increase, children begin to recognize certain forms related to their movements and to repeat these (Controlled Scribble Stage). An understanding of space, direction, and shape emerges and is evident in their art works as they combine these elements in designs (Basic Forms Stage). Children begin symbolizing as configurations are recognized and named and they try to fit an object they recognize with a drawing (Early Pictorial Stage). Finally, children select a theme before drawing a picture; concepts of line, shape, and color make it possible to create designs of considerable complexity (Later Pictorial Stage). Such progression is an important indicator of children's art and symbolic representational abilities (Mayesky, Neuman, & Wlodkowski 1985; Smith, 1982).

In addition to concepts of configuration, various factors affect children's developmental stages of art. Two of these are children's concepts of materials and their increasing reservoir of personal meanings about experiences of objects and events. These meanings are the mental representations, or referents, upon which they draw to form symbols. Through practice and repetition, children develop specific, recognizable symbols for specific images. In time, children's acceptance of appropriate referents changes and symbols are modified and become more complex. However, symbols developed

with one material may decline in level of art stages when attempted with new material (Smith, 1982); thus, it is possible that such regression may occur for previously appropriate symbols when attempted on computers. While the capacities of different materials are distinct, children come to generalize properties that are not medium-specific and produce similar shapes in different media. However, it is necessary for children to learn the nature of materials before they can use them in creating symbols. When introduced to new materials, children become familiar with the new properties and capabilities by exploring and manipulating the materials as process becomes more important than product. In so doing, products may revert to earlier stages of art development: there is a possibility that when children are introduced to software drawing programs, their usual developmental levels of art will regress to an earlier level as they experiment with the capabilities of the computer much as they would with any new material.

Questions of Study

In order to analyze computer-generated drawings in terms of developmental stages of art and symbolic representation, the following research questions were formulated: (a) What is the nature of children's computer-generated drawings in terms of the developmental stages of art? (b) How do the stages evident in children's computer-generated drawings compare with those evident in the drawings produced with traditional art materials? (c) What evidence is there to indicate that children used the computer as a means of symbolic representation? To answer these questions, a descriptive design was utilized in the study. The stages of art evident in the graphic works were summarized by the use of percentages and were compared to stages evident in selected works produced with traditional art materials. The audio and video tapes of the children's language were coordinated with the proper computer-generated drawings and both were reviewed for evidence of symbolic representation.

Method and Procedure

The primary sources of data for the study were the computer-generated graphics saved on diskettes and printed on hard copy, video and audio tapes, and field notes. The computer-generated drawings were produced by four middle-class children, two males (a 4-year-old and a 5-year -old) and two females (a 4-year-old and a 5-year-old). The children had no prior exposure to Apple computers or to the mouse attachment. They had limited experience with computers at their preschool using software that provided ready-made graphics but no freehand capabilities.

The laboratory type setting included a color-monitor Apple IIGS computer with color monitor utilizing a PaintWorks Plus software program and a black and white Macintosh SE with MacPaint to produce the drawings; both computers used the mouse attachment to manipulate the cursor on the screen and activate the software menus. The two software programs used were exactly the same in terms of available menu, procedures, and icons except that PaintWorks Plus contained 16 color and 16 visual pattern choices while previous MacPaint offered 36 patterns but no color (Appendix A); these were selected because of their simple, iconic menus and their freehand drawing capabilities. In addition, the setting included a drawing table arranged with concrete art materials.

The data were collected during eight 1 1/2 hour sessions held weekly in an observation room of a College of Education. Videotapes were made of the activity at the computers and art table; also, videotapes were obtained of the children's work by directly connecting the Apple IIGS computer to a video recorder and a microphone. Thus the language and total procedure used to complete the drawings at this computer were recorded. The activity at the Macintosh was audiotaped. Careful documentation was kept of the process that took place at the art table with traditional art materials; the child's language and/or labels were recorded on the back of each depiction. Four researchers were involved in collecting the data and writing notes after each session: One functioned as main teacher conducting the group instruction and supervising the

activity at one computer, one supervised the other computer, one monitored the art table, and one observed and took field notes.

During the sessions the children were rotated after 15 minutes at each of the computers and spent the remaining time at the art table. Weekly lesson plans based on broad topics, formulated prior to the study and modified as needed, guided the general direction of instruction for the sessions. The lessons provided hands-on demonstrations to introduce the children to the capabilities of the computers and functions of the software menus; included also were certain art concepts such as actual and visual texture. A child-centered, guided-discovery approach was used to introduce the children to art activities and computer usage. No specific tasks were required, as it was expected that the children would initiate their own graphic work through play experimentations and manipulate the computer to create their own art works much as they would do with concrete art materials. This assumption was based on assertations that children's acquisition of skills in Logo is conditional upon discovery learning that allows the development and exploration of self-initiated projects (Papert, 1980).

Data Analysis

Preparation of data prior to analysis included coding the graphics into appropriate categories, transcribing the audiotapes and entering the data into a word-processing file. Two coders independently reviewed and categorized both the computer and art table drawings. Interrater agreement was 96%. The verbal transcriptions were checked against field notes and videotapes to coordinate the language and actions of the children with the action on the computers. These were then coordinated with the proper computer-generated drawings.

The unit of analysis for the first part of this study was each individual computer graphic/drawing. To answer the first question--"What was the nature of the computer generated drawings in terms of developmental stages of art?"--computer-generated graphics (75 black and white and 56 color) were reviewed and categorized into previously established categories. The categories used were based

on the work of Mayesky, Neuman, and Wlodkowski (1985): Scribble Stage, Basic Forms Stage, and Pictorial Stage. Initial analysis of the data revealed the need to add a fourth category, Nondrawings, for graphics that consisted mostly or totally of letters and numbers produced as a result of children's experimentation with the keyboard. Overlapping stages or a combination of two or more stages is a normal occurrence; thus when combination of stages occurred, the depictions were categorized in terms of the predominate characteristics. Often the children's language associated with the drawings was used to make the determination.

To answer the second question--"How did the stages evident in the children's computer generated drawings compare with those evident in drawings produced with traditional art materials?"--the developmental stages of art in drawings produced at the art table were compared with the stages in the computer-generated graphics. For the third question-- "What evidence was there to indicate that the children used the computer as means of symbolic representation?"--selected segments of the video and audio tapes, coordinated with the computer-generated graphics, were transcribed to obtain information regarding the symbolization intent associated with the drawings.

Results and Conclusions

An analysis to determine stages of art of the total computer graphics produced by the children on both computers (question 1), showed that the drawings fell into the three broad stages of art development. An analysis of the art produced at the Macintosh revealed that the Controlled Scribble Stage accounted for 36% of the graphics, the Basic Forms Stage accounted for 36%, the Pictorial Stage for 22.8%, and the Nonpictorial Stage for 5.3%. The graphics produced at the Apple followed approximately the same pattern, with 30.4% at the Controlled Scribble Stage, 33 % at the Basic Forms Stage, 28.6% at the Pictorial Stage and 7.1% at the Nonpictorial (Table 1). Further analysis of the results showed that over half of the depictions at the Scribble Stage were produced during the first four sessions and a smaller percentage during the last four. For the

Pictorial and Non-Pictorial stages, the results were reversed with a greater number of depictions in these categories made during the last four sessions (Table 2).

Analysis of each child's drawings with traditional art materials established the stages of art for each individual child; these were then compared with stages evident in each child's computer graphics. A study of the work by Leila (the youngest female) showed that 63.2% of her depictions made at the Macintosh were categorized as being in the Controlled Scribble Stage; none of these depictions were in the Pictorial Stage. Similar findings resulted from studying the Apple depictions, at which 60% were in the Controlled Scribble Stage and none in the Pictorial Stage (Table 3). Analyses of the depictions made with the traditional art materials and review of the records kept for the art table revealed that these drawings reflected the same levels of stages of art as the computer graphics. Leila was content to use traditional art materials to make designs with different shapes and lines. She made only one representational drawing with traditional art materials and that occurred at the last session. Her computer graphics again revealed the Controlled Scribble Stage characteristics of scribbling with lines, zigzags, circles, and repeated motions (Figure 1, Leila). She exhibited interest in manipulating material to discover what can be done with it, which is typical of this stage. Her evident fascination with the menu pattern icons, preference for using only certain tool shapes, and repeated combinations of these were also evidence of this level. A lesser number of her depictions also revealed the circles, ovals, and shapes of the next stage, Basic Forms, which is consistent with the normal overlapping of stages.

Categorization of Walter's computer depictions by Walter (the second youngest) showed that the greater number of his graphics were in the Basic Forms Stage; at the Macintosh 61% were in the Basic Forms Stage and 27.7% in the Pictorial Stage while of those made with the Apple 70% were in the Basic Forms Stage and 10% in the Pictorial Stage. Walter's artworks with traditional art materials were most often completed by combinations of shapes or

half circles, characteristic of the Basic Forms Stage. However, in several drawings he found a relationship between the shapes he had drawn and then made a representational drawing, for example a house; thus, some of his drawings were in the Pictorial Stage. His computer graphics also revealed a preference for combining shapes and the four Basic Forms. Figure 2 (Walter) shows the ability to draw separate lines of desired length, control over direction and size, and an organized format, which are also typical of the Basic Forms Stage. Walter's pictorial computer drawings resulted from Basic Forms that suggested images or ideas in his mind. He elaborated these images and ideas to make them into symbols, as is common in the Early Pictorial Stage.

The computer graphics of both Jeremy and Kiah were predominantly in the Pictorial Stage. A study of the work by Jeremy (the oldest child) at the Apple computer revealed that 53.2% of his depictions were in the Pictorial Stage while 20% were in the Controlled Scribble Stage. This pattern was not carried out in the depictions made at the Macintosh, where 28.3% of the depictions were in the Pictorial and Nonpictorial stages and 33.3% in the Controlled Scribble Stage. Analysis of the work Kiah (the second to oldest child) revealed that 52.9% of her Macintosh depictions were in the Pictorial Stage and 35.3% in the Controlled Scribble Stage. Graphics completed at the Apple Apple also indicated that a majority of her work, 43.8%, was in the Pictorial Stage and 18.8% in the Controlled Scribble Stage. Jeremy and Kiah both used traditional art materials and the computer to produce many representational or pictorial works; they both followed specific themes (for example, dinosaurs, Ghost Busters, flowers or other subjects that came to mind). They told stories about their depictions and often announced what they were going to make. Figure 3 (Jeremy) and Figure 4 (Kiah) are examples of of their computer drawings. As is characteristic of the later Pictorial Stage, symbols were used to tell a story or describe an event; also, the depictions are clear, well drawn, and reflected a unique style characteristic of this stage. Thus, the symbols are clear forms of visual communication.

For question 3, evidence of symbolic representation, a study of the computer-generated graphics and language indicated that the children used the computer as a tool to create symbols for representational purposes. Transcribed tapes of the language associated with the graphics revealed that the stages of representation varied across levels from naming objects (denotation) to depiction (recreating objects pictorially). Depictions also varied in that in sometimes an image was discovered accidently through experimental scribbling and then elaborated into a symbol. In other instances, the ideas were preplanned and expressed verbally before being depicted.

Because the selected software menu offered many ready-made patterns and shapes, the children could merely name these as symbols without having to actually possess drawing skills beyond the early Scribbling stages. Thus, even Leila, whose computer graphics were predominantly in the Scribble stage, often used the computer as a tool for creating symbolic representations. Figure 5 is an example of scribblings Leila made using the different patterns to which she attached names; the patterns suggested images that stood for ideas in her mind and thus symbolic representations of known objects. The names she chose were descriptive of the pattern: the apple pattern, the pie crust, bricks going up, bricks falling down, the sweater pattern, glitter, and the tights pattern. During one session, she filled the screen with the sweater pattern for a drawing to take to her friend who had a sweater like it. The labels transferred to the other children and project members who also used the names to refer to the patterns.

There is evidence that the children perceived an image in experimental scribblings that brought a concept to mind and then elaborated on the depiction to make it correspond to their own mental representation. All three of the older children completed depictions that started in this fashion; all of Walter's computer depictions are of this nature. Figure 6 is an example of the Early Pictorial Stage in which language established the representational intent. On this occasion, Walter discovered that his drawing

resembled a small teapot and elaborated pictorially to complete the depiction.

Walter Look, I made a teapot (*filling in outline with the paint brush*).

Escobedo Oh, yes, that's a nice one.

Walter That's the steam.

Escobedo So it is.

Walter Another one. (*Outlined a bigger teapot and sang:*) "I' a little teapot short . . . just tip me over and pour me out." (*Connected spout to steam. As he sang and drew, he kept time to the singing by moving the upper part of his body.*)

The two older children often used the computer and the software tools to make preplanned symbolic representations of many of their mental representations. At times they announced their intentions prior to beginning their drawings. At other times they expressed their ideas later incidentally or through games. The following is an example of the language associated with a symbolic representation (Figure 3) that was preplanned and previously announced. The depiction was executed as Jeremy and the teacher explored the Macintosh. Jeremy drew in the circles and named the planets but did not want them labeled until he finished.

Jeremy I want the paintbrush ...
(*Draws a circle with a line through it.*) I did what I wanted to do, Ms Yeatman. (*At the Apple.*)

Yeatman You did. You made Saturn like we talked right outside. Jeremy said that he had wanted to make the planet Saturn.

Jeremy And all the other planets.

Yeatman --And all the other planets.

Teacher You know what we should do? We should put the name here under Saturn so we'll remember what it is. You wanna do that?

Jeremy Oh, I can remember because of the ring.

(*Drew Mars.*)

Jeremy This dot's a meteor. (*Long silence as J. works.*)

Jeremy Lots of meteors.

Teacher Oh, you have lots of meteors. What's this one?"

Jeremy "That's Earth's."

Teacher Earth?

Jeremy Yea, where we live.

Jeremy This is the Milky Way. See, it's a can pouring milk. (*Laughs.*)

At a later session he portrayed this joke in a subsequent drawing.

Kiah, the oldest female, used the computer very effectively as a tool for pictorial representations. She delighted in playing guessing games with the teachers as she worked. It was obvious that the drawings were preplanned, but she did not care to announce her plans. The author and Kiah were at the Macintosh as she played a guessing game and made the drawing in Figure 4.

Kiah Look what I's doing. (*Using the paintbrush.*)

Teacher Looks like a long tail.

Kiah A long, long tail and its dangerous, for any people who wear no houseshoes, and no (not clear) and no nothing. (*Continues working.*)

Teacher That must be a dinosaur.

Kiah Boy, are you right.

Teacher Yeah. Uh, that's a big ocean --. Oh, it must be in the water, huh? Oh, part of him is in the water.

Kiah It's something, it's a fish.

Teacher Oh, it's a fish.

Kiah Laura. look, I drew a dinosaur. (*To girl at Apple.*) (*Continued adding and conversing.*)

Teacher Do you want to save that picture next?

Kiah No I gotta make an Island **. . . . And. Yeah, it's a little tree.

An unexpected finding was that the children also used the computer for symbolic or dramatic play. Symbolic play develops when children attach symbolic representation to an object, gesture, or verbal substitution which is used to represent the real situation (Seefeldt & Barbour, 1990). In the following excerpt, Leila was experimenting with the shapes and patterns at the Apple by selecting a shape, filling it with a pattern, and using resulting form to stand for the real object. The procedure was Basic Forms scribbling in that the menu tools used produced readymade shapes and had no bearing on the child's developmental stages of art. The shapes and patterns, however, were symbolic representations that evolved into dramatic play. This is evident in Figure 7 and in the language transcribed from the videotape.

Yeatman O.K. you're making a hollow circle now.

Laura I wanna fill it in with this pattern.

Yeatman You look like you're choosing a pattern. (*Chose what she called the pie pattern.*) O.K. Now to fill it in with a pattern. You need to move your mouse over to paint can. Woops. Move it up to paint can. Now move your pointer once to the middle of the circle and now click and look what happened. Your circles fill up with the pattern you chose. What are you wanting to do now Laura?

Laura (*Continued making shapes and filling them in with patterns.*)

Yeatman You were using the circle. (*Continued giving guidance.*)

Laura I want to slice it like a pizza slice.

Yeatman A slice like a pizza slice. Hmm.

Laura One of those (*tools*?).

Yeatman I wonder how you could do that. You could use the straight line tool. Choose it. Click it. Click Oop. Try again. Make sure the arrow's in the middle of the (*circle*). There. O.K. Now click, there you go. O.K.

Laura (*Had followed instructions and used the straight line tool to pretend cut the circle.*)

Yeatman	Now you have to press and hold it down and move it. Now let go. Is that the kind of slice you want?
Laura	Yeah.
Yeatman	There you go. Looks like you're cutting the pizza Laura.
Laura	It's not a pizza.
Yeatman	It's not a pizza?
Laura	It's a pie.
Yeatman	A pie. Wow.
Yeatman	Right now you're on straight line tool. If you need a different tool, go back to the menu. There you go. You have a circle. Is this the pattern you want to go inside that shape?
Laura	Oops. (It is.)
	(*Laura. continued making circles and Y. giving guidance.*)
Yeatman	More shapes. There's a circle. And another one. You're making circles all over your drawing window Laura.
Yeatman	There you go. You filled your circle up.
Laura	One is cut and one is not cut.
Yeatman	That's right. One is cut and one is not cut. What would you like to do next Laura?

The elements of dramatic play are evident in that symbolic representation was attached to an object and that object used as substitution for a real situation. The teacher was leading Laura through the steps of selecting a hallow icon to make a circle and then choosing the pattern to fill it in. While Laura was learning the procedure, she was also imagining that the shapes she filled in with the pie crust pattern were pies and was pretending to cut them. She was in fact, using the shape in dramatic play much as she would have used a real object such as mud pies. In another of Jeremy's depictions of the universe, he carried out his joke of the Milky Way being a can of milk thus attaching symbolic representation and using substitution in pretend play. This is seen in Figure 8 after he had changed the background to black.

Teacher	Jeremy likes to use a black background and the white pencil.
Jeremy	This is the Milky Way. It's a can pouring milk. (*He drew a milk carton upside down with the contents spilling.*)
Teacher	That's right (*laughs*). The Milky Way is pouring milk. Where are the stars?
Jeremy	I'll show ya. Look, this one is going to be the big dipper. (*Dipper drawn in shape of a pan.*)
Teacher	Oh, okay. Have you seen the big dipper, at night?
Jeremy	No. Now I'm going to make the little dipper (*small pan shape.*)
Teacher	That is a nice sky. The big dipper and the little dipper and
Jeremy	Meteor. Meteor. (*Drew in circles.*)
Teacher	You could draw a spaceship right here.
Jeremy	Meteor. I can make one. Meteor. Meteor. (*Ignored suggestion and drew in dots.*). Okay. Those are the stars.
Teacher	There you go. . . . Yeah, now it looks like the Milky Way.
Jeremy	That's all.

Children used symbolic representation at the computer not only as an avenue to express their knowledge but also as a means of integrating new knowledge about the computer. In learning to manipulate the menu procedures, the children incorporated isolated bits of information about the various functions such as combining the use of specific tools with different patterns and colors for one task or unique result. Often these combinations were discovered incidentally as the children created their depictions. Figure 9, in color, is one such example and was created as Jeremy experimented at the Apple computer. In scribbling with the patterns and colors, he found that he could combine an open pattern with a color and use the paint can tool to get a unique background. He associated the result with a Christmas night sky and he proceeded to add the tree, but in the process he accidently lost the background. To reconstruct the combined effect he analyzed the steps involved as he explained the procedure: (Selected tool was on paint can.) "I chose the star

pattern then I dumped it. Then I chose blue and got the paint bucket and just dumped it." When asked by the other children, he demonstrated the steps with explicit explanations. Similar integration of knowledge occurred for several menu functions such as canceling, the Fat Bits, and erasing.

Discussion

The purpose of this study was to investigate the nature of children's computer drawings in terms of stages of art and symbolic representational competence. The findings reported above provide answers to the questions posed. First, the computer generated graphics exhibited the traditional three broad developmental stages of art, indicating that appropriate computer experiences can provide children the opportunity for artistic development similar to that provided by concrete art materials. A comparison of output from the Macintosh black and white computer and the Apple IIE with color monitor reveals that percentage of the artwork produced on each was similar for each stage of art development, although a greater number of drawings were produced on the Macintosh. This can be interrupted to mean that color had no impact on the stages of art. Since equal amount of time at both computers provided equal opportunity for production, however, color may have motivated greater exploration for each depiction and thus curtailed production. It may be that this resulted in greater complexity in the color depictions, but this remains to be determined as drawings were not analyzed in terms of complexity for this report. All the drawings produced during the first session were in the Scribble Stage. Classification of total output by session revealed that Controlled Scribble Stage depictions were produced predominantly during the first four sessions while those in the Pictorial Stage were produced predominantly during the last four sessions. This indicates that introduction of the computer and new menu procedures resulted in regression in the stages of art; such a regression is expected when children experiment any new art medium (Smith, 1983). In addition, in order to manipulate the menu procedures, the children in this study had to develop hand coordination to control the mouse and

awareness that hand movements caused the effects on the screen. While predominance of the Pictorial Stage is evident in later sessions, drawings in the Scribble Stage and Basic Forms Stage were produced during all sessions and were related to the introduction of new menu choices and drawing tools. In learning the new menu functions, children attended to the procedures at the expense of symbol representation and thus drawings reverted to the earlier stages. This was in keeping with Smith's assertion that it is necessary for children to learn the nature of materials before they can use them symboically (Smith, 1982).

The stages of art evident in the computer drawings of each child were consistent with the stages evident in works produced with traditional art materials. Although regression of developmental art stages occurred for all the children when introducted to computers and to new menu procedures, with experience all the children recovered to the stage evident in their noncomputer drawings. This finding is consistent with developmental stage theory that postulates that if a developmental level has been reached and a regression or deflection occurs, recovery of the developmental process will unfold to the previous level but at a faster rate (Werner & Kaplan, 1963). An age difference was noted in the stages of art of both computer and noncomputer drawings, with the two older children operating at the Pictorial Stage for a greater number of drawings, the younger male at the Basic Forms Stage and Early Pictorial Stage and the younger female predominantly at the Scribble Stage and Basic Forms Stage.

The computer-generated drawings indicate that the children used the computer as a medium to create expressive and symbolic representations. Their dipictions reflect the stages of representational development: from contemplation (knowing objects exist), to denotation (pointing to or naming objects), to depiction of objects (recreating the object pictorially), (Werner & Kaplan, 1963). Transcribed language coordinated with the computer drawings reveales the depiction stage of representation: In some instances the children expressed their ideas verbally and then depicted them pictorially; in some drawings, symbols discovered in experimental

scribbling were elaborated to correspond to some mental referent. The denotation stage of representation was evident when some scribble depictions produced with the ready-made shapes were also named as symbolic representations though the drawing level was at the Scribble stage. There was no age difference in the children's use of the computer as a symbolic medium. However, the pictorial representations by the two older children were more detailed and their associated language was more elaborate, indicating more complex mental representations or referents.

The use of the computer for creating symbolic representations also provided the children many opportunities for integrating new knowledge. In using the menu functions to create pictorial depictions, the children were acquiring and combining knowledge of the menu procedures. Findings reported by others that children move from experimentation to carefully planned symbolic representations followed by explanations (Church & Wright, 1986) were also present in this study, especially in the computer drawings and associated language of the two older children. Jeremy, the oldest, often explained how he achieved certain results in drawing--for example, by combining pattern with color.

Authors cite the importance of imagination or pretend play to symbolic thought in children's drawings (Mayesky, Neuman, Wlodkowski, 1985). In symbolic or dramatic play, children pretend one object is another thus building their own reality by taking roles, building, and making things to represent known objects (Seefeldt & Barbour, 1990; Reifel, 1982). Pretend play at computers previously reported (Beaty & Tucker, 1987) was evident in this study. The children's language and their drawings exhibited as in the creation of a pretend milk can and pans in the night sky.

Implications

While computers can never replace concrete materials in classrooms for young children, they can be used to advantage and can be another medium for children to manipulate and explore. Analysis of the computer-generated drawings in this study indicate that computer art software can offer children appropriate experiences

for artistic development in terms of developmental art stages as well as symbolic representation abilities much as traditional drawing materials do. Teachers must expect regression in stages of art abilities as children learn the new procedures. Sufficient time for children to develop hand coordination and cause and effect awareness of their actions on the screen is necessary. An opportunity for children to practice using the menu procedures is also needed before representational drawings can be expected. Recovery to noncomputer levels should, however, be anticipated; delay in recovery and frustration may be an indication that the software program is too difficult. In choosing software, teachers and parents should look for programs that include ease of using menus and a wide range of menu choices, from free hand drawing to ready-made shape options, to accommodate children at the various developmental art stages. Color, an incentive for the three older children in this study, can also provide wider choices and promote interest in detail. A balance of teacher guidance and child self-directed exploration is necessary for children to learn the parameters of the new medium. Computer art software can offer children another avenue for symbolic representation, including pretend play. Thus teachers can use the symbolic capabilities of the computer to have children express their mental representations of experiences or concepts much as they do with traditional art materials. Some software menus may encourage this development in children who are not yet able to draw freehand symbols by providing ready-made symbols to which they can attach meaning.

- There is a need for additional research that explores questions regarding computer use with young children. This study used a laboratory type of setting. It would be useful to investigate whether children in a natural setting, given other activity choices, would evidence the same interest and invest the same amount of time at the computer that the children in this study did. The descriptive nature of this study prohibits generalizations. Thus there is a need to further quantitatively analyze the drawings from this study as well as for other studies of sufficient sample size to investigate computer art programs for young children.

Table 1
Classification of Basic Output by Computer

Computer	Scribble Stage	Basic Forms	Pictorial	Nonpictorial	Total
	Stages of Art				
Apple IIE					
Total	17	19	16	4	56
Percent	30.4	33.9	28.6	7.1	100.0
Macintosh					
Totals	27	27	17	4	75
Percent	36	36	22.67	5.33	100
Totals	44	46	33	8	131
Percent	33.6	35.1	25.2	6.9	100

Table 2
Classification of Total Basic Output by Session Number

Stage	Sessions 1-4	Sessions 5-8
Scribble stage		
Apple IIE	58.82%	41.18%
Macintosh	70.04%	29.6%
Basic Form stage		
Apple	78.95%	21.05%
Macintosh	48.01%	51.9%
Pictorial stage		
Apple	18.75%	81.25%
Macintosh	41.1%	58.8%
Non-pictorial		
Apple	25.00%	75.00%
Macintosh	25.00%	75.00%

Table 3
Classification of Basic Output by Subject and Computer

CHILD		Stages of the Art: Scribble Stage	Basic Form	Pictorial	Nonpictorial	Total
LEILA	Apple IIE	9 60.0%	3 20.0%	0 0.0%	3 20.0%	15 100.0%
	Macintosh	12 63.2%	6 31.6%	0 0.0%	1 5.3%	19 100.0%
WALTER	Apple	2 20.0%	7 70.0%	1 10.0%	0 0.0%	10 100.0%
	Macintosh	2 11.1%	11 61.1%	5 27.7%	0 0.0%	18 100.0%
JEREMY	Apple	3 20.0%	4 26.8%	8 53.2%	0 0.0%	15 100.00%
	Macintosh	7 33.3%	8 38.0%	3 14.3%	3 14.3%	21 100.0%
KIAH	Apple	3 18.8%	5 31.3%	7 43.8%	1 6.3%	16 100.0%
	Macintosh	6 35.3%	2 11.8%	9 52.9%	0 0.0%	17 100.0%

Figure 1 - Leila
Controlled Scribbling Stage

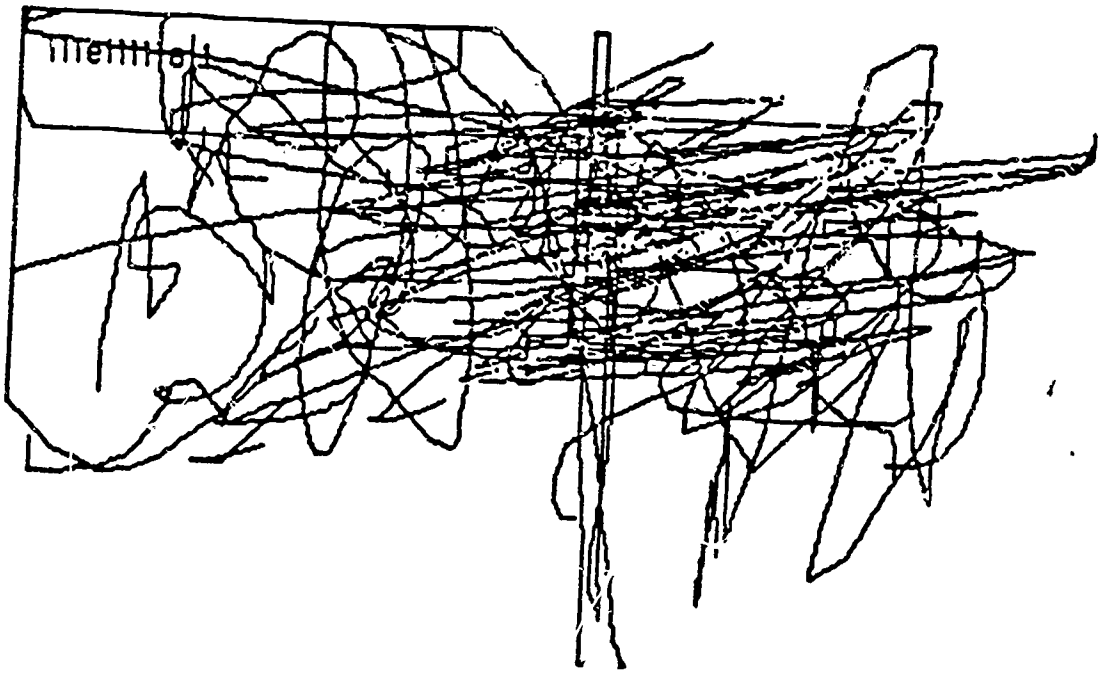

Figure 2 - Walter
Basic Forms Stage

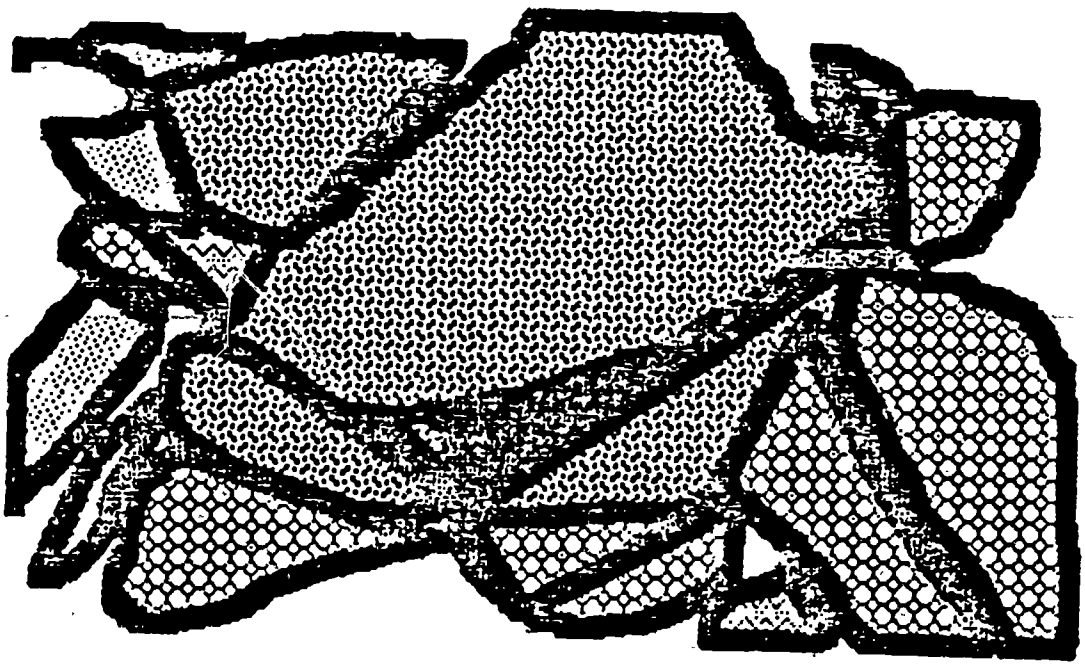

Figure 3 - Jeremy
Pictorial Stage

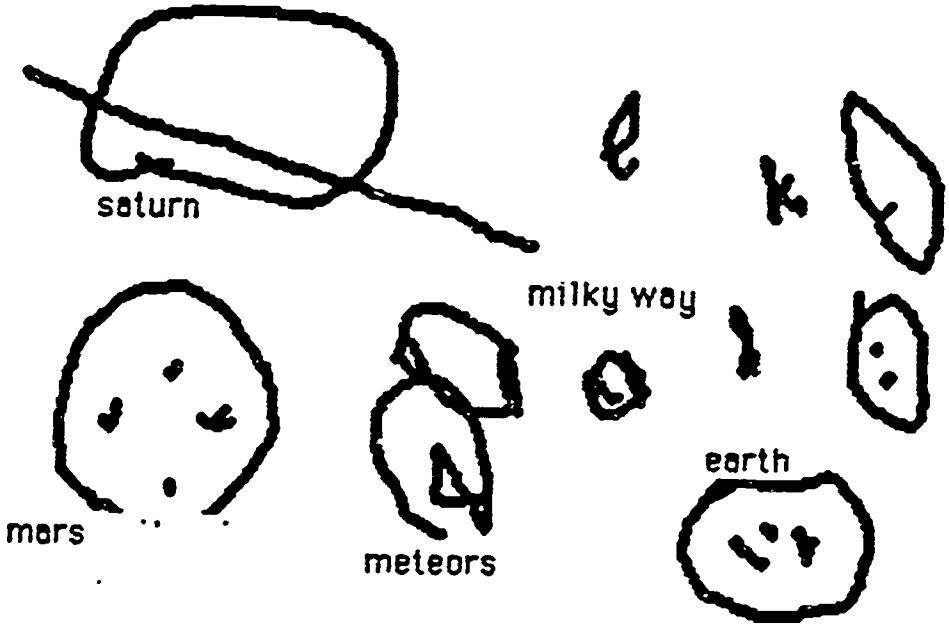

Figure 4 - Kiah
Pictorial Stage

Figure 5 - Leila
Symbolic Representations

Figure 6 - Walter
Early Pictorial Stage

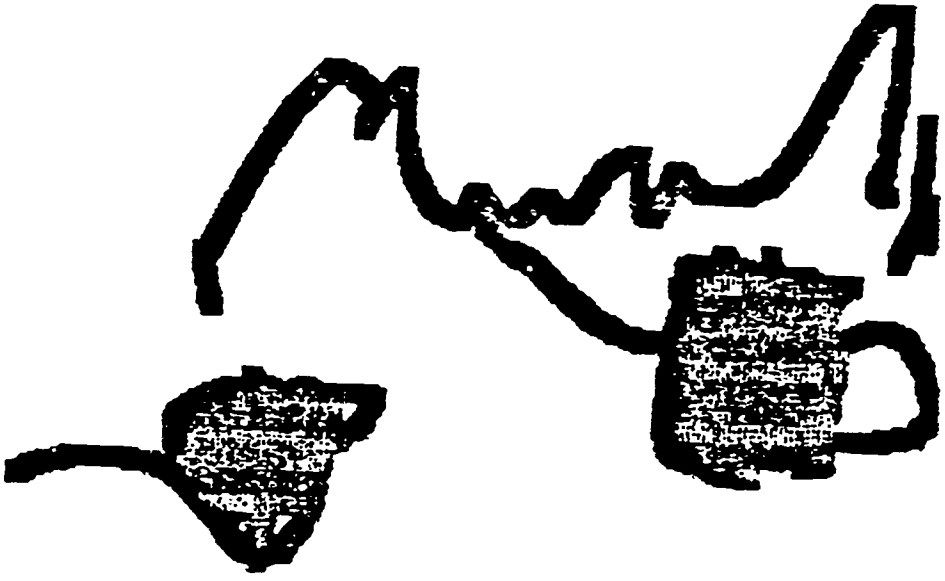

Figure 7 - Leila
Symbolic Play

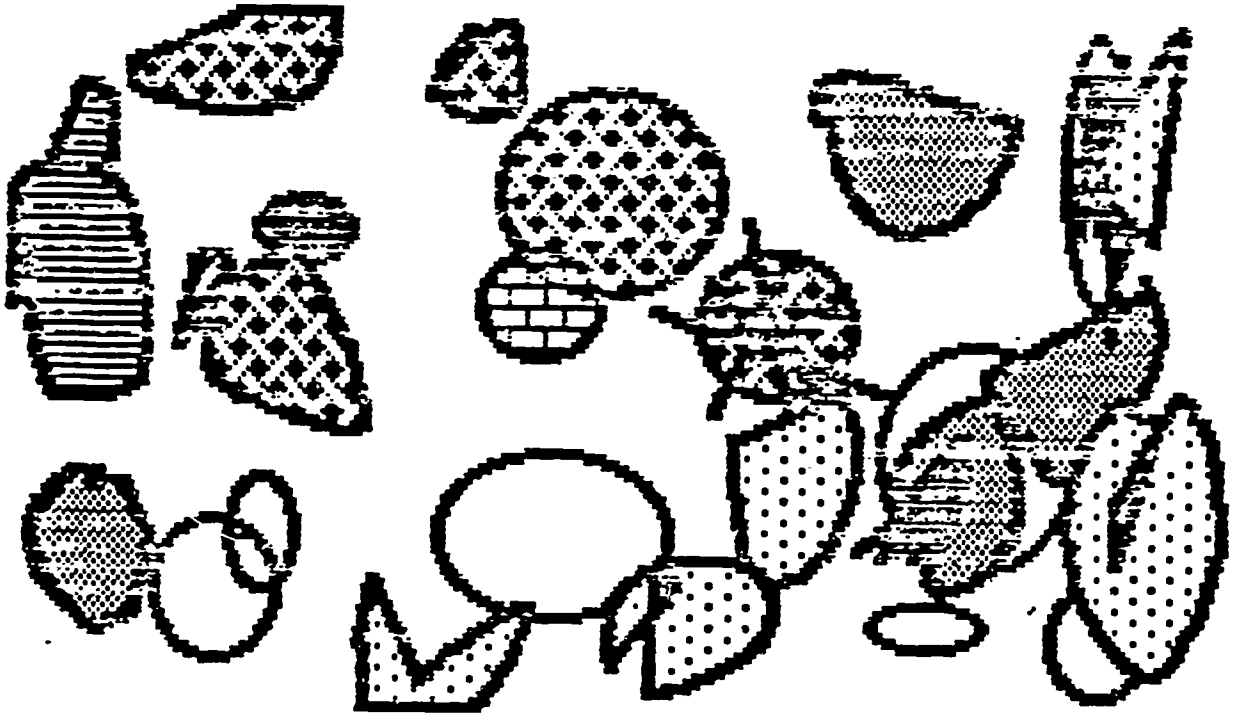

Figure 8 - Jeremy
Symbolic Play

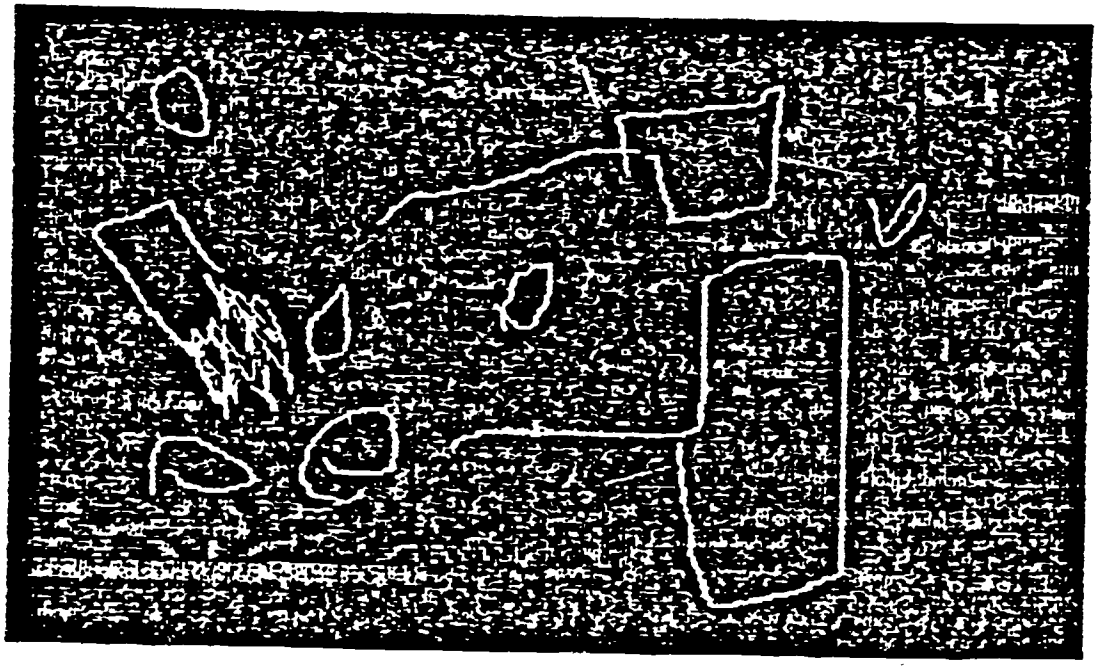

Figure 9 - Color Reproduction not available for distribution

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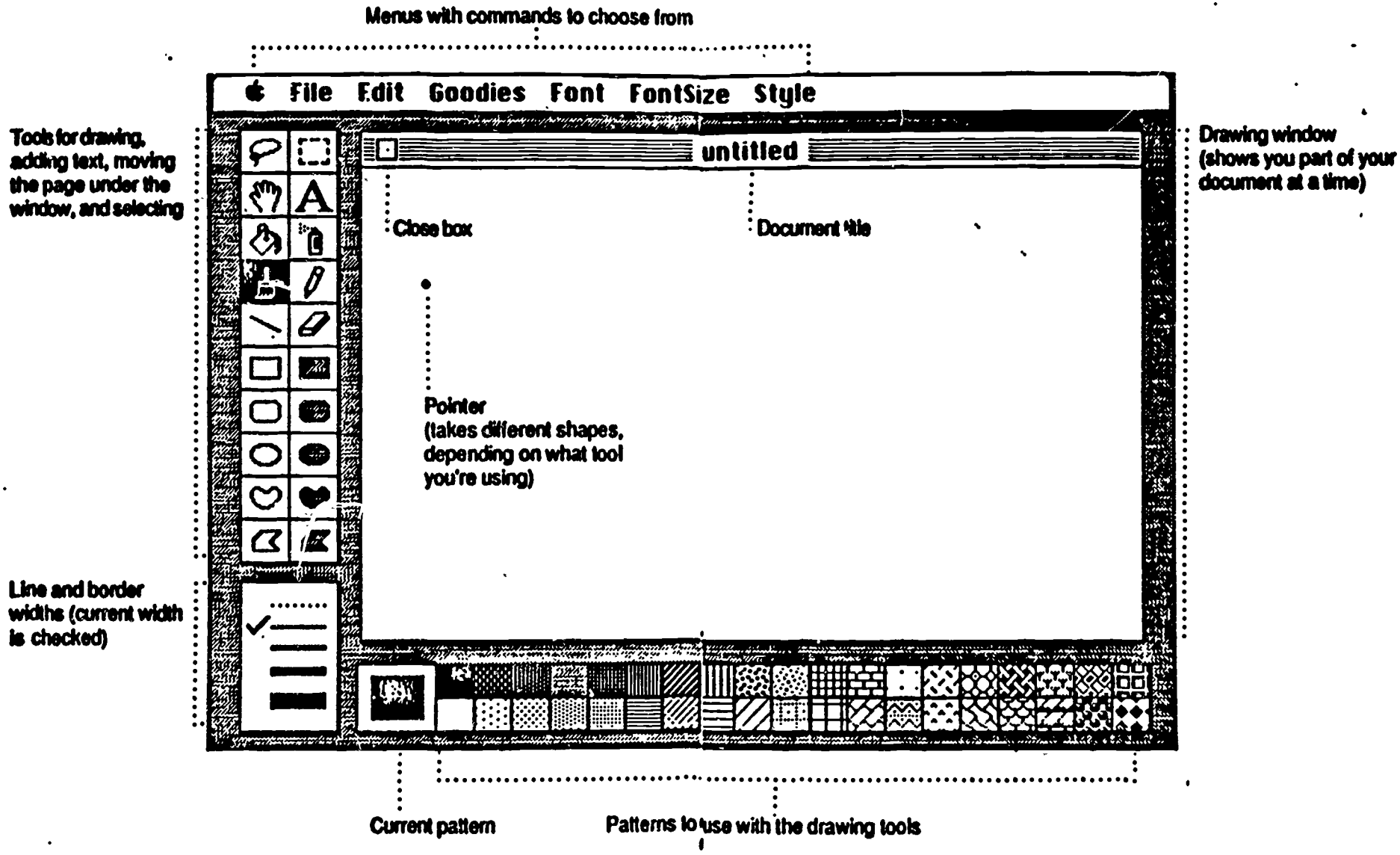
Appendix A


Menus with commands to choose from
File
Edit
Goodies
Font
FontSize
Style
Tools for drawing, adding text, moving the page under the window, and selecting
untitled
Drawing window (shows you part of your document at a time)
Close box
Document title
Pointer (takes different shapes, depending on what tool you're using)
Line and border widths (current width is checked)
Current pattern
Patterns to use with the drawing tools