Visual literacy and how children use icons

Janet Cooke & John Woollard

When a child paints, when a child draws and when a child pastes they participate in Piagetian concrete activity. The activities are concrete because they are the combination of mental processing and physical activities. On the computer the situation is similar. The extent to which painting, drawing and pasting are concrete activities is reflected in the way in which young children can learn and apply their learning with relatively little reinforcement. Our research work suggests that the icons associated with the computer activities of painting, drawing and pasting are remembered more easily than the verbal oral instructions and perhaps as easily as the practical objects themselves. The work therefore shows the importance of computer based painting both in the expressive and artistic development of the child and his or her computer awareness and computer skills education.

By using a range of stimulating materials on the screen and by giving the children opportunities to move and organise those images, we are helping to develop their visual literacy. These activities are enjoyable and educative. They remain in the concrete domain yet use tools that can equally be used to support cognitive developments. The computer can also be used to present the child with a range of images and visual devices to support pre-reading and literacy development. The means by which teachers can assess the skills, knowledge and understanding within the expressive and computer domain are discussed along with how those skills and assessments relate to other areas of the curriculum or other aspects of education of the young child.

Symbolic activities and symbolic distancing

From an early age young children engage in activities which are symbolic and this is demonstrated in their use of language and their play. From the age of eighteen months children are able to create meaning in their minds and to express that meaning through gesture, language and objects. This ability to transform objects or situations through the use of imagination into meanings that are different from the original object or situation forms the foundation for intellectual development and communication. Young children's play is characterised by the use of symbols to represent objects, ideas and situations not present in the immediate time and place and symbolic play often provides a vehicle for children to explore new concepts and experiences.

The research in this area has sought to document a sequence of progressive symbolic distancing. As children mature, they are able to use objects that are increasingly removed in form and function from the objects they wish to symbolise (Nourot and Van Hoorn, 1991). Vygotsky regarded symbolic play as critical for facilitating the child's construction of a functioning symbol system and as this symbolism develops, meaning is then independent of objects so that the child can operate with more arbitrary and abstract symbols. Potter (1996) describes research where young children have been given

specific play experiences to aid this process of developing symbolism. The findings of Rosen (1974) demonstrated that children given training in symbolic play developed greater skills in problem-solving and early literacy activities. Thus symbolic play can help children move towards an understanding of more formal symbolic representation such as shapes, letters and numbers.

From an early age, young children are in a similar way initiated into the use of metaphor in language. Children become familiar with this symbolic use of language and appear to understand it intuitively. They meet it in everyday conversation, through riddles and word play and it is used to communicate and develop meaning. It can be argued that although metaphor is a powerful means of communication, in order to become fully involved, it is necessary for a child to possess the knowledge needed to interpret the metaphor within its context. It is easy for metaphor to become a type of code, which can be interpreted only by those initiated into its secrets. The interpretation and use of metaphor however, can extend the capacity to reason and think reflectively and it is important to develop this potential in children.

This evidence indicates that young children readily engage with symbolism in their play and language and are able to understand and use this in their activities. It is suggested Vygotosky (1978) however, that symbolism is more easily interpreted and integrated into their understanding when it is supported through a real context and linked to existing knowledge and learning.

Considering metaphor and icon

The term 'metaphor' is traditionally associated with language use. When we want to convey an abstract concept in a more familiar and accessible form, we frequently resort to a metaphoric expression and we use prior knowledge to understand new situations. The interface metaphor has developed from a need to communicate the abstract concepts of a computer system and functions through concrete associations. By using real-world objects to present abstract ideas, it is believed that users draw from previous learning and therefore learn more quickly and with less effort. Interface metaphors enable users to construct a mental model (Lynch, 1994) and through reference to familiar habits, tasks and concrete objects make the abstract and invisible functions of the computer easier to understand and remember. Successful interface metaphors should be simple systems which offer consistency and do not require the user to learn and remember many rules and procedures.

Interface metaphors are increasingly becoming a prominent part of commercially available software with more generalised 'container' metaphors to represent the nature of the application. The original metaphor of the 'desktop' for business applications such as word processors and spreadsheets represents office objects, such as folders, clipboards, waste baskets as icons on the screen. Interface metaphors have evolved for other types of application and one good example is the art application, which uses the artist's 'canvas', a palette of colours and a range of icons to represent the drawing and painting tools available. Many of these container metaphors are

becoming standardised between the different commercial versions and are beginning to offer some transferability and consistency between applications.

The graphical user interfaces developed for programs for children generally follow the same container metaphors as those used for adult programs. Art applications for children use a colour palette and a selection of simple painting tools. If the concept behind the use of metaphor is to enable the user to make abstract associations with concrete objects, it should follow that in order to understand and use the interface effectively, children need these concrete experiences.

From the iconic to the concrete

Many of the functions of an application with a graphical user interface are represented in pictorial form, as icons. Some of these are direct representations of the function, for example a picture of a printer for Print. Some use metaphor to represent a more complex or abstract function such as a picture of a pair of scissors to depict the function cut. Many icons are now being generalised across applications and their functions are becoming standardised on a variety of interfaces. Most graphical user interfaces designed for adults however, offer alternative methods of presentation in addition to the use of icons, such as menus and text labels which appear when the cursor is positioned over the icon. This additional level of support enables the user to select the method he prefers or use a choice of both but is not a viable option for supporting young children with limited reading skills.

Icon and interface design is an evolving discipline which endeavours to improve human-computer interaction and improve usability. The organisation and position of icons on the screen can be important for the user and many applications allow the user to customise the interface to present icons in a horizontal or vertical format, change the size of the icon or remove icons not frequently used from the screen. 'Direct manipulation' aims to provide the user with a feeling of control over the objects they are working with and feedback to their actions. For example, when an icon is selected it will 'depress' in the same way as a button on a machine to indicate that it has been switched on. Other features in icon design which can influence the interaction between the computer and the user include use of colour, style of drawing, three dimensional effects and animation and these are implemented to a greater or lesser degree on the graphical user interface.

Given that icons comprise a large part of a graphical user interface and that this design method is the key approach currently adopted for applications for young children, it is important to consider the nature of icons for use with young children. Jones (1993) states that icons designed for use by children should "clearly depict, indicate and distinguish a program's commands and operations" and "should suggest and indicate a command intention rather than just duplicate or represent a particular pictorial form". This is particularly important for young children who with little or no reading skills are not able to use the additional verbal support such as text labels which are available to adults. The goal for educational software developers should therefore be to

incorporate icons which are realistic and meaningful for children and which leave little room for misinterpretation. Jones (1993) says at present the iconic component in existing interfaces for children's use generally mirrors what is available in the commercial marketplace and does not respond to the developmental world of the child.

Quantifying children's understanding

Our research focussed upon four aspects of children's use of painting programs. At the simplest level it is the children's ability to match an icon name with the image they see. This is akin to responding "bus" in response to the picture of a bus or "b" in response to the letter shape **b**. The second aspect is determined the children's ability to carry out the skill associated with the functions of the art packages. Although not requiring the physical dexterity necessary to paint with the same brush both flowing water colours or thick stipple effect the children's ability to produce the limited functions offered by the painting program were observed. The children's ability to describe the functions of an art program simply by viewing the icon associated with it was recorded. The product of the children's art work was then considered in the light of visual literacy skills analysis. There were 52 children aged between 4 years 10 months and 5 years 6 months taken from three different schools in the original investigation; they were divided into two groups which were taught differently. One group was given extra interaction away from the computer handling 'real' objects associated with painting and the icons that are used in the computer programs. The other group were introduced straight-away to the computer painting program. A week later, their recollection of their understanding of the icons and functions was assessed.

The following words are used to describe the results: nearly all means over 90%, most means over 75%, over half means between 60 and 75%, half means between 40 and 60%, less than half means between 30% and 40%, some means between 10% and 30% and few means less than 10%. The full data set and its analysis is available on http://www.cblt.soton.ac.uk/chapter9.

The icons which are a pictorial representation of objects in the children's immediate experience of creating pictures were quickly recognised. For example the majority of children identified the paintbrush and the shapes correctly and associated these with their experience of art activities, enabling them to make a link with the function in the computer application.

The spray can and roller of the Spray and Fill icons were recognised by some children, particularly those who had had the opportunity to handle and use these items. However, most of the children found it difficult to link these objects with functions in the application and describe the effects that would be achieved. For example, they were unable to associate painting a wall with a roller, with filling in a large space on the program Splosh.

The Text, Undo and Brush size icons were not consistently recognised. The children who could read the text labels were able to make a more accurate or informed guess at the function, than those who could not. However, the

abstract nature of the pictorial representation on the icon and the children's inability to make an association between this and something they recognised within their own experience seemed to prevent the children from recognising or suggesting a function for these icons.

Recognition of icons through practical exploration

Through exploration of the Brush and Colour bar all the children were able to describe the function of these icons and demonstrated this without further support. All of the children were able to describe the purpose of the Fill tool after they had used it, as a tool which 'fills in' a whole area but required further demonstration of the need for the area to be enclosed to fully understand its function. Most children correctly described the Spray tool after they had used it and used appropriate language to convey the action. 3 children could not describe or could not discriminate between the Brush and the Spray. The more experienced children used the word 'spray' to describe the action.

All of the children identified the function of the Circle, Rectangle, Triangle and Line tools but a lot were unable to achieve making shapes unaided and needed demonstration to complete these independently. This appeared to make the children question whether they were right in their judgement and they were frustrated that they could not draw shapes more easily. This was particularly the case with the Triangle tool where the user is required to click on the three points of triangle, before the shape is achieved. So although the children believed these icons enabled the drawing of shapes, their practical experience of this did not really confirm or support this. Even with practical experience of the Undo icon, few children recognised its function. As the function is to only undo the last mouse action, where this was a small movement or mark on the screen the children often did not see that it had been erased. Even when they clicked on the icon for a second time, which restores the action, some children did not notice what had happened and could not identify the function. When the children clicked on the Text icon, only a small number noticed the insertion of the caret. Interestingly, two children recognised this as the same screen character as they had seen in a word processing program and quickly realised that they could use the keyboard to insert text. A small number of children identified that clicking on the icon enabled writing and with prompting tested this by trying the keyboard.

All of the children needed some prompting to fully explore the Brush size tool. The children were told to click on the large and small arrows but needed to be prompted to explore the effect this had on the size of the tool they were using. Once this had been experienced, the children were able to fully explain the function of the arrows and the Brush size icon. The children were then prompted to change the colour using the Colour bar and then most of them recognised that the colour of the circle changed to match the colour they had selected.

The opportunity to explore the icons and then describe the function rapidly increased the children's understanding of some of the icons, particularly the Spray and Fill tools. Being able to see the effect achieved with these tools, the

children found it easier to describe the function by pointing and demonstrating the effect. They were not so dependent on their language skills. The children who had been told the word 'spray' used it frequently to describe the effect of the Spray tool, but other children still conveyed the function effectively using language within their general vocabulary, for example "it makes little dots". All of the children were confident that they understood the function of the Brush and Colour bar icons and demonstrated this independently, selecting colours and making brush strokes across the screen. Practical experience of these icons confirmed their understanding of the function from their visual recognition.

Measuring children's applied skills

The children tackled the task of creating their own picture with confidence and used some of the icons independently. They all used the Brush and the Colour bar but some were content to just use these two tools. These children were prompted to try to change the size of the brush and use other effects but could not remember or work out from the icons how to achieve this. Most children used the Brush size tool to adjust the size of the Brush but some needed help to decrease the size using the small arrow. None of the children appeared to use the colour of the circle to check the colour selected but preferred to look at the colour of the end of the paintbrush or the contents of the spray can. Most children used the Spray and selected the colour for this but only a small number changed the size using the Brush size tool. Some children used the Fill tool, while the remainder of the children filled in areas using the Brush tool. Some of the children tried to find colours which were not available on the Colour bar.

Some children tried to use the Circle, Rectangle, Triangle and Line tools but needed support to achieve the shape and position it. All of the children made mistakes that they wished to erase but only half children used the Undo function to achieve this. The other children recognised that they could over paint an error or use white paint to 'rub out' a mistake and preferred to use this method.

Writing and then printing a picture

The children were asked to 'write' their name on the screen but a lot did not remember which icon to use to achieve this. All of the children needed help to complete this, either to position the caret in the correct place or prompting to change the colour in the Colour bar so that they could see their text.

The final part of the task was to print the picture. The children were asked if they could find an icon or something on the screen which would achieve this. Most children located the printer icon on the icon bar and believed that clicking on this would print their picture. Two children who had previous experience of a word processing package remembered that they needed to use the Menu button and then located the Print command. When asked to look at the keyboard, some children found the Print key and printed their picture in this way. The other children were all shown how to use the Menu

button and asked to look for Print in the list of commands. Locating the method to print a picture was confusing for all the children and they all scanned the toolbar on Splosh for an icon which would achieve this. The children were creative and increased their search to the whole screen and most found the printer icon on the icon bar.

The children tackled their task with confidence and were content to work with some of the icons independently. All of the children were able to create a picture using the Brush and Colour bar but some needed prompting to extend and develop their work. Most of the children had retained their recognition of the icons from their practical exploration and if they were prompted, for example to increase their brush size they immediately pointed to the correct icon. Where the children had not fully recognised or understood a function and its icon, they were reluctant to try it and did not use it independently. The limited range of colours on the Colour bar was frustrating for some children, as they could not locate some of the basic colours they wanted for their pictures.

Making mistakes and ‘undo’

Most of the children at some stage wanted to 'undo' a mistake but were not really sure of how the Undo function worked. This function was also not effective for some of the 'mistakes' as it would only undo the last action, and some of the mistakes were made up of several mouse movements. However, all the children were creative in solving this problem and found alternative methods of making the desired changes to their work. Several of the children chose to use white paint as a rubber and said this method "worked better" than the Undo function.

Most of the children avoided the shape tools and preferred to draw freehand because they were not confident using these tools. The major issues appeared to be controlling the size and the position of the shape, which often 'jumped' on top of the children's work and they then felt they could not remove it and their picture was spoilt.

Importantly, some children transferred their experience of another application and using the mouse Menu button, experimented to see if the same result could be achieved in Splosh. Operating the Print button on the keyboard was effective for the children who found this and simpler than using the Menu button. A few children were concerned when the Menu window opened on top of their picture and needed reassurance that their picture would not be spoilt. Most of the children who used the Menu button were able to scan down the list of commands and effectively use their letter recognition skills to locate a word beginning with 'p'. Although the children achieved this with adult support, an icon with a picture of a printer located on the toolbar of Splosh would have made the operation simpler and enabled the children to achieve this independently.

Long term visual recognition

A second assessment of the children's visual recognition of the icons was carried one week later and after the children had had substantial practical experience of using the painting program. There was a substantial increase in the results for some of the icons but not others. For example, on the initial assessment only 4 children identified the function of Brush size but on the second assessment most children described the function correctly. A similar increase was demonstrated by the Text, Fill and Undo functions. Only 5 more children recognised the Spray function on the second assessment which was surprising as nearly all the children had used this tool extensively in their independent work. A possible explanation for this is that the majority of children found it hard to describe the effect of Spray and did not have the vocabulary to do this adequately.

The children were confident using the application, learnt rapidly and did not show any concerns about exploring the majority of icons. The assessment of the children's visual recognition of the icons was heavily dependent on the children's language and communication skills and many of the children did not have the range of qualitative vocabulary to effectively describe a function of an icon.

It was observed that children responded quite differently to presentation of certain icons. The icons with a clear picture of an object in the child's experience of art activities were quickly identified by the children and the function linked to the object. The icons with a picture of an object in the child's experience but not generally associated with art activities, were identified but the function was not remembered. The children did not understand the metaphor of the spray can or roller and required practical experience of the function, in order to link the icon to the function. Recognition of these icons was not retained as readily over a period of one week, as those associated with art activities. Where children were given the opportunity to handle and experience objects such as the spray can and roller, they were more able to associate the object and the pictorial representation of the icon with the function and developed a clearer understanding of the metaphor.

Although the icons were understood, this alone did not necessarily enable children to use them.

Forgiveness in the user interface

The children quickly learned a function and used it independently if it was simple, flexible and forgiving. Although the shape tools were recognised by all the children, they were not used by the majority in their independent work because the children did not fully understand how to use them, the skills required were more complex and the children found it hard to remove their mistakes. Functions that are forgiving are those that can be intuitively undone. Two unforgiving actions are printing and text entry. It was observed that some children tried to click on their text to change it (as they would with a word processor) but this simply created more inappropriate text.

Although 22 children recognised that the 'T' of the Text icon was associated with 'writing', none of the children knew the word text and made the link. The effect of selecting the Text icon would be more obvious to young children if the caret were contained in a frame or were bolder and blinking. The majority of children were unable to read 'Undo' on the Undo icon and, even where they could, they did not understand what this meant in relation to the application. A more abstract symbol, such as a red X, may have been more effective in conveying that this could be used to remove mistakes.

The colour palette should contain colours young children know and want to use in their work, for example some palettes do not contain pink or brown; some of the children wanted to draw pictures of themselves. The Undo function is not sufficient for removing errors. A rubber or similar function would have enabled them to remove some mistakes more simply. Painting in white or the same colour as the background for example, is a difficult concept for some children to understand and a negative way of learning.

Summary of the main findings

Young children are able to use a simple graphical user interface independently and effectively. Young children learn rapidly and we should have high expectations of their skills and capacity to learn with computers. They are able to independently recognise and use the graphic symbolism of icon design and associate these with functions in an application, providing the representation on the icon is within their realm of experience. Icons are more readily understood by the young child if he has direct experience of it and can associate it with the activity offered by the application. For example, young children associate a paintbrush with creating a picture but they do not generally associate a spray can or a roller. Where a function represented by an icon is more abstract, young children are able to learn the function through practical experience and retain it, providing it is easy to use and they are able to operate it independently. They do not need to understand the metaphors. However, there is a need for the standardisation of metaphors and icons between programs. Young children are able to learn and operate abstract functions represented by metaphors, but this learning can be further facilitated and consolidated by a common approach between programs.

The effect of selecting an icon should be clear and immediate to the child, so that the effect of choice can be quickly seen. Direct manipulation and more subtle features are not always recognised by young children. Simpler effects, such as an icon changing colour on selection may be more effective. Animation of some icons may assist understanding of more abstract functions.

Wherever possible, verbal instructions should be avoided. The child becomes frustrated and loses independence, if faced by a menu of written choices. Pictures and symbols should be used where possible. Young children are however, able to learn a sequence of actions to achieve a function but need to be taught to do this.

Young children are confident to experiment and learn by trial and error. Software for young children needs to be flexible and forgiving to allow them to learn in this way. Error messages should be pictorial and easy to rectify. The organisation of the screen should be simple and logical. The functions to print, save, load and exit should be icon based and the process should be as simple as possible, that is, by restricting options and using pictures and symbols. The skills and interests of the child must be considered in the design, for example the colours offered in the palette should be those recognised and wanted by young children and icons should be large enough not to require very precise mouse control.

Programs should allow customisation by an adult to allow the child to learn progressively, gain confidence over a period of time and not be overwhelmed by too many choices. New functions can then be added as the child becomes more accomplished or requires additional options. There is a need to establish whether interface metaphors and language should be those within the experience of the young child or whether the young child should be taught specific computer language and concepts, as part of their computer based learning experiences. The evaluation of usability was administered purely in terms of the interface icons and operating the software. There was little consideration of the implications of usability features for the use of the programs to achieve educational goals. This opens a different perspective for the evaluation of the usability of the software.

The implications for classroom practice are important and clear. Teachers and assistants should be:

- *making informed decisions regarding the purchase of software;*
- *making explicit to the children the relationship between icon, name and function through a multiplicity of approaches;*
- *developing a child's visual literacy through the manipulation of images;*
- *developing a sense of enjoyment and satisfaction from success;*
- *exploiting the generalisations with other learning and developing those connections.*

For many children, the painting program is the first experience of using the computer to be creative. Up until this point they would have used content programs such as adventure games, reading materials and interactive multimedia. In the main, those programs guide the user and give them limited and contextualised choices. The painting program, like word processing and other generic programs, is different. The child starts with a blank screen and needs to make choices without any further prompt of context than the icons presented. They are dependent upon their own computer visual literacy.

The design of the painting interface is a metaphor based upon the palette and tool set. Its iconisation is not standard across all programs and one major

factor in its success in enabling children to use the program is the appropriateness of the pictorial representation.

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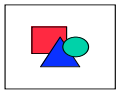
	Correct function describe	Icon described but not function	Function & icon not known	Alternative suggestions

Table 1.

Brush

Main tool for painting or drawing lines on paper. 	Visual recognition	46	3		3
	Visual recognition after one week	52			
	Recognition after practical exploration	52			
	Independent use during task	52			
Brush size Changes size of current tool and shows current colour. 					
	Visual recognition	4	10	16	22
	Visual recognition after one week	38		14	
	Recognition after practical exploration	33	9	10	
	Independent use during task	36			
Spray Creates a dotted spray effect. 					
	Visual recognition	7	9	20	16
	Visual recognition after one week	12	28	2	10
	Recognition after practical exploration	44	7	3	
	Independent use during task	45			
Fill Fills an enclosed area with colour. 					
	Visual recognition	9	27	6	8
	Visual recognition after one week	28	18	6	
	Recognition after practical exploration	52			
	Independent use during task	16			
Circle/Triangle/Line Enables shapes to be drawn. 					
	Visual recognition	50			2
	Visual recognition after one week	52			
	Recognition after practical exploration	52			
	Independent use during task	15			
Text Enables text to be painted onto the picture. 					
	Visual recognition	6	16	30	
	Visual recognition after one week	22		30	
	Recognition after practical exploration	10		42	
	Independent use during task	36			
Undo Cancels last mouse action. 					
	Visual recognition	2	6	44	
	Visual recognition after one week	16	14		22
	Recognition after practical exploration	17	26	9	
	Independent use during task	20			
Colour Bar/Palette					
Colours available for use by brush/spray/fill tools	Visual recognition	52			
	Visual recognition after one week	52			
	Recognition after practical exploration	52			
	Independent use during task	52			

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