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COMPUTER-BASED ART LEARNING: PRIMARY CHILDREN'S RESPONSES

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Abstract—This article documents and analyses the work of two computer-based art projects, the Saturday Morning Art (SMART) programme and the School Computers Art Media Project (SCAMP) where primary children were involved in art production using a computer. The children's actions and their art works were closely monitored by participant observers to see how they learned to manipulate the technology, to work collaboratively and developed the ability to exercise judgement and control over the medium. Examples of the children's work are included and discussed in the paper so that the quality and degree of control exhibited by these young children may be fully appreciated by those reading the text.

"A type of heresy is developing which affirms that technological progress is a monster ... is the incarnation of evil... We are ashamed of technology, some are turning their backs on it, fleeing the technological present" [1, p. 20]

INTRODUCTION

Computers are making unprecedented aesthetic experiences possible and revolutionizing the way art is conceived, created, perceived and taught. The profound impact of digital technology on the art of the last 20 years and what it portends for the future is only beginning to be appreciated.

Although enthusiastically welcomed by the film and broadcasting industries, computers have not been readily accepted by most artists or art educators. With their enormous potential as visualizing tools, the reticence of the art community is somewhat perplexing. Whilst it is certainly true that the liaison between art and technology has been an uneasy one for some artists and art educators, their ideas and apprehensions are becoming outdated in the current context of computer knowledge and available machines and programs.

Unfortunately, images of large mainframe computers with people locked into their machines in a laboratory setting persist. Both the ambiance and the manner of working in an automated environment conflict disturbingly with artists and art teachers who are used to realizing their creative ideas in charcoal, paint, or a whole range of other materials.

Today, the easy availability of personal computers and very sophisticated programs invite the artist to work directly on their own computers, so that intermediaries are no longer required. However, there is still a need for art teachers to work alongside programmers to improve the artistic and educational quality of art education software. Interestingly, some of the most spectacular digital imaging is still being done in the large, scientific institutes as only they are equipped with the technology and personnel who can develop some of the more advanced imaging capabilities for the entire field.

Additionally, the mention of computer art usually conjures up commercial imagery rather than the less-publicized other arts applications, although the tools and results of commercial and other art forms are frequently similar. But computers are protean and constantly evolving with new programs and access to data expanding the possibilities and potential of the medium for artists. We as art educators need to review these capabilities regularly to ensure we have fully assimilated and synthesized these developments for our own artistic purposes:

"... computers in all likelihood will soon be unchallenged as one of the implements available for the creation of a work of art. Research and development in computer

> graphics is proceeding apace around the world, suggesting future developments in computer imaging capabilities that will be adaptable to the creative needs of virtually any artist" [1, p. 17].

THE SMART AND SCAMP PROGRAMMES

During the period 1991–93, the authors, who are lecturing staff in the Division of Art at the National Institute of Education, Singapore, initiated two projects which focused upon primary children using computers to create art work. The two projects, in chronological sequence, were: the Saturday Morning Art (SMART) programme and the School Computers Art Media Project (SCAMP).

In essence, the two projects differed in that the SMART programme involved us working with primary children together with a group of teacher training students and our art specialist, whereas the SCAMP work enabled us to work with children plus a group of their teachers in a school. SCAMP evolved from SMART as there were many issues we wanted to pursue further, specifically within the area of student interaction and the social context of computer-based art learning. Both projects involved children ranging in age from 8 to 12 years old, with the SMART children tending to be at the younger end of the range.

Unfortunately, there are many documented cases of educational initiatives failing to last once the hero-innovator has disappeared off the scene. This would seem to indicate that the initiatives themselves were imposed, or not well-supported by the schools' management teams, or insufficiently understood by teachers, or seemingly superficial and irrelevant to their teaching situations. Ensuring that our work was congruent with existing art practice and could then be viewed as an extension by teachers rather than an adjunct, was crucial if such work was to continue when our projects ended. Also, by involving our teachers in a genuine, collaborative partnership with us, as researchers, evaluators and art educators, we did feel in some measure assured that the work would extend beyond our direct involvement in the two projects. Indeed, as we still maintain contact with the participating schools through our professional activities, generally we have been able to witness further developments from this early work. Part of the effect of our work has been a growing number of requests for in-service programmes which deal specifically with computer-based art work in schools, and, within our own institution, where we already have several modules which focus specifically on art and technology, we are constantly attempting to locate and identify additional projects where we can appropriately utilize computer-based art work.

Having collected quite a substantial body of work by primary children who have used the computer in the process of art production and analysed all our data, we now have the opportunity to pursue and review some of our earlier ideas in more depth and to look in greater detail at the qualities inherent in the work itself.

COMPUTER-BASED ART LEARNING

The use of technology to create art works has much in common with making art using traditional media, but the conceptual and technical differences involved in the use of computers do need to be considered when developing art programmes using computer technology. The potential application of computers to art making are much broader than might be expected:

> "For some artists, the computer is merely the tool that facilitates design decisions; for others, the artwork itself assumes the form of direct computer output; still others think of computer output as the point of departure for further elaboration and execution in an entirely different medium" [1, p. 14].

As art educators, we experienced on occasions in the early stages of the work, the sensation that we and the children were searching for meaningful creative expression in the midst of a sometimes overwhelming technological environment. This was particularly true for us during the

SMART project which was our first experience of using technology with primary children. In computer-based art work, traditional skills are often of little help and familiarity with computers in general seem irrelevant and of no great advantage when embarking on computer-based art work with children. Consequently, the programmes we devised were designed to develop the children's confidence, to enable them to quickly master a range of technical skills and to allow time for a great deal of experimentation and purposeful play in the early stages of the projects. Two essential features of our planning are relevant here.

Firstly, that we made constant links between computer-based art production and the schools' art curricula. Sometimes, this involved outdoor observational studies using traditional media which then formed the basis of source material for the computer work. For computer-based art work to become a feature of art curricula, it needs to be seen by students and teachers as integral to a programme and not of peripheral status. Teachers need to determine the most appropriate medium for any art work and to comprehend where the computer *is* that medium. They need to view computers as another tool for creating art work, one that will extend the potential for experimentation and art production for their students. Students require opportunities to master a range of techniques and understanding which they can then use and be brought to comprehend, through experience, the possibilities and limitations of the medium.

Secondly, to introduce children gradually to the process of drawing directly onto the monitor, we used scanned images of their original drawings (many of which were observational environmental studies) as a transitional learning phase. This decision proved to be extremely important with the SMART children and so we repeated it with the SCAMP students. We believe the importance for all the children of this strategy was that it supported the development of the children's confidence to see and use their own drawings rather than use commercially produced programs which we considered unsatisfactory in an art learning context.

Experimentation and doodling

Experimentation by the students was very much in evidence in both of our projects and this took the form of doodling on the screen during the early sessions of both programmes. Children seem to doodle initially and, gradually, we evolved this into structured exercises during the very first session. Thereafter, as this activity seemed important to their learning, we encouraged doodling within the context of our planned programmes, indeed we built in time for this kind of self-directed activity as part of every session where a new set of skills were being introduced.

Doodling seems important as a means of familiarizing the children in an unthreatening way with some of the functions of the computer. Furthermore, doodling was something the students reverted to frequently and, as such, seems to be an important learning strategy in this context. Sometimes, they doodled with shapes rather than lines but once shapes were put together into some kind of spatial relationship, then compositional aspects were being considered. Line and shape doodling were important initial experiences and experimental exercises for the children (Fig. 1). Doodling was also a means for students to learn for themselves what to expect from particular computer functions and to engage in a technological orienteering through the menus, discovering amazing artistic possibilities en route.

Thus it would seem that doodling, experimenting and manipulating shapes enables children to develop familiarity and confidence with the technology and to gain some understanding of the capabilities and limitations of the system. Exploration through the use of many pages on a screen means that students can experiment more quickly, which may encourage them to try ideas out more readily on a computer than with other media. Indeed, it seemed to us that utilizing a computer to generate art work supported experimentation and that exploration was inherent in the medium.

Computer based art production

Our experience with the SMART and SCAMP projects greatly enhanced our understanding of how students create computer graphics and provided us with useful insights into the development of teaching strategies. Students develop images using computers which are both similar and different from the ways they develop images using other art materials and techniques and art educators need to understand these crucial differences.

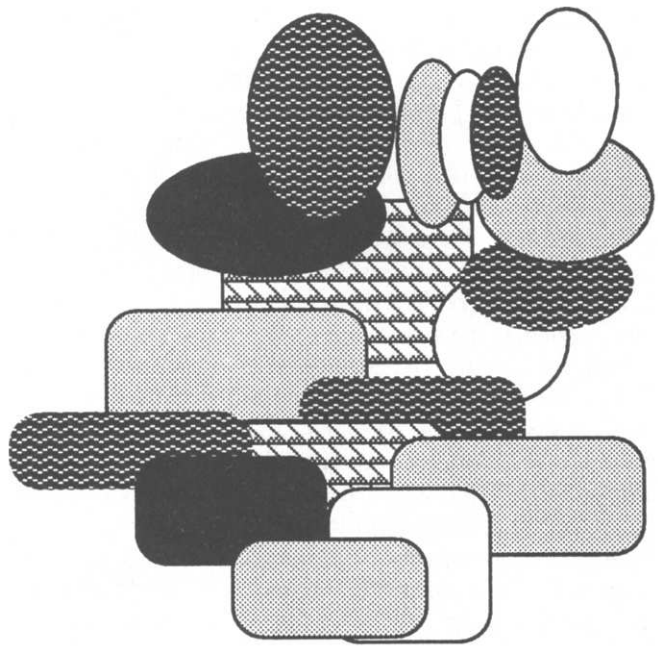

Fig. 1. Shape composition exercise, Liu Peixan (9.1 yr).

For example, as with other media, students doodle, play with and try out techniques in a manner which acquaints them with the limitations and possibilities of the medium. However, this trying out is also an integral part of the work in hand as ideas can be reworked and modified directly during the process of production in a way which is not possible with traditional materials; a great advantage of computer-based art work.

Many students experience initial difficulties in translating drawings from paper to a computer to produce a final piece. This was not a problem with either of our projects where we worked with scanned images of the childrens' drawings during the early stages of both programmes. Working directly onto a screen requires experience and practice and appears to require a level of technical and perceptual understanding which children develop over time. Eventually, the scanned image strategy became obsolete as most children preferred to work directly onto a computer screen.

Nonetheless, the transition phase of scanned childrens' imagery, we believe, is a crucial one in developing their confidence with the technology and in terms of ownership and direct involvement in the final piece of work. Additionally, children gradually became aware of the subtle differences between their original drawings and their scanned and subsequently elaborated imagery. This formed a useful basis for discussions with them about evaluating, perceiving and differentiating the aesthetic qualities of art work which has been generated using a computer and that produced by traditional means.

Implications for art teaching and learning in schools

It has become evident to us that the ways in which teachers and students use technology in the process of art production, and the context of that learning, are as important as the construction of the software itself. Social interaction, for instance, seems especially important and teachers need to create opportunities for collaborative endeavours. Social interaction clearly influenced the production process and resultant imagery of the children and this led, on occasions, to the development of quite sophisticated learning strategies, e.g. in group critical appraisal of work in progress and work produced by pairs of children working collaboratively (Fig. 2).

However, classroom activities do not always exploit the particular advantages of computers and some teachers appear to use the software in ways similar to the practices which were current prior

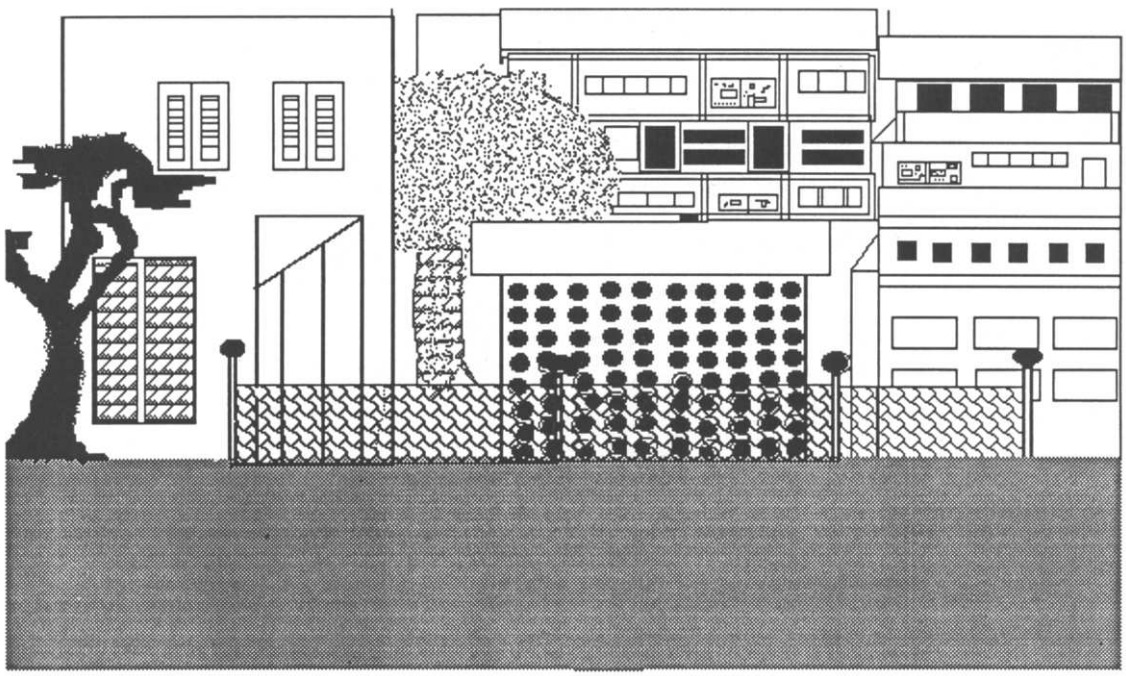

Fig. 2. Joint composition, "Neighbourhood Buildings", Chin Kok (10.5 yr) and Cheng Leong (10.7 yr).

to the advent of the technology and which may be inappropriate to this medium. Computer use in art teaching certainly requires new teaching strategies (which may be developed from existing ones) if students are to benefit from this teaching resource and medium for creating art works.

Technical and conceptual differences within the technology which we discuss in this paper need to be addressed when planning programmes. Issues such as which particular art concepts can and should be taught using computers, how computers might best be used in teaching art concepts, at what age these concepts can be taught: all need to be considered carefully. Interactive programs of the type we have used can be utilized to help develop problem-solving skills and the technology affords students the opportunity to engage in new, interactive, evaluative and critique-type experiences, often with work in progress, which enables them to explore new expressive forms.

TECHNOLOGICAL ISSUES

The variety of computer hardware and software available is truly amazing and changing at an alarming rate. There is certainly no such thing as *a* computer. We have worked with many computers and made inputs using a variety of means such as keyboards, roller balls, mice and buttons, and have found it useful and necessary to review our practice and experiment with the developments as they become available so as not to limit our work as art educators.

Active computer work in any sphere involves two-way communication between the user and the machine. Almost instantaneous feedback is required to provide effective participation between the user and the computer. Response must be immediate in art-based computer work to emulate the analogy with pencil on paper. When commands are invoked the displays must be generated fast enough to give the appearance of active user control.

As it was our intention to research ways of embedding computer-based art work into existing art programmes, we felt it was important to utilize a system, the Apple Macintosh, which was already available in schools. Additionally, we decided to utilize this particular computer as we consider it to be the most usable system for our work with primary children, and our choice had to coincide with a system which is widely available in Singapore.

The Macintosh system is icon-oriented and mouse-driven and provides a polymorph of many tools. In common with most other computers, this system can enlarge and reduce, isolate and unite, remember and forget, frustrate and delight. Using computers in the process of art production requires patience and effort to master it sufficiently. It seems to us crucial that children and artists should reach a stage where the computer as an art tool is no longer strange and awkward to manipulate and does not produce art work by total serendipity. Of course, chance and experimentation are central to all art learning but, with experience and practice, students gain control of the medium and begin to be able to predict certain results. Computer art work, like all art work, is not random but planned, considered and intentional.

During the course of the studies, certain salient technological issues emerged as being those which art educators need to be aware of and consider when planning art programmes which incorporate computers as a means of art production. These we have summarized as: position of screen and keyboard, mouse control and enlarging and reducing.

Position of screen and keyboard

With computer-based art work, the work appears not where the hand is but vertically in front of the artist. This requires an adjustment in perception and practice to enable children to reorientate themselves to this mode of art production. There is also a need to encourage children not to keep looking down at their hands, which is the initial tendency, because of the separation between the hand, eye and art work plane. This might be considered a disadvantage of the medium. Computers could be criticized for not enabling children to focus on the art surface and that the unified and easily controllable relationship of hand, eye and art surface in the very direct and familiar way, as in the use of traditional media, is central to a child's artistic development.

However, we observed an advantage in the emergence of this kind of skill when the children were engaged in drawing outdoors. They tended to concentrate much more intently on the objects of their observational studies rather than the movements of their hands. Consequently, and unexpectedly, we were able to monitor and compare to some extent, the children's skills in recording information in their drawings. We believe that the quality of these drawings, which were then scanned into a computer, undoubtedly affected the children's final art pieces and that their observational drawing skills using traditional media improved as a result of using the computer.

Mouse control

A mouse-driven system, such as the one we used, can cause initial difficulties for children. The mouse can be very sensitive yet requires a painstaking accuracy which can be frustrating for children who are beginning to work in this way. Manipulation of the mouse involves a spatial separation of the hand and eye which would traditionally be focused jointly on a piece of paper in a very direct and proximate relationship. Additionally, the motion of the hand manipulating the mouse will not be mirrored by the drawing on the screen and a very slight movement of the mouse can cause the cursor to move rapidly off the screen altogether. Sometimes, too, lines appear broken on the screen as a result of moving the mouse too quickly.

Drawing shapes with a mouse requires children to comprehend almost the inverse of traditional drawing techniques; i.e. shapes are drawn from the inside out rather than drawing enclosing circumferences or perimeters. Controlling size of shapes is yet another skill children have to acquire and this requires patience and persistence.

Screen images frequently have a slight shake which can be visually distracting but this appears something that the children adjusted to quickly. In the early stages of our work, children new to computers would ask each other if there was indeed screen movement when hands were nowhere near the keyboards. Later, it became almost a game with children sometimes naming this almost imperceptible flicker as an "almost move".

Inevitably, art-based computer work has limitations as does any other medium. Once students have mastered mouse manipulation, a skill they develop rapidly in our experience, they then have to become aware of the maximum speed at which the mouse can be moved and of the limitation of screen size. A computer screen is small and can rapidly become filled but the storage capability enables students to save many versions and ideas and to work with many pages on the screen at any given time.

The Save and Save As File commands are ones students need to master early on to exploit the computer memory to support their artistic intentions. Additionally, it is a simple matter to copy and paste sections from many saved work files which replaces the tedium of redrawing by hand using traditional materials. This feature, which is unique to computers, rapidly replaced a sketch book of preparatory studies for our students. Creating and making many files plus the ability to keep one's image at the same time as experimenting with changes and elaborations has been termed "seriation" by Freedman [2]. It has been suggested that students experiment more on the computer than is common with other media as the organization and collection of a vast array of visual ideas can be so easily accessed.

It has certainly been our experience that students experiment a great deal when involved in computer-based art production. In the SMART programme, for example, some children went significantly beyond the limited range of tools they were introduced to in the first session and experienced delight in using sections of their images as a brush and capitalizing on the computer's apparent ability to readily generate dynamic imagery and the storage facility.

All 24 children in this project responded positively to this initial, doodling, exercise with 21 recording saved changes to their original file drawing. Twelve children made significant changes which enhanced and elaborated their work. A group of the children (7) made little or few changes to their original file, although they had had considerable computer experience. This suggested that the particular skills required to manipulate graphic imagery directly with a mouse are essentially different from other computer skills. Only two children had no previous experience with computers, but few had used a mouse before. Most of their experience was on IBM-compatible personal computers which, until recently, were less usable for developing visual imagery, being keyboard-driven rather than mouse-driven. This points to the inevitable time-lag between technical advances and educational resources, and the need for particular devices and applications for different curriculum areas.

With the SCAMP project, we often met with considerable practical difficulties when the myriad files the children had created on the disks were unnamed. Of the 20 children, working over a 10-week period for two sessions per week, 11 of them had generated work on more than two disks and of the remaining 9 children, no child had less than twenty-five files. Simply keeping abreast of all this artistic activity required a great deal of time and meticulous file keeping of annotated hard copies.

Even with a high degree of manipulative skills, many of the children in both projects completely abandoned the mouse in times of excitement or frustration. A common reaction in such circumstances was for a student to pound the monitor with a finger or fingers in an attempt to stop or encourage a command they had generated. Possibly, even towards the end of both projects, the use of the mouse had still not become completely natural or automatic to the children as we still observed some screen touching. However, some of the children seemed to find computers easier to control than other materials and media. These students frequently commented that this means of art production was "less messy" than using other materials. Probably as many students commented that the computer lab "didn't look right" and certainly "didn't smell right"! Nonetheless, the manipulative aspects became quickly manageable for most students and they gained sufficient mastery of the mouse to create art work of quality.

Enlarging and reducing

The ability to enlarge and reduce images, or sections of an image, with ease on a computer is a major advantage which can be exploited in art teaching. Typically, the instruction "Zoom" causes the entire image to be placed on one part of the screen while the magnified portion occupies another part. As the enlarged section is worked on, it is therefore possible to view concurrently the changes on the image as a whole. Changes and their effects can thus be observed down to individual pixels. This important feature is not easy using traditional media, where artists who concentrate on fine details have used magnifying lenses. However, it is crucial to retain a sense of the entire image so as to understand the impact of work on individual pixels. Children have to view the entire image at regular intervals and need to understand the importance of doing this. Frequently, in the early stages of both projects, children became so absorbed in working on

enlarged sections of their work that they became disoriented when trying to associate these sections to their total images. Getting lost in a piece of art work was a common occurrence in the initial stages:

> "Things look different bigger and I forget about the rest of it. Getting lost so many times to start" (Minghui, 11 years)

AESTHETIC ASPECTS OF CHILDREN'S COMPUTER-BASED ART WORK

> "What is unique about the computer is that it is evolutionary. As a medium and consortium of tools it is not static. The more you understand it, the more you make it subservient to your imagination as an extension of your creative act, the more its evolutionary character will challenge you" [3, p. 61].

Using a very apposite analogy, Schwartz [3, p. xv] has described the development of artistic talent using the computer to create art work as an accumulation within the artist of an internal database of skills, understanding and knowledge honed by practice and experience of traditional media to counter the formidable and sometimes overwhelming and disorienting external database of the computer. She further suggests that these skills and understanding concerning computer-based art work are stored in the artist's internal database just as the computer will store databases created by the artist:

> "The goal is to integrate these internal and external databases into a seamless, comfortable universe through which the creative act is expressed unimpeded .... As your eye evolves, and with it the requirements for expression, the machine can be finessed to its next level of obedient co-operation" [3, p. 17].

Students' internal databases include intangibles such as inspiration, creativity and imagination. More specifically, they encompass to varying degrees an awareness of artistic elements and principles such as shape, colour, line, perspective and proportion. As children work in a particular cultural context, so will their artistic thinking be influenced, directly and indirectly, by cultural phenomena.

An interesting and particularly striking example of cultural influences on children's art work, emerged during the SCAMP programme. The introductory exercise was about creating textures within a shape, which requires a great deal of technical control and a high level of manipulative skill. The shape in question was Dürer's Rhinoceros which we had scanned into a computer. There was a great deal of discussion concerning the original work which led on to the textural exercise (Fig. 3). Quite spontaneously, one child began drawing a dragon (Fig. 4) which resulted in some comparative art history work on dragons and eventually the dragon group work activity. Yet another child developed the Scarecrow image, drawing straight onto the computer screen and applying his skills and awareness of textural qualities (Fig. 5).

The forms and qualities of computer graphics are important considerations when teaching art criticism and aesthetics in relation to the medium. Inevitably, with any artwork, the final piece is always in part an expression of a compromise between the idea and the restraints and possibilities of the selected medium. Computer imagery is no exception, and artwork using this tool is developed in relation to the qualities specific to the medium, through the process of learning about the potentials and limitations of the medium and in consideration of the age and experience of the students. As with other media, the materials available have an effect upon the process of production. In the case of computer graphics, what is available in terms of software and hardware will direct imagery.

For example, certain systems, such as Paint, are designed to simulate paint. This simulation means that certain culturally specific aspects are taken for granted for example brushes and brushstrokes. However, the simulation makes only certain effects possible, and the possibilities are not necessarily those of real paint. There are crucial differences in the process of production, as well as in the visual and tactile qualities, of computer graphics as compared to real paint, which

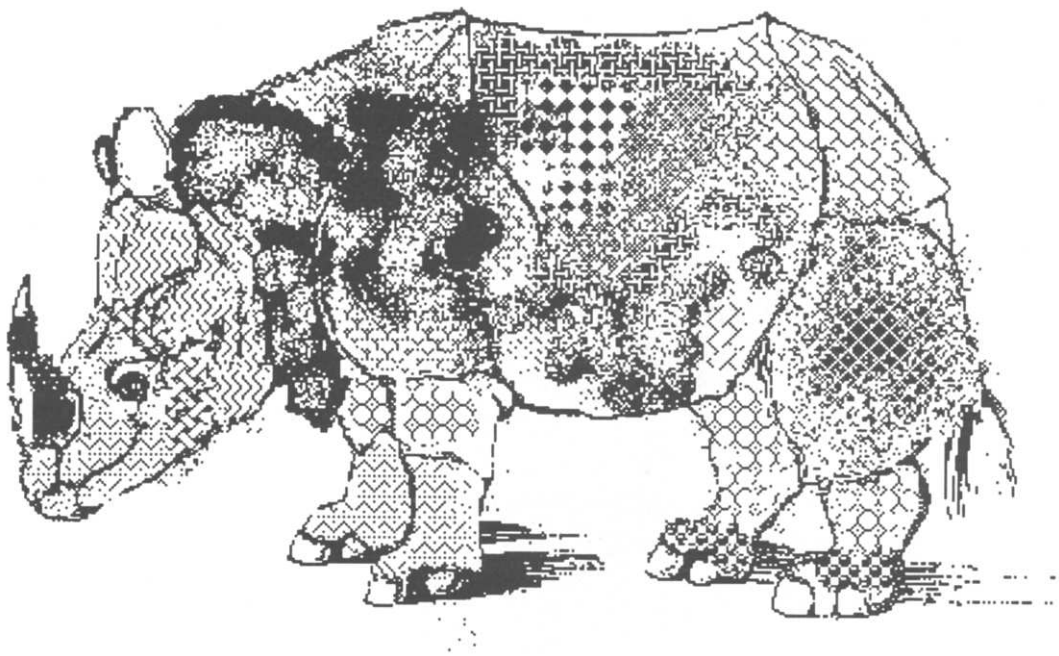

Fig. 3. Textural exercise, "Rhino", Tan Chin Kok (10.5 yr).

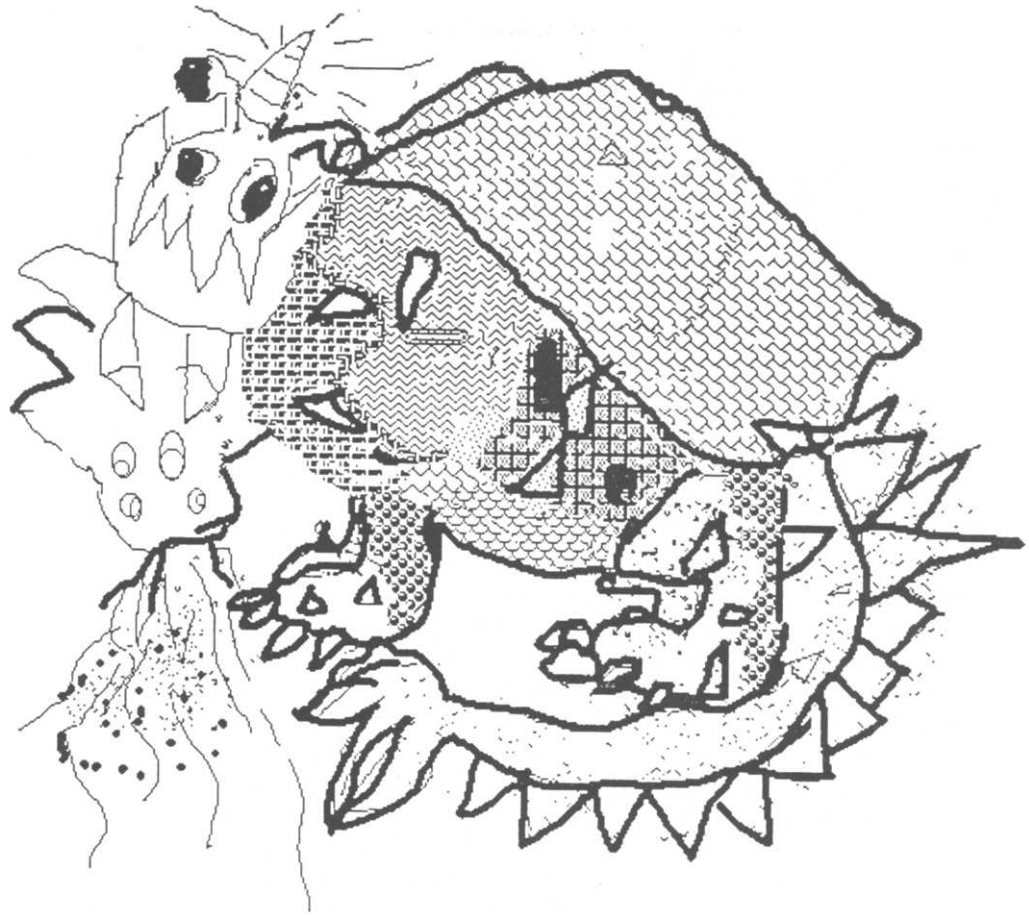

Fig. 4. "Dragon", Sng Puay Li (10.4 yr).

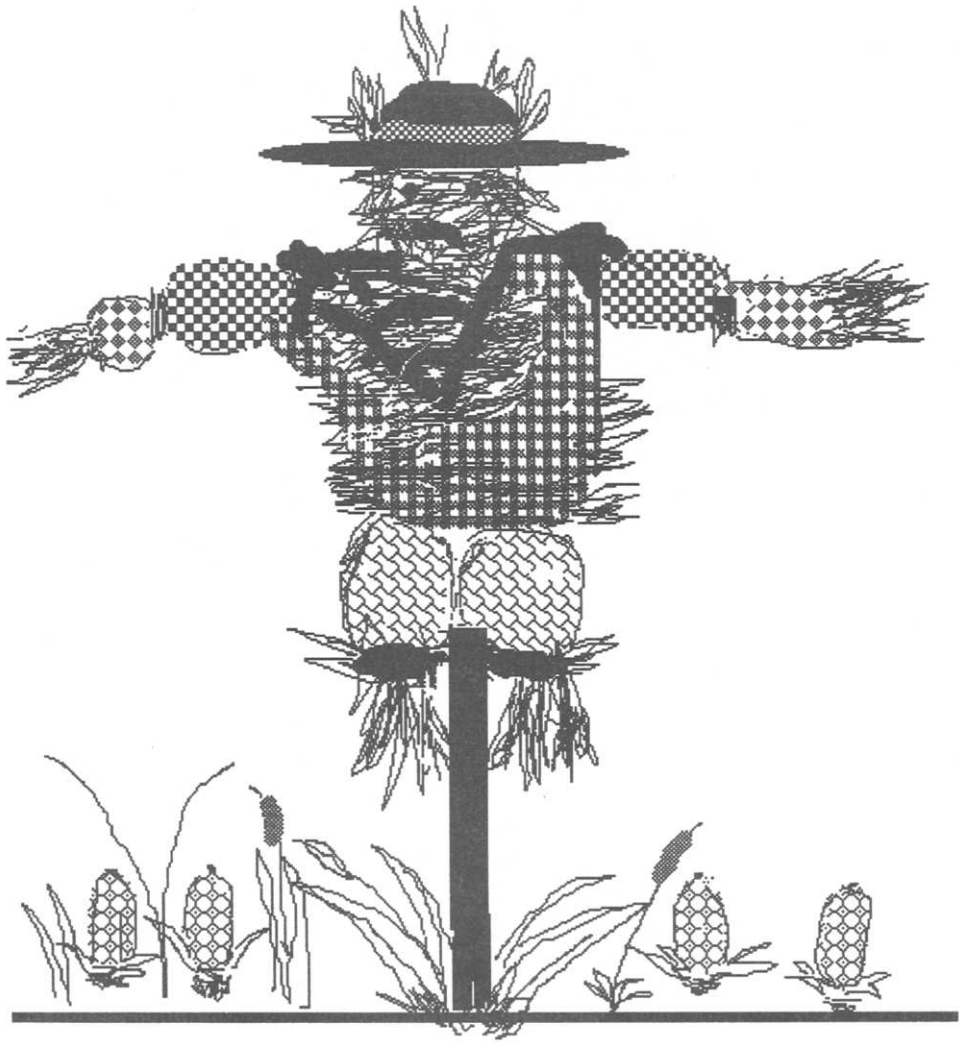

Fig. 5. "Scarecrow", Zhong Wei (10.7 yr).

children need to comprehend and perceive. Students need to be brought to understand how the qualities of "paint", in this instance, differ from the use of paint generally and how the particular computer effects have different and yet aesthetic possibilities which can be explored.

Another obvious example of differences between the use of computers and traditional media to make art work is in the depiction of three-dimensional effects on a two-dimensional plane. Conventionally, three-dimensions are shown using various conventions such as the addition of shading or highlights to the surface of an image or the use of linear perspective creating three-dimensional representation on a two-dimensional plane. Three-dimensional qualities are technically difficult to achieve for children with most drawing programs although there are sophisticated and expensive programmes, such as wireframe imaging which can create these effects. The children did, in some instances, simulate the third dimension through well-known devices such as object size, overlapping and placement of imagery on the pictorial plane (Figs 6 and 7). Additionally, some of them became adroit at the use of lines and the spray command and could use these functions to create the illusion of depth in their work (Fig. 8).

Unfortunately, computer imagery can be prone to stereotyping as any image can be scanned into a machine, e.g. comic books, popular imagery, and then be reproduced. Perhaps this is more apparent with computers than in work produced by more traditional means. Additionally, disenchantment can be a problem as remarkably repetitive images can be produced by those with

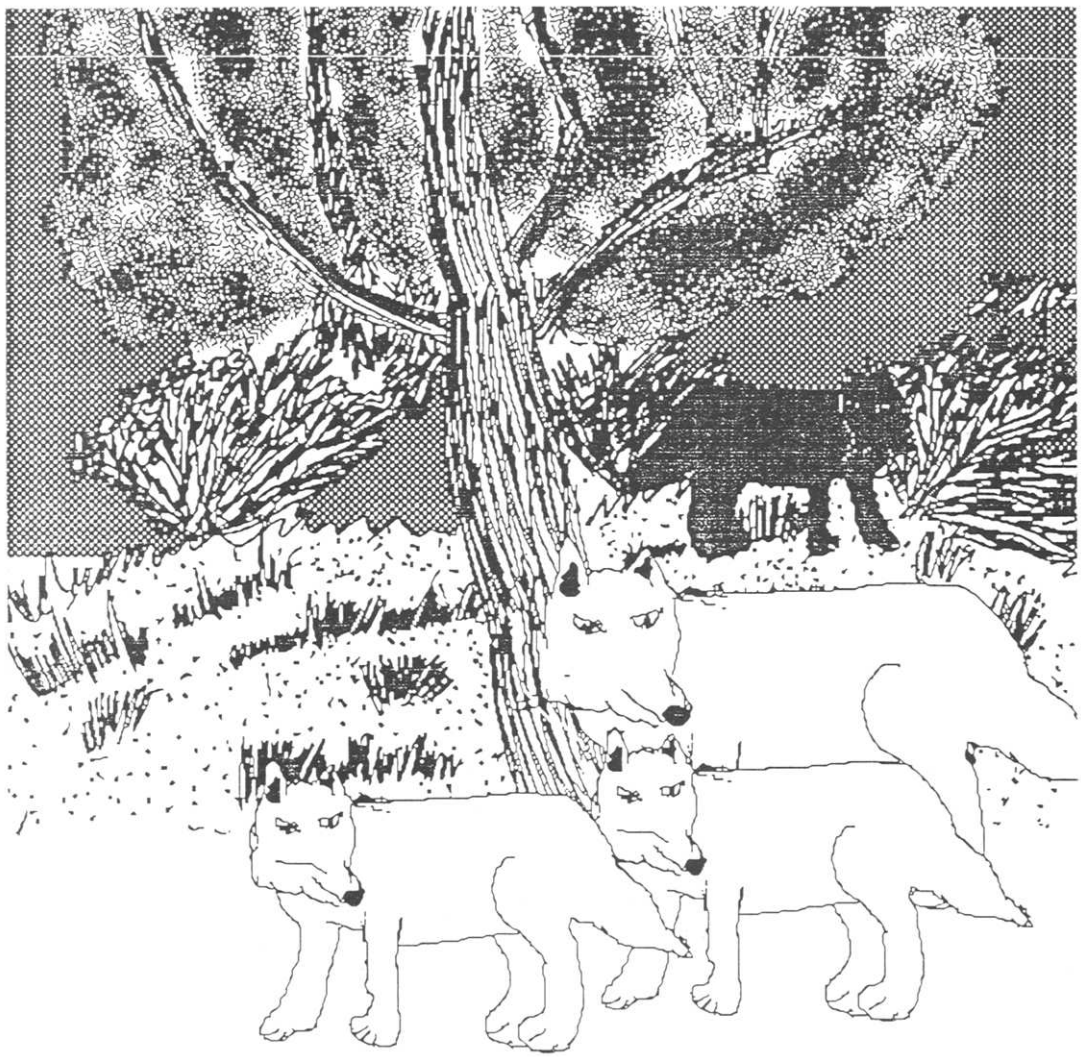

Fig. 6. "He Who Dances With Wolves", Hang Quiming (9.8 yr).

access to the same software and computer, for example in the shape manipulation exercise to create recognizable imagery by the SMART children (Fig. 2). Indeed, it is often possible to identify a program which has been used but not an individual artist's hand when viewing art work generated by a computer. However, with our strategy of scanning children's own drawings, we overcame this problem to a large extent. Technologically too, such obstacles are being overcome with the advent of increasingly sophisticated software.

Adults seemed to be more concerned about perceived similarities between the children's work in the early phases of both projects. The children themselves, however, were largely unconcerned with many of them expressing the view that their finished pieces were more professional in appearance than their work in other media. Undoubtedly, the medium is very conducive to experimentation which can be done in a minimum amount of time unlike with traditional media. When using computers, our students seem to focus on at least four art elements: contrast, texture, chance/randomness and audience interaction. These four elements seem to be some of the particular aesthetic qualities of computer graphics and could be brought into the classroom through the use of computers.

A truly unique feature of creating computer graphics is that work in progress can be readily evaluated and modified *in process*. This is therefore an aspect which can be valuably exploited to help develop critical, aesthetic judgements about art works; both those of students and well-known

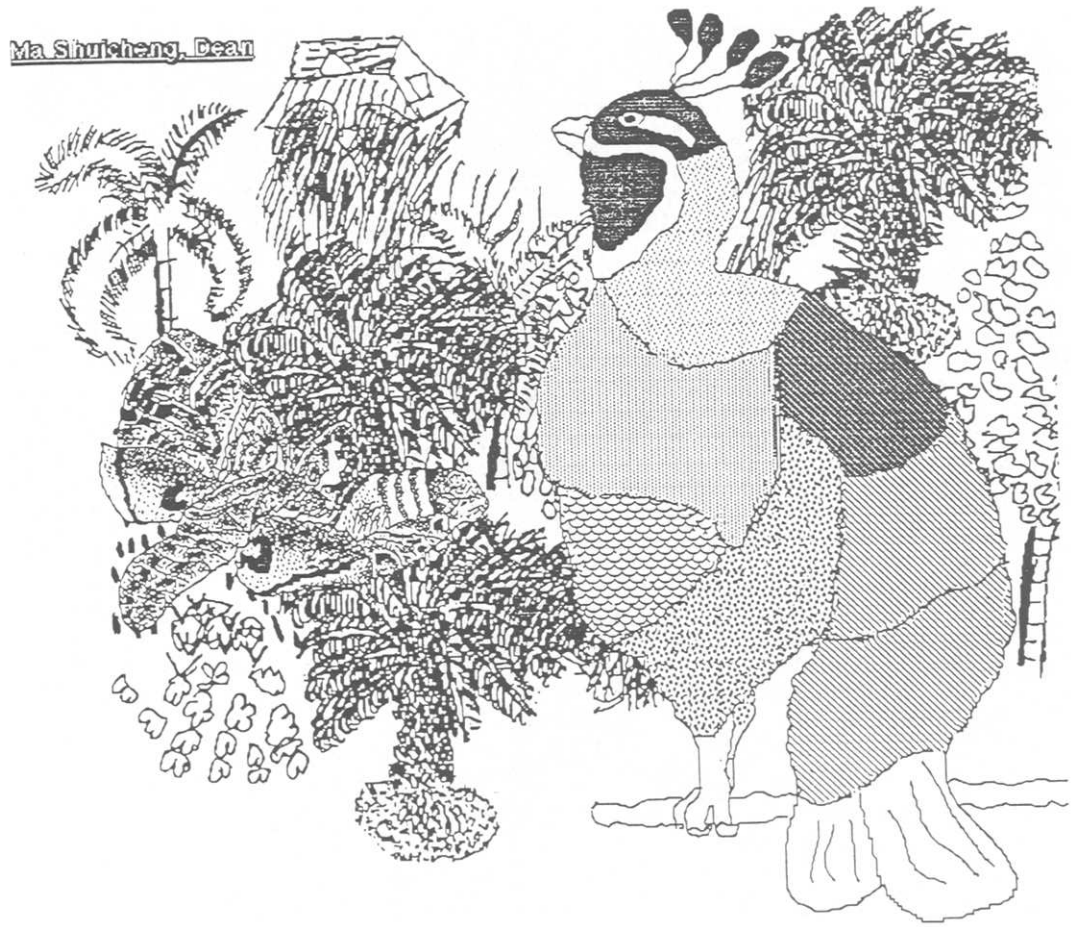

Fig. 7. Ma Shui Cheng (9.7 yr).

artists. With computers, students now have the facility which will enable them very easily to elaborate and refine their imagery.

Aesthetics should be part of all art programmes and as such, the aesthetic dimension of computer graphics needs to be part of those programmes. As computer images look very different from images produced with traditional materials, students need to develop the skills to evaluate this work, just as for all other art work. Also, just as for other art areas, students have to be made consciously aware of those qualities which distinguish well-designed computer images from those which are less successful and to be able to make intelligent and sensitive judgements about them. Art teachers too, need to be educated so that they can help their students make these distinctions and judgements.

CONCLUSION

Before being accepted unquestioningly as a legitimate artistic medium for art educators, some of the challenging aesthetic, pedagogical and practical issues raised by computer-based art work need to be addressed. Some of these issues concern the impact of technology on the artist, the creative process and the nature of art itself. New technologies offer fantastic possibilities for expanding and enriching art teaching and art teachers need to be familiar with computers as students are coming to school with a greater acceptance and aptitude for the medium.

Recent accomplishments by artists and our work with primary children, clearly demonstrate to us the ability of an individual working with computer technology to assert a distinct form of artistic expression. However, we should not be distracted from our artistic intentions and ideas

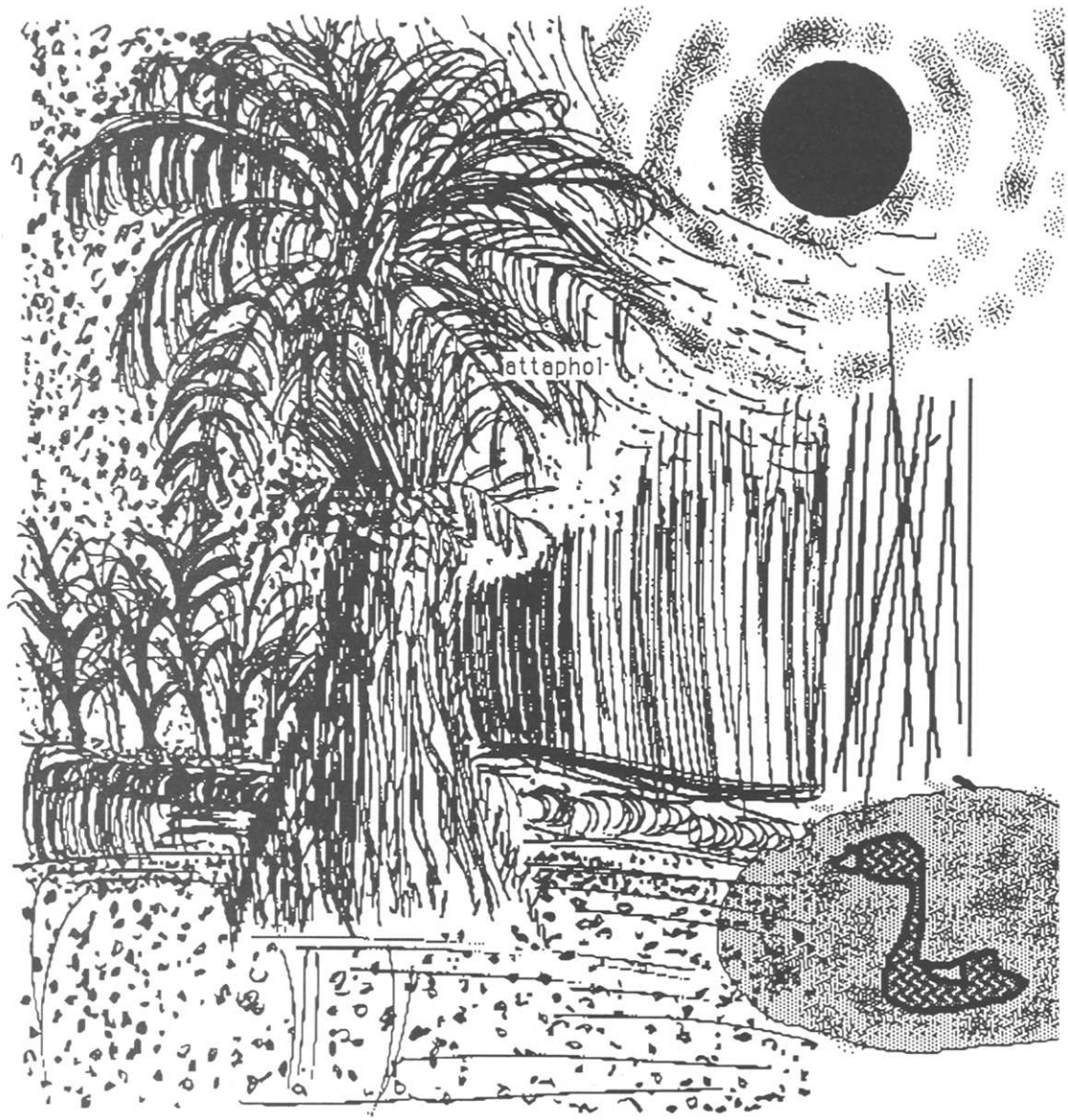

Fig. 8. Attaphol (12.1 yr).

by the astonishing and frequently dazzling technical feats of the computer, as artistic principles need to function in collaboration with machine.

What we teach are processes and methods by which personal art forms of value can be created and evaluated. In this sense, we do not teach computers, they become just another tool for teachers and students to exploit for their own artistic purposes and intentions.

Electronic imaging has created a new art form, a new means of art production, a new visual language and a new aesthetic for the visual arts. This new art form should not detract from nor trivialize traditional art experiences or processes. Rather, it should extend and complement existing art education practices when considered and included within a newly evolving art teaching paradigm.

REFERENCES

1. Goodman C., *Digital Visions: Computers and Art.* Abrahams, New York (1987).
2. Freedman K., Micro computers and the dynamics of image making and social life in three art classrooms. *J. Res. Comput. Educ.* **21**, 290–298. (1989).
3. Schwartz L. F., *The Computer Artist's Handbook: Concepts, Techniques and Applications.* Norton, New York (1992).