Iconic Interfaces For Kids On The Internet

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Abstract

Use of the Internet, in particular searching the Internet, is becoming an essential part of school education at all levels. In particular, in the UK it is part of the National Curriculum, which must be taught to all children at state schools. However, for the youngest children text-based searches are difficult or impossible to use as the children are only starting to read and write fluently. For such children visual and iconic interfaces are essential. However, the metaphors and icons that are appropriate for adults are not necessarily easy for children to recognise and understand. This paper describes some of the issues that arose during the design of an iconic search tool aimed at children aged 5—6.

Keywords

primary education, Internet, search tools, iconic interface, metaphor

Introduction

The Internet is becoming an essential part of day-to-day life in many workplaces and in the home. It is thus important that children are introduced to the Internet and other information environments while at school. In the UK this is recognised in the National Curriculum. However, for young school children lack of reading skills makes conventional interfaces problematic. Graphical interfaces are thus needed, but this raises new problems as the metaphors and icons that are used for adults may not be suitable for younger children.

This paper discusses issues in the design of an iconic graphical search tool for children aged 5—6.

In the next section we look at some of the background to this area: the importance of the Internet in education and the specific interface needs of children. We then look briefly at a specific case study — the design of a search tool for a primary school in Birmingham, UK. In Section 4 we discuss the design model which drove this case study and in Section 5 the design process for the iconic interface. In particular we will discuss the problems faced by children in understanding common icons. Finally we discuss some of the lessons we have learnt from this case study.

Background

The Internet

The Internet has become an invaluable resource for educators and researchers in higher education. This is partly due to the mass of information available, but as important has been the consistent and easily learned interface to that information through web browsers.

Increasingly the Internet is being used in schools both at secondary and primary level offering tremendous educational potential. The Internet acts as a resource base for any style of learning. In addition, it provides unique opportunities for enquiry-based learning where children and teachers can network, study, and collaborate with others around the world, and freely access global information.

However, the promise of the Internet for education can only be fulfilled if it is easy to learn and use. Whereas the browser interface, which has proved so successful, is acceptable for older school pupils, there are real problems for young and pre-school children. This will be a major block to large-scale acceptance by primary schools (ages seven and under).

Interface For Kids

Although interface design is a well supported concept in the literature on adult computer products, not until recently have publications begun to appear addressing the design of children's computer products [9]. Examples of research work on children's interfaces include guidelines for usability testing with children [9], various forms of collaborative design [5,6,11] and reports from various CHI kids programs since 1996. Beyond those works we have found little research in iconic interfacing for children on the Internet, despite its increasing use.

Modern Kids Must Be Internet-Literate

To be successful, children of today and future workers of tomorrow, must be able to use the Internet. They need it not only for school work, but for business or work in the adult world. Currently over 60% of the jobs in the USA require computer and information literate employees able to use some type of network to do their jobs [14]. Competencies that almost all workers need in the work force include the ability to:

(1) acquire and evaluate information;
(2) organise and maintain information;
(3) interpret and communicate information;
(4) use a computer to process information

According to Rakes [14], the acquisition of information literacy then becomes a paramount educational issue. Consequently the Internet has become a central component of today's educational system. Both the American and British governments have urged industry to help schools to be connected to the Information Superhighway.

The U.K. National Curriculum

British educational policies for schools require that pupils should be given opportunities, where appropriate, to develop and apply their Information Technology (IT) across their studies. This is a strong, regulated requirement. Within the UK all publicly funded schools must adhere to the National Curriculum which specifies both the content of the curriculum and the expected levels of attainment at different ages. The National Curriculum is organised by 'Keystages', which roughly correspond to school stages. We are focusing on children in Keystage 1 (ages 5-7).

According to the National Curriculum, Keystage 1 pupils should be given the opportunity to use a variety of IT equipment and software and to carry out a variety of functions in a range of contexts. They should be taught to use IT to supplement their problem-solving, recording and expressive work. To examine and discuss their experience of IT, and look at the uses of IT in the outside world.

pupils should be taught to generate and communicate their ideas in different forms, using text, tables, pictures and sound; to enter and store information; to retrieve, process and display information that has been stored.

Despite the positive attitudes of teachers toward the use of the Internet to achieve the above objectives, many teachers from primary schools express grave concern about its use. The main concerns are that the interface of the Internet, in particular its search facilities, is not suitable for younger children. Primary school teachers would like to have a more user-friendly front end to the search engines and also a repository which is easy to use to store their frequently used and updated information. Without these tools, many felt that teachers would not be able to integrate the Internet into their curriculum. If the teachers are to achieve the National Curriculum requirements, they must be provided with the tools that can help them to use technology effectively.

Iconic Interfaces

The children in the age group we are focussing on are just learning to read. Because of this, text-orientated interfaces are not suitable. There is a vast literature on the design of iconic interfaces and the accompanying metaphors. We will review some of this literature before going on to describe our own experiences.

For a system to be usable, the user (the child in our case) must develop a mental model or a conceptual understanding of how the system works. Research by Norman [12] and others indicates that users' mental models play a key role in helping them use systems intelligently and efficiently [15]. Ideally, the mental model should completely map onto the design model (the conceptualisation of the system held by the designer) [12] so that users are able to use the system's full capability as intended by the designer. In order to be easy-to-use and easy-to-learn, the Internet interface should be consistent with the user's mental models [4]. The mental model must be built by analogy, drawing on existing knowledge, that is, by using metaphors.

The importance of metaphors lies in their ability to initiate cognitive transfer from one (familiar) knowledge domain to another less familiar one [16]. The overall impact of metaphors used in iconic interfaces can be twofold. First, metaphors can play a part in the development of a functional specification. Metaphor usage should be made explicit at the design stage of application development so that the maximum benefits can be attained and functions can be identified for which icons are required. Second, metaphors can assist interface design by providing ideas for individual icon designs, cues for the recognition of iconic symbolism, and a framework in which users can identify the functional meanings of icons.

Icons are increasingly used in interfaces because they are compact universal pictographic representations of computer functionality and processing and exploit the graphical ability of the computer. Many of the advantages of iconic interfaces are summarised by Gittens [7] including: inference and mapping,; error reduction; metaphor; common attributes; object orientation; direct manipulation; and display space. The design of effective iconic interfaces, however, is problematic. The disadvantages of iconic interfaces arise mainly from difficulties in implementation, rather than any inherent properties of icons. For example, it is difficult to design icons to convey the desired meaning without invoking other connotations. Whilst an icon may be worth a thousand words, it is not always the particular thousand words the designer has in mind. The interpretation of a user and the intent of the designer may be quite different [2]. The ambiguity in meaning arises because there is no universal set of icons or principles to guide iconic design [10].

Another problem associated with iconic interfaces is the use of the metaphor itself. Whilst facilitating user learning and recall, it can also have dysfunctional consequences [8]. The user may infer unintended aspects of the metaphor leading to confusion and error.

Case Study - the design of a Kids Internet Search Tool

Given the growing, but still relatively sparse theoretical knowledge about kids interface we are

	Internal	External
System	Functionality	Interface Constraints
User	Metaphors	Icons

Figure 1. The Design Matrix

basing our own on a case study. Several teachers from primary schools were interviewed to identify the type of tools they need. The survey revealed that the primary school teachers would like to have a front end user interface which is icon based so that young children who cannot read and write well can search the Internet, even if it is only for pictures. For example, if the class were doing a topic on animals, instead of typing in the sort of animal they wish to look for, they would simply click on an icon of that animal. It would also be useful if the teacher could change the icon depending on the topic they were doing. Following extensive discussions with the teachers, it was decided to develop a Children's Internet Front End for use by children aged between 5—6 years.

Subsequent sections of this paper describe aspects of the design and development of the Internet interface for children of age 5—6 years at a primary school in Birmingham, U.K. Essentially, the Internet interface was designed to provide the children with a functional, if incomplete cognitive model of the learning task, the content or domain material, and the procedures or processes that can be explored and tested to realise the task(s). According to the National Curriculum, the domain identified for the children at the school are:

- to search for animals;
- to listen to different types of music;
- to chat with another person on the Web;
- to write letters to a scientist;
- to e-mail others about the project.

The Design Model

We have adopted a two-dimensional framework to understand the stages during design, as illustrated in Figure 1. This reflects the external constraints and influences on the system and user, both from each other and the surrounding context.

Functionality

First of all the system must have appropriate internal functionality — what the system must do. This is partly found through conducting a requirements analysis.

The school introduced the Internet for the children as part of the National Curriculum. Internet lessons are typically conducted in groups, the main reason being that the children are too young to perform Internet searches on their own. Because these children are too young to spell or type well, they are taught to generate and communicate their ideas using pictures and sound which they can retrieve from the Internet or from a repository arranged by the teacher. Often the children have no idea what is going on during the search process and are frequently getting lost. The teacher had to constantly get them to focus on what they were doing. Teachers also had to find the right information (pictures and sound) for the children to use. Thus, the purposes of the search tool were:

- to be easy for children to use;
- to enable the children to understand and learn how to search for topics;
- to support the National Curriculum;
- to reduce teacher intervention due to the children s inability to spell;
- to motivate children to learn.

Our main goal in the design of the interface for the Internet is for children to have the interface positively support their endeavour and never intrude adversely. The interface should be transparent to the task the children are trying to accomplish, and be efficient, satisfying, and fun to use. The new interface should resemble something familiar to help the children to get started, and be intuitive and engaging to encourage them to explore new concepts. The concept of undertaking a learning program for its own sake is paramount in the Internet use. Ideally the children should experience an intrinsic desire to engage in the tasks or activities of the program.

There is also an element of interface design as the way the functionality is structured can be chosen so as to fit the users' expected mental models. Together, the content and structure of the functionality give the internal system model. In the case of UK Keystage 1 children, the former is determined largely by National Curriculum requirements influenced by the pedagogic situation of the classroom. The latter requires an understanding of children's own mental models.

Mental model and metaphor

The mental model a child will use in a given environment is considered next. The first step in the design process is to identify and assess these models through familiarity with the children's background or by interviewing the children. The model of the target, (roughly what the teacher expects as outcome), must connect with the mental model in order to be internalised [3]. In theory, a learner (child) will apply some mental model to the target in order to interpret it. It is the goal of the designer to seek a target that matches with the mental model, thus facilitating learning. For example, take a target of teaching children the use of e-mail on the Internet to send letters to their friends using the computer. If we realise the children's mental model of using the Internet is conceptualised as using the postal service, it might facilitate learning to focus on writing mails before introducing pointing and clicking to open and send letters. The children's ability to apply a previously held mental model to the target will enhance

(i) (ii) (iii) (iv)

Figure 3. . Clip-art icons for 'watch a movie'

the incorporation of new knowledge, in this case the importance of the commands to send e-mail.

Users always have some mental model of the system using a variety of metaphors and analogies. Of course, the metaphors suitable for adults may not be appropriate for young children and one of our main challenges is discovering useful metaphors that can be used to help children understand the underlying functionality and also help shape its structure.

The primary goal of our design is to create and support an appropriate and coherent mental model of the operations and organisation of the computer system. Successful interface metaphors should be simple systems that do not require the children to learn and remember many rules and procedures. The metaphors should also draw heavily on the children's knowledge of the world around them, and in established connotations that allow them to predict the results of their action in advance [12].

Constraints

We do not have absolute design freedom in mapping between this internal image and its external appearance. The context of use puts constraints on the kind of interface which is acceptable. In typical 'adult' applications this may include physical constraints due, for example, to needing hands-free interaction in a jet fighter. For 5 and 6 year olds we have different, but equally compelling constraints, reading may be difficult, thus demanding an iconic interface of a purity seldom seen in adult interfaces. In addition, still developing hand-eye co-ordination may not allow fine selection, implying relatively large icons.

Icon design

The icons which are chosen to represent the metaphors must be closely tied to the mental model of the children. We must develop icons that actually look like familiar objects to which the children can relate. The conceptual model thus provides a context in which children are aided in interpreting the icons in the Internet interface. Relationships between icons and their referents must be clear because their functions are directly analogous to the functions performed on physical objects found in real life, and the icons resemble those objects.

The fact that the icons are tightly coupled to the conceptual model reduces the range of possible interpretation and confusion and helps to make their functions easier to understand and predict.

Finally, we have the externalisation of that metaphor in the design of icons, screen layout and interactive behaviour. On the one hand this icon design is driven by the chosen interface metaphor. However, it also influences it. If a metaphor, however compelling, has no simple iconic mapping it will not be useful. Furthermore, there are always many possible metaphors compatible with parts of a given system, but some of these may lead the user astray in more complex use. Choosing the right icons can suggest appropriate metaphors and discourage others. As we shall see, this choice is by no means straightforward when we consider Keystage 1 children.

Design Process

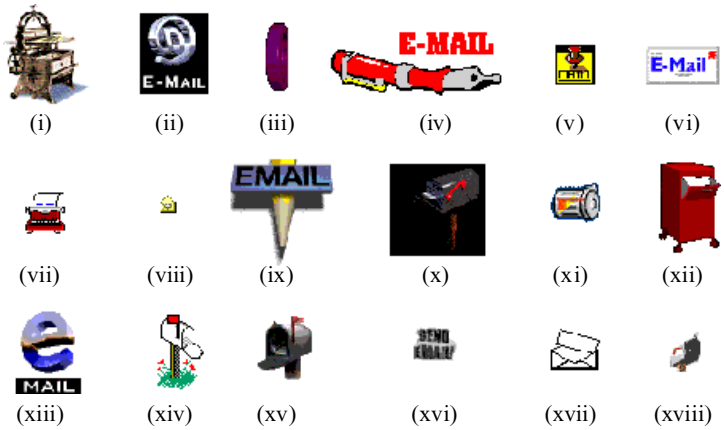
As there is limited literature on the design of effective icons for children, a simple version of the design process recommended by Lodding (1983) was initially adopted. This process consists of three phases: (1) stating the message, (2) rendering the design, and (3) testing the resulting icon.

Stating the message

We will examine what constitutes a meaningful icon before determining the appropriate one to use. According to Preece (1996), there are several factors that determine the meaningfulness of icons. These include the *context* in which the icon is used; the *function* for which it is being used; the surface *form of representation*; and the nature of the *underlying concept* that is being represented. We concur with Preece the importance of context, function, and underlying concept in determining the meaningfulness of an icon, the representational form plays a critical role in our iconic interfaces for children. The extent to which the meaning of an icon can be understood depends on how it is represented. Because of the different representational forms used to depict icons, they are classified into different categories by different researchers (Gittens 1986). Space does not permit a detailed review here. However, it is worth recalling some of the major distinctions. First, icons are often categorised by their metaphoric qualities:

- **representational icons** — a "typical" example of a general class of objects (e.g. knife and fork to represent a restaurant)
- **abstract icons** — representing a concept at a higher level of abstraction than the image itself. (e.g. cracked wine glass to convey 'fragility')
- **arbitrary icons** — bearing no relation to the underlying concept (e.g. the international radiation warning sign)

Another important distinction is between static icons and dynamic (or animated) icons. Animated icons are a recent development aimed at 'bringing icons to life' Baecker, Small & Mandler (1991). It is suggested that



(i) (ii) (iii) (iv) (v) (vi)

(vii) (viii) (ix) (x) (xi) (xii)

(xiii) (xiv) (xv) (xvi) (xvii) (xviii)

Figure 2. Clip-art icons for e-mail

animated icons should be easier to recall and be more meaningful.

Instinctively, one would think that concrete and animated icons would be most meaningful and engaging for young children.

Three pieces of information are required to ensure the successful interpretation of icons: the caption, the context, and the image. The caption is the message - what is to be communicated. For our examples we want to have icons for sending electronic mail and for watching a movie. Next we should consider the context in which the message will appear. Here the question is, 'How distinct is the message?' Both message and context in which the icon will be used must be well defined prior to attempting the design of the icons. The next, and most difficult part of the process, is choosing the design style for the image. We chose to use both static and animated icons for both tasks and the category chosen was the representational icon.

Rendering the design

Several icons were taken from existing clipart and icon catalogues to represent both e-mail and watching a movie. The aim was to make the characteristics and drawing of the icons as simple and distinctive as possible. The choice was based on previous discussions with the children.

Ideally, icons would be designed afresh for each application. However, limited budgets, time and artistic talent all mean that icons are often drawn from standard icon sets and clip art.

Testing the icons

The icons were given to several different groups of children to evaluate. The subjects involved in the evaluation were children from Keystage 1 who had not seen the icons before. The aim of this stage was to test the comprehensibility of the various icon variants developed for the two functions: sending e-mail and watching a movie.

Figure 2 shows a collection of icons drawn from standard sources for sending e-mail. Similarly, a collection of icons drawn from standard sources for watching a movie is shown in Figure 3.

Some were animated, all were in colour. Indeed, one of the early lessons we learnt was that black and white icons were very hard for children to recognise and were certainly disliked.

Subjects were asked to answer two major questions; the first being, "What do think this is a picture of?" The second question was, "What would you expect this to be used for?" Both of these questions were asked because some subjects may recognise what the icon depicts, but have no idea what they could be used for. The icons were ranked based on their responses.

The children s preferred icons are boxed, (2.xvii) for e-mail and (3.ii) for watching a movie.

For both email and watching a movie, the animated icons were correctly recognised by all subjects. Many of the static icons were incorrectly recognised.

Although some are a little obscure even for an adult, for example (2.i) is an old printing press and (2.xi) which is a form of US mailbox (which does look more recognisable in full colour). Putting yourself into a 5-year-old child's position virtually all are meaningless.

The first thing to notice is that many of the e-mail icons in Figure 2. depend largely or solely on linguistic cues. Icons (2.x), (xiii) and (xvi) have only text and (2.ii) and (iii) depend on recognising the '@' sign as referring to e-mail ((2.iii) is a rotating animated icon caught side-on in the still). Both (2.v) and (vi) have visual images (pin-board memo and letter), but the text is dominant. These are all but meaningless for young children (until 'e-mail' is in first reading books!).

Second another group of the e-mail icons, (2.x) through (xv), use specific US images of mailboxes. These are recognisable to older children and adults in the UK from films and television (although icon (2.xii) causes some problems!). However, for younger children these are again virtually meaningless. Although there is a lot of concern in the HCI community about cultural

issues in interface design, the global nature of mass-media means that adult users will recognise many US and 'mid-Atlantic' images. Children are a far more discerning and demanding design audience.

Another group of icons are reasonably specific, but decidedly old fashioned, even quaint. In the e-mail group we have an old hand printing press (2.i), a fountain pen (2.iv) and an antique manual typewriter (2.vii). How many 5-year-old children would recognise the old typewriter or even the fountain pen? In the movie collection, both cameras/projectors, (3.ii) and (3.iv) are of the large external cine/celluloid film variety, rather than video or TV cameras, which are more likely to have been seen by small children. Even the television set (3.ii) has a small aerial on top and splayed legs, both unusual in any television in the last 20 years. Possibly UK children may recognise these clues purely because of the popularity of Teletubbies.

Why the preponderance of old-fashioned images? A secret longing for the age of innocence before computers? In fact, if you start to imagine icons based on more modern designs, the reason becomes obvious. Think of an icon of a modern television, a computer screen, a typewriter, an electric organ, a video camera, a telephone. All are either simple boxes, boxes with screens, or boxes with buttons on. It is rather like the tales of the family with a new kitchen who have lost the washing machine and have to open every door in turn. Yes there are differences between these appliances, but when reduced to a 32x32 icon not much survives. In contrast, older devices betray their mechanics in their shape, the typewriter surrounding its arc of type-hammers, the dial and handset of an old telephone and of course the reels of celluloid film. Even a biro is far less defined than a fountain pen.

So, old icons are likely to be most visually distinctive, but may not be recognised by 5 year olds (in some cases, possibly even under 30s). On the other hand, these same images are often found in cartoons and magazines and so it is not simply a matter of 'old equals difficult'.

Finally, note that several of the icons refer to parts of a process that may not be recognised by younger children. Icon (3.i) shows a piece of celluloid film, (3.ii) shows the act of filming and (3.iv) shows a projector, which is usually hidden in a cinema. In the e-mail images (2.vi) focuses on the writing of a letter with a typewriter, unusual outside an office, and the pin-board memo is also more likely to be seen in an office environment. Again, it may be that children have been exposed to some of these processes and images via picture books, magazines or television, but children are far less likely to make these quite complex process leaps between icon and meaning.

Having gone through these factors, it is fairly obvious why most of the icons are not chosen! Indeed, looking at the e-mail icons, only (2.vi), (viii) and (xvii) are even candidates and given (2.viii) is very small and (2.vi) is largely obscured by the big letters 'E-mail' it is not surprising that (2.xvii) is the preferred option. This is further re-enforced by the fact that this icon is animated, which both makes it easier to recognise and also makes it more attractive to children.

The choice for watching a movie is less obvious. Given the above discussion the most likely option for directness of representation and relevance to the children's day-to-day life is the television set (3.iii). However, the children found (3.ii) a clearer indication of function. The fact that it is animated and colourful again heavily influence this choice, but these would not be enough if the image was not also recognisable. Possibly, the 'cameraman' image is used frequently enough in children's media for it to be recognised.

Whereas it is clear that some of these icons are totally incomprehensible from a 5-year-old's perspective, the last example shows that we cannot do without quite extensive user testing with children.

What We Have Learnt

Design of the Iconic Interface

Although icon choice is far from simple, the children from Keystage 1 prefer an iconic interface because they found it easy to use. All of the children liked the animations and recognised the icons' functions and meanings. They preferred the animated icons because they could identify the conceptual models used by the animated icons for the concepts represented. The animated icons were also preferred because the children found animated icons can demonstrate function as well as answering the "what can I do with this?" question. The children also found that the interface was stimulating, interesting, and captured their imagination. They all had a clear indication of what the icons meant. Our observation of the children's interaction during evaluation showed that the children liked to see the animations and reported they found them very useful. Their enthusiasm was much in evidence when they saw another screen pop up which showed an animated picture of the process of fetching the information. It was encouraging to see the joy and fun expressed by children using the Internet.

The teacher commented "I am very pleased with the software. It will certainly help the children and encourage them to use and search the Internet, but I also feel that teachers will feel confident in allowing them to do so because of the ease of use and the control the teachers have over it."

Broader Lessons

We have learned many valuable lessons from our research work. Designing a user-friendly information search tool for children is not a trivial task. It involves understanding the mental models of the children. We thought we understood them when we talked with them, but our mental models were very often not the same as theirs, which resulted in a mismatch between the conceptual model and their mental models. This mismatch caused great difficulty for them in being able

to recognise the icons correctly. Children are experts at being kids. They could not offer us a list of what they wanted to see or use because they are not that self-aware or articulate about their needs.

Although the nature of children is that they are dependent on others, they are empowered when they feel in control of their environment and when they feel they 'own' the environment. Our research has shown us that children make decisions about what they like or dislike, and what they want to do. If our conceptual models of the target system do not match their mental models, it is difficult to force them to accept our models. In our research we also saw that when the interface offered them limited paths of interaction the children quickly became bored and uninterested. When the interface offered options for varied interaction, such as icons only animated when a mouse placed on them was being clicked, the children spent a considerable amount of time exploring and actively engaged. Another thing we observed about our children was that they love to draw and design icons for themselves. They did not take too kindly to accepting the drawings made by us. They wanted to tell us how they thought the drawings should look even though they were unable to draw them themselves. They appeared to expect us to read their thoughts and produce what they wanted. We found this demand hard to meet because apart of not being mind-readers, none of us are artists who could visualise their requests. This was frustrating as we had to repeatedly reiterate the design and modify the drawings.

We found that children want to learn things very quickly. If they have to struggle to learn, they have little patience with the subject. Conversely, if it is easy to learn they will quickly become motivated and keen to use the interface. When something is meaningful to them, they can be kept amused for a long time.

Because the children are growing up in a multimedia environment, with modern technologies such as video games, TV, movies, etc., they expected the interface to be interactive and animated. They preferred animated icons to static ones because animated icons bring to life symbols representing complete applications or functions within an application.

Finally, we have learned a lot from the children by working with them., From our research, we found that if we want to develop an effective interface which supports children in searching for information on the Internet, we must listen to what they have to say and want to do. We must understand their mental models. Without this understanding, it is very doubtful that we would ever be able to develop interfaces which would help them to learn the Internet effectively. By understanding the children and their mental models, we can learn a great deal about their playfulness, enthusiasm and the types of metaphors to include in the interface. We must never underestimate the children's intelligence. They may want the same things as adults, but they have different understandings and concepts from us. We must endeavour to unravel their mental models to design better interfaces for them.

Conclusion

Children in schools are increasingly using the Internet to search for information to use in their school work. Although web browsers enable users to search for information easily, the interface is not well suited to children who have limited reading and spelling abilities. To overcome this, a graphic interface is needed. The design of an effective iconic interface is not a simple task. We must understand the mental models of the children so that appropriate icons can be developed.

From our studies we have seen how the icons and metaphors used in systems often depend on a large amount of background knowledge and cultural context. They may also be divorced from the physical thing they represent depending on knowledge of related items and processes. Children lack the experience from primary and secondary sources needed to interpret these images. However, in this they may reflect broader cultural issues that are missed by many studies.

As expected we found that children preferred animated icons because these icons 'come alive' when the mouse is placed over them and clicked.

The lack of visual distinction of contemporary artefacts was an unexpected problem. Children again highlight an issue which may become increasingly problematic for all users.

Despite their lack of knowledge, we found that children are empowered when they are in control of their environment. They know what they like and want. They loved assisting us in our design and expected us to understand their insights. When the interface matched their mental models they were motivated to use the Internet and actually enjoyed using it. We have learned never to under estimate the children's abilities in knowing what they like.

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