

Screen design for children's reading: some key issues

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ABSTRACT

This paper draws attention to design issues that are likely to affect the way that children interact with screen-based information texts. It is based on the findings of the *Interactive Multimedia in Primary Schools* (IMPS) project funded by the British Library, carried out at The University of Reading. The paper summarises the design-related aspects of the project, highlighting those issues that relate to access, navigation and typography. It draws together observations from teachers and children based on tape-recorded interviews and video recordings, and research from the fields of human computer interaction, information design and education.

INTRODUCTION

Reading from computer screens is part of daily life in primary classrooms. This paper draws attention to design issues that are likely to influence the way in which children use interactive multimedia. The principal concern here is with screen design from two perspectives: interaction with the interface, and the visual appearance of the interface. The findings are based on a project entitled *Interactive Multimedia in Primary Schools* (IMPS), funded by the British Library at The University of Reading (see Walker, Reynolds and Edwards, 1999). An important part of this project was to consider how aspects of screen design affect children's use and understanding of information. In addition, we wanted to find out what concerned teachers regarding issues such as classroom management and curriculum integration, and what kinds of design features might be helpful to them and the children they teach.

The IMPS project has provided a considerable amount of information about children and teachers using interactive multi-media in class. This includes: expectations and fears; video evidence of children's excursions through large amounts of data; strategies that inexperienced teacher-users of CD-ROM adopted to make sure that children stayed 'on task' when using information-based CD-ROMs; and aspects

of visual interface design that children thought to be confusing. This information has drawn our attention to aspects of classroom management and screen design that are likely to be important for the successful use of CD-ROM within the primary classroom.

METHOD

The project took a case-study approach in an attempt to discover how individual cases can help us understand wider issues (Hammersley and Atkinson 1995). It involved a long-term relationship with two primary schools in the Reading area of southern England. The first was a multi-cultural inner-city school with no previous experience of using interactive multimedia, although the children were familiar with computers in school for some learning activities such as word-processing and mathematics. The second school was located on the outskirts of Reading and had used CD-ROM based texts for some years. In both schools we concentrated on children at the upper end of Key Stage 2, i.e. those aged 10–12 years. One of the constraints we adopted in the project was to fit in with the programme of work being followed in the schools. This meant we targeted particular topics from those aspects of the curriculum that teachers felt would be most beneficial to the children learning from CD-ROM. Electricity and magnetism, the solar system, forces, and different religious faiths were four areas that teachers in the schools identified. We provided the schools with CD-ROMs that covered these topics, and used these as the basis for our observations. Classroom observation was carried out in two ways: semi-structured interviews with children and teachers, and video-recordings of children working with information texts on CD-ROM.

The project brought together information from a number of sources: children; teachers; research in the fields of human computer interaction (HCI), information design and education; and expert opinion. The value of user opinion and feedback is essential to any effective design. Until relatively recently, however, the views of teachers and children have rarely been sought as part of the design process for information texts for children, either on paper or on screen (Walker 1992; Scaife, Rogers, Aldrich and Davies, 1997). It is also the case that research in the area of interactive multimedia tends to be carried out from a number of different perspectives, often with little overlap. One of the intentions of the IMPS project was to take as a starting point the likely needs of teachers and designers, and trawl several subject domains for relevant material. The IMPS research team included a typographer, a specialist in language and education, a psychologist, and an educationalist interested in the teaching of science. The interdisciplinary nature of this team further enhanced our ability to look at the use of interactive multimedia from a number of perspectives: education, HCI, and visual design on screens.

RESULTS

Access and navigation

Access to the information available on a particular CD should be considered in relation to the level of cognitive interactivity taking place, rather than in terms of the

level of physical activity at the interface, i.e. button presses and mouse clicks (cf. Aldrich, Rogers and Scaife, 1998). The most effective interaction, in terms of children getting where they needed to be in order to find the information they required, was found to combine navigational cues with questions relating to content.

In the IMPS project it was evident that children could easily become lost in CD-ROMs that allowed them to access information by many different routes. One of the main concerns of teachers in our project was that children 'lost their way' in the program:

'I got the feeling they just didn't know where they were. I vaguely remember watching them on video early on, and they seemed a little bemused by it all as it just kept on unfolding and unfolding and unfolding and they didn't have a strategy for getting back.'

This kind of uncertainty is confirmed by Kobayashi, Sasaki and Takeya (1997) who point out that the learner will want to ask the following questions:

- Where am I?
- Where do I want to go?
- How do I get there?

There is some evidence to suggest that navigation aids, such as network maps, guided tours and help facilities are likely to be helpful (see Park and Hannafin, 1993; Koller and Wöhr, 1997; Plowman, 1996).

In our interviews with children, several said that they liked being in control, and some felt that screens that were visually complex, or that provided many opportunities for interactivity, reduced their control. One of the teachers we spoke with commented that she found she had to put time limits on some of the tasks she set, in order to encourage the children to focus on the task in hand. This supports other observations that have been made. A number of authors have pointed out that while hypermedia and similar structures can allow the learner to explore the information in their own way and at their own pace, this degree of freedom is not appropriate for all applications and all users (Lowe, 1992; Kobayashi, Sasaki and Takeya, 1997). Although users like the control that they are given, they do not always choose the best paths to the information they require. However, according to Oliver and Perzyló (1994), it is likely that students can be taught to become better users of hypermedia environments.

Referring to information resources, Laurillard (1995) points out that while a multimedia database may be a wonderful tool for an expert scholar, it is not necessarily as useful for the learner. The learner expects to have control, but does not necessarily know enough to benefit from full control. Learners who are unfamiliar with the subject domain and with the multimedia environment cannot be expected to set appropriate goals or plot a reasonable path. They are likely to under-specify the problem, be distracted by irrelevancies, be unsure how to evaluate the information they find, over-generalise from specific instances, be unaware of incompleteness, or fail to recognise inconsistencies (Laurillard, 1995). Teacher input will be needed in the form of preparation, supervision and de-briefing (Kobayashi, Sasaki and Takeya, 1997; Oliver and Oliver, 1996). This observation was confirmed in the IMPS project – by one teacher who found it particularly helpful to have large group sessions that

introduced pupils to computer conventions and procedures, and by another who found that her most effective worksheets were those that combined navigational prompts with those about content.

Searching and retrieving

There have been a number of studies that have investigated the effectiveness of a range of tools for searching and retrieving, but few involving children (e.g. Simpson and McKnight, 1990; Fasick, 1992, cited in Oliver and Perzylo, 1994; Banet, 1995). In the IMPS project, finding their way around the information was difficult for some children, and one of the issues that concerned teachers most. Indexes, menus, key words and icons were all encountered in the software used by the children in the project. There is a need to learn new research skills in order to make the best use of CD-ROM products, but there is also a need for competence in skills that are applicable to both books and CD-ROMs. Cockerton and Shimell (1997), following a study of Year 7 children using a hypermedia history program, commented that:

'... skills which are assumed to be learnt by children using the paper medium (e.g. using contents pages and indexes) are taken for granted and should be made more explicit by those concerned with improving children's literacy skills.' (p. 144)

Oliver and Oliver (1996) noted that 12-year-old children's previous levels of computer experience and computer confidence affected the range of search options and features that they chose to use. The more experienced children also tended to experiment more and to devise short cuts, while others tended to continue to re-apply a strategy that had worked before.

Some children in our study showed a reluctance to use indexes, hoping to find what they wanted by browsing or by systematically working their way through a body of information. In part, this reluctance may be due to uncertainty about the alphabetical search task itself, but it may also be related to the way in which the alphabet is presented. There is evidence that alphabetical lists can be difficult for novice users, especially when indexes use bands such as D–J and S–V (Fasick, 1992, cited in Oliver and Perzylo 1994). In other instances, though, children in our study were frustrated by the presentation of the index. A 'Who's Who' section in one of the CDs we studied opens with an array of lettered tiles from which the child must select the required letter. This caused no difficulties. The next screen is an array of pictures of scientists whose names begin with that letter or subsequent letters. If there are no names under the letter the child has chosen, then the array begins at the next letter that does have names under it. Selecting S, for example, gives an array of scientists whose names begin with R, T, V or W. This did cause confusion. The children assumed that there was information under S but for some reason they couldn't get at it. The fact that there was no information under some letters needed to be made explicit.

Icons and symbols

The research evidence on the value of icons is conflicting (Shirk and Smith, 1994). Some researchers have concluded that there are no advantages associated with iconic

representations compared to text-based representations of objects and actions, while others have found that icons lead to faster decision-making than textual representation. However, there is also evidence that users have a preference for icons, even though their performance may be no better or worse than with text labels. Others have found that a combination of icons and text labels provided the greatest accuracy (Benbasat and Todd, 1993). Feifer and Tazbaz (1997) argue that, ideally, icons should be non-ambiguous without text labels, and that if a text label is used it should merely confirm what the user already thinks the icon will do. These authors maintain that if no suitable icon exists for an action, plain text would be preferable. Lee (1996) provides a helpful list of recommendations for the design of icons in instructional materials. Shirk and Smith (1994) conclude that:

- successful icons are inherently stereotypical and metaphoric of the procedures they represent;
- there is a trade-off between an icon's simplicity and ambiguity; and
- activating an icon causes a transition from one state of affairs to another; communicating what the new state of affairs will be is critical to the success of the icon.

All the CDs we looked at in the project used icons as one means of navigation, though there was very little consistency in their form, location or shape. Analysis of our video data showed that the icons used on some CDs were ambiguous and caused difficulties for the children. In some instances they caused children to move to another part of the database when they had not intended to, and in others the lack of understanding meant that they could not work out how to do what they wanted.

In one of the CDs (about different religious faiths), one pair of children had difficulty with a 'Compare' facility because they could not work out how to select a second religion to compare with the first. A 'Religions' icon is clearly displayed above the blank half of the screen, but beneath it is the word 'Unselected', meaning that the second religion has not yet been selected. The children may have taken this to mean that the icon was inoperative, but whatever the reason, the icon had to be pointed out to them twice before they were persuaded to try it. They wasted about 5 minutes on this. A more explicit caption, such as 'Click here to choose a religion to compare', would have been more helpful. This kind of confusion occurs because sometimes the icon provides no immediate clue to the action. It has been suggested that icons are most useful when they represent concrete rather than abstract actions, but this places severe limitations on their use. It has also been suggested that they may be more appropriate for experienced users. Dillon (1992) concludes that icons are particularly useful for simple or repetitive actions but are less suitable for conveying information on abstract actions.

Layout of text on screen

One of the main focuses of the IMPS project was the visual design of the interface; in particular, issues to do with the presentation of text. The way in which the text is graphically structured (either on paper or on screen) was thought to be important by the teachers in our study:

'... as with a good reference book, the text and the information should be arranged in such a way that it is accessible to all: where there are pictures, where

the text is broken up, where there are headings, sub-headings, small chunks of text going with pictures, perhaps in larger print.'

One part of the project involved describing the typography used on the screens in order to see whether any norms or conventions are beginning to be established. Most of the CDs in our core set of CDs (those that related to the curriculum areas being followed in the schools) displayed text in two or more sizes within a larger window. Some screens maintained common areas for text and picture; on others it depended on the levels of information being accessed. On some the text was presented in a more complex form using boxed frames, unframed text wrapped round a related image, unframed text in two half-page columns, unframed comments on images, and labels for images.

Treatment of headings

The treatment of headings was varied. Most, but not all, main headings were in a larger type size than the text; all were emboldened, except for an example in which the main headings were in capitals; all had extra space above and/or below them. Some were in colour, usually blue. Where subordinate headings occurred they tended to be in the same type size as the text. A number of different methods were used to distinguish them from the text, including extra space above and/or below, use of bold type, or out-denting. Although headings were shown in a variety of different ways, this is also true of the treatment of headings in books, so there is no reason to believe that the children were confused by this.

Treatment of paragraphs

In our survey, most paragraphs were set full-out with space between them ranging from 17–39 pixels; only one of our sample had indented paragraphs and one was organised so that there was only ever one block of text on screen at any one time. The options chosen by designers were inconsistent and arbitrary. Although on paper we are used to different ways of presenting paragraphs, our choices are often restricted by convention or driven by what we know to be helpful to readers. For example, in books and some other publications, by convention the first paragraph of a chapter or section is set fully left-justified, whereas subsequent paragraphs have only the first line indented. Another example is that instructional material is typically presented in chunks, perhaps numbered.

Research with children using printed materials suggests that either a line space with no indent, or an indent with no line space, are likely to be equally suitable. A new line with no indent and no space is likely to be less effective (Hartley, Burnhill and Davis, 1978). Quoted matter was denoted by being in italic, or by being enclosed in double or single quotation marks. Children would be familiar with these conventions in printed books.

Treatment of keywords, or 'hot spots'

Most of the children we spoke with and observed were familiar with the notion of clicking on a coloured word or words to find more information: '*... nearly all the*

programs have key highlighted words you can click on to find out about loads of specific things.' The use of highlighted words was a common feature in the CDs in our survey. There was no consistency in the way colour was used or the colours chosen: such words were shown either by a grey background or by being coloured green, dark blue, blue or red.

Type size

From the reader's point of view, the most important things are the x-height and the capital height of the type as it appears on the screen. However, these will depend not only on the point size specified by the developer, but also on the resolution of the screen. Furthermore, the user may have the option of displaying the type in an enlarged size, and the user's system may even use a substitute typeface if the one specified by the developer is not available. This makes it difficult to identify the sizes specified by the developer of any given CD-ROM, and to recommend an optimum type size. To allow comparison of the type sizes used on the CD-ROMs in this study, we measured the capital height and x-height in pixels. There was considerable variation in the sizes used, and some typefaces had more differentiation between x-height and capital height than others. It could well be that this is a typeface feature that is important for children. When there is a greater rather than a lesser differentiation between capital height and x-height, ascenders tend to be long; this may help to enhance the shape of the top half of the word, which is important for legibility (see Walker, 1992). Few teachers commented on the type sizes and faces they read, and, when they did, it was in such a way that suggested they did not have a vocabulary for doing so: they used terms such as 'clear writing' and 'slightly blurry text'. The children were rather more explicit: one pair felt that 'the letters should be bold enough to see, and not too small'.

Typeface

More sans serif than serif typefaces were used in the CD-ROMs that we surveyed. In some cases the user could select from a number of typefaces. In general, however, the typefaces used were versions of those designed for use in printed material. The legibility of such typefaces on screen depends on how well they are rasterised (i.e. converted from digital form to a pattern of scanning lines on the screen), in combination with how well character, word and line spacing are managed by an application. Kahn and Lenk (1993) considered that at the time of writing there were very few fonts with reasonable character bitmaps and inter-character spacing.

Kahn and Lenk (1993) suggest the main difficulty is that at screen resolutions of 72 dpi there are not enough pixels to represent well the letter forms in 9 or 10 point type. (A resolution of 72 dpi is the standard system default for Macintosh computers, and for web-based applications; the default for Microsoft *Windows* is 96 dpi.). Bigelow (1985) argues that the only solution is to 'design screen fonts within the limitations of the available raster system, to optimise the font's features to the mechanisms of the human visual system, and to make sure these features conform to the familiar historical principles of letter design'. Arial and Times New Roman, as supplied by Microsoft, have been optimised for screen presentation, as well as for legibility when printed (Kingery and Furuta, 1997). Two other typefaces recently designed for screen

viewing, Georgia and Verdana, rely on larger x-heights than Times New Roman and therefore need more generous line spacing. It is therefore important to consider typeface in relation to type size, line length and line spacing (Boyarski et al, 1998). Mason (1997) mentions the problems that can occur when a presentation in a particular typeface is run on a computer that does not have that typeface installed. Use of a substitute font may cause the text to become unreadable.

Line length

One of our teachers commented that children were used to reading information books that often had text in two columns. She thought it would be unacceptable for text to go right across a screen. The children were often observed to be using either the cursor or a finger to follow the text as they were reading, suggesting that they felt some insecurity about being able to keep their place. In our analysis of CDs the line-length varied considerably, depending on the width of the window or frame. In some cases, the average number of characters per line exceeded that held to be comfortable for reading, though this was usually when there were not many lines of text on screen at the same time. For the most part, however, the number of characters per line ranged from 22 to 25. Research on printed materials has shown that the optimum line length is about 60 letters and spaces (Spencer, 1969). Very long lines create difficulties for the reader in making an accurate return sweep with the eyes from the end of one line to the beginning of the next. Generous line spacing can help, but long lines have a very daunting appearance. It is therefore counter-productive to try to use the full width of the screen for a single column of text. On the other hand, a two-column layout would produce too short a line. Kahn and Lenk (1993) note that the use of multiple columns of text is rare on screen because of the large point size needed to present clear letter forms and the size of most monitors. The challenge for the designer, therefore, is to make good use of the total screen area without compromising legibility by using very long lines.

Line spacing

In printed materials using type at sizes intended for reading at a normal distance, it is generally accepted that legibility is improved by the addition of two or three points of extra space between lines (Spencer, 1969). This makes the shapes of letters and words more easily perceptible. It also helps to prevent the formation of distracting vertical rivers of white space, and it helps the eyes to make an accurate backsweep at the end of each line. There is every reason to think that the same applies to text on screen. Phillips and DiGeorgio (1997) suggest that the space between lines should be two to four points sizes larger than the actual size of the font, but if there is too much space the concept of continuation may be lost (Aspillaga, 1992).

On screen, the most meaningful measure of line spacing is the distance in pixels from the baseline of one line of type to the baseline of the next. As far as the reader is concerned, the most important factor is the apparent amount of space between lines in relation to the size of the type. In our sample the line spacing in pixels was usually twice the x-height plus two pixels, for x-heights ranging from 6–10 pixels. In some cases the spacing was much more generous however (e.g. x-height 6 pixels, line spacing 17 pixels).

Justified versus unjustified text

Research on the relative legibility of ranged left versus fully justified setting in printed materials is inconclusive. However, the hyphenation and uneven word and letter spacing associated with fully justified setting can be distracting, especially with short line lengths (Aspillaga, 1992). Aspillaga also suggests that a ragged right-hand margin assists the learner to recall the location of information because the shape of the paragraph is irregular. Hartley (1987) concludes that unjustified text is more suitable for screen viewing. Kahn and Lenk (1993) argue that if text is to be justified, the system should calculate the total number of pixels to be devoted to the characters and should then calculate the word spacing to the nearest pixel, making adjustments to the space between specific character pairs if necessary. They reported that at that time (1993) no software vendor was offering hyphenation and justification routines specifically tuned for display on the computer screen.

The majority of the text on the CDs that were examined in the IMPS study was left justified with a ragged right-hand margin, so in this respect current practice appears to be in accord with what designers and researchers would recommend.

Margins

Spencer (1969) argues that in printed materials margins are important for both practical and aesthetic reasons. For screen viewing, it can be argued that margins expose the edge of the text block, clearly separating it from other text blocks and from the window/page border, and that margins also help the eye in locating the beginning of each new line (Kahn and Lenk 1993). However, most applications allow a margin of only a few pixels at the left-hand edge of the text block, on the assumption that wider margins waste space. However, as we have seen, long lines reduce legibility. It is also likely that the cramped appearance that results from narrow margins will be off-putting.

Kahn and Lenk (1993) comment that most computer users neither see nor value margins in relation to text, but children in our study commented on the lack of margins on screens as compared with books: '... on books it's just plain on the outside'. Narrow margins to the left and right of the text was one of the few consistent features of the CDs we analysed.

DISCUSSION

The IMPS project has demonstrated that that it is likely that there is much to be gained from collaboration between software designers, and teachers and children working in the classroom. Together they need to consider how best to produce material that integrates with the curriculum, to exploit the constraints that children and teachers work within, and to consider the level of involvement teachers and children need to have to ensure efficient and effective use. Some of the issues that emerged most strongly from the IMPS studies were in relation to classroom use, to children's reading activity, and to particular features of interaction or interface design.

It became clear that giving children access to vast quantities of information via CD-ROMs will not in itself make them better researchers. They need to be shown

how to use specific CD-ROMs, as well as more general computing procedures, and to be made familiar with terms used for particular features of CD design (menu, opening screen/title page, toolbar, etc.). Some children in our survey were reluctant to use indexes or other kinds of search strategy, and preferred to browse or systematically search through a large body of information. In the classrooms we studied, children rarely worked on their own: a common scenario was for children to work in pairs, often sharing the mouse and making joint decisions about which icon to click on or which route to take. Clearly structured, accessible information is important to help children feel they are in control – and this is what they wanted to be. They were very frustrated by icons that were ambiguous or abstract; they did not understand these, and could not make intuitive assumptions about their meaning. This suggests one area to which designers could usefully pay careful attention, and where input from children may be particularly helpful.

The IMPS project has drawn attention to the challenge that teachers face using interactive multimedia in class, and that children and teachers have views about its use and about the way information is presented. The project has also shown how research techniques widely used in education have a part to play in obtaining the kind of feedback essential to effective, focused designing. Qualitative research of the type adopted in this project can be extremely effective when designing for children, and particularly for children in a classroom environment. Children were observed in a situation where they felt comfortable about making insightful comments, and to be free to use the materials in ways helpful to them. The IMPS project also highlighted the finding that teachers and children lacked confidence about the new ways of reading afforded by multimedia, and needed to become familiar with the conventions for presenting information within it.

Acknowledgements

The authors would like to acknowledge the other members of the project team: Viv Edwards, Professor of Language in Education and Director of the Reading and Language Information Centre at the University of Reading, and Carol Boulter, our researcher in the early stages of the project. We are particularly grateful to children and teachers at Redlands Primary and Willowbank Junior Schools in Reading for their co-operation. The IMPS project was funded by the British Library Research and Development Department.

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