A Typographic Case Study: Children's Digital Books in New Zealand Primary Schools

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Abstract: Increasingly children's educational reading material is presented in a screen-based environment. This includes a range of interactive learning tools, interactive whiteboards, on-line standardized testing material, digital books including CD-ROMs and E-Books, as well as digital reference books such as encyclopedia and dictionary. With this increase in on-screen educational reading material and use of on-screen reading material in the school, it seems clear that the quality of material intended for children's on-screen reading requires careful consideration to ensure that it is of a high standard and that it will facilitate children's learning. This investigation case study's digital books intended for learning through reading as found to be available to students of New Zealand Primary Schools. The writer analyses a selection of the products of the two publishers that were found available to primary and intermediate school children at two different schools in two different socio-economic school regions. The writer outlines specific consideration of typographic presentation with respect to eye movements that will aid in the development of material for children's on-screen learning including CD-ROM, E-Book, and web-based reading material.

Keywords: Children's On-screen Learning, Children's On-screen Reading, Design for Children, Design of On-screen Text, Design of On-screen Typography, E-Books, Enhanced E-Books, CD-ROM Books, Digital Books

Background

INCREASINGLY, CHILDREN'S EDUCATIONAL reading material is in a screen-based environment. This spans interactive learning tools, on-line standardized testing material, digital books including CD-ROMs and E-Books and digital reference books such as encyclopedia and dictionary. It is, therefore, clear that the quality of material used in classrooms and available in schools for children's on-screen reading requires careful consideration to ensure that it is of a high standard and that it will facilitate children's learning. While research continues with respect to navigation, interaction and learning requirements for interactive software, little research is available to conclude definitive direction for the use of text in children's on-screen reading material. Greater understanding of how the presentation and spacing of text will influence the "readability" of these interactive reading materials is a pre-requisite to achieving this goal of facilitating children's learning, reading and comprehension on-screen.

Vanderschantz (2008; 2009) argues, that it would appear from the research available today, that much of this literature regarding children's reading is extrapolated from experiments that have been performed predominantly with adults. Vanderschantz (2009) continues to argue that until recently, only assumptions were made regarding children's reading and typographic requirements. It is apparent that theories and findings concerning adults, were often extrapolated and applied to children without specific empirical testing being performed.

COMMON GROUND

It is also apparent that theories and discoveries found in the reading of print, were initially extrapolated and then applied to type for the screen. Dillon (2004) argues that the research in screen-based reading is still without rigour and much of the literature relevant to print is yet to be satisfactorily replicated for the screen.

Since the early (1908) work of Huey and his contemporaries, much has been known about the movements of the eye during reading in print. Eye movements are affected by both contextual and typographic variables. These variables can increase fixation duration and shorten saccade length, whilst increasing the frequency of saccadic regressions. All of which will negatively impact the successful and efficient reading of a text. Typographic variables such as typeface, line length, and spacing all appear to influence eye movements (Rayner, 1998).

The literature indicates spacing as an important factor in leading the eye along a line of text. Separation of text blocks from images and edges, through use of margin and padding, is shown to be important for children (Bringhurst, 2004; Burt, 1959). Suitable line spacing has been found to be a key factor, to ensuring, that the eye remained on the line being read, while finding the next line with ease (Burt, 1959). Suitable line length is an influential decision, to reduce fatiguing of the eye during reading, and again, to ease finding the next line (Dyson & Kipping, 1998; Tinker, 1965; Watts & Nisbet, 1974). Word spacing is recognized as a central concern, to enable the eye to effectively differentiate words with ease during peripheral information processing and saccadic programming (Epelboim, Booth, Ashkenazy, Taleghani, & Steinman, 1997; Rayner, 1998; Rayner, Fischer, & Pollatsek, 1998).

Presently there is much discussion in the media of ongoing production of *Enhanced E-Book s* for today's market; therefore, research which analyses past trends, successes and failures is judicious at this time. The findings of this paper should prove beneficial with moving towards the use of these technologies in the future classroom or the near future in the homes of early adopters.

This paper will analyze and identify typographic characteristics as used within screen-based material for children intended for learning through reading. The issues raised by this research, will assist both design and teaching professionals, in creating appropriately set type, for both computer software, E-Books, CD-ROM books, as well as on-screen worksheets and on-screen materials presented to children in the classroom.

Hypothesis

Typographic presentation of text, with particular consideration of typographic spacing, has not been used consistently or sensitively within children's on-screen reading material currently available in New Zealand primary schools, independent of *decile rating*. The New Zealand decile rating (Ministry of Education, n.d.) indicates the range of students from low-socio-economic communities at a specified school. A decile 1 rating indicates a high proportion of students from low-socio-economic communities while a rating of 10 indicates a low proportion of students from low-socio-economic communities.

Methodology

An audit of a publicly funded, decile four intermediate school library in Wanganui, New Zealand, conducted in 2007 and repeated in 2009, found digital books in the form of CD-

ROM books, intended for children from two different publishers. This school has a roll of 575 students at Years 7 and 8 (predominantly 11 and 12 year old children).

A second school library in Wanganui was also approached. This second school was a private, full primary school, Years 1 through 8 (5 to 12 year old children). This school is a decile nine school with a role of 237. This second school also held a very similar range of interactive learning materials for children. It was found that this school did not have any children's digital books, produced by a different publisher, than was available from the first school poled.

The CD-ROM books, available for analysis, were produced by two different publishers. To avoid identification of these publishers they will be referred to as *Publisher X* & *Publisher Y*. There were 10 CD-ROMs available from Publisher X and 5 CD-ROMs available from Publisher Y. Three different CD-ROMs were chosen from each publisher to be analyzed in this investigation. The CD-ROMs or software packages will be referenced as PX B1, PX B2, PX B3, PY B1, PY B2, PY B3, representing Publisher X Book 1 through 3 and Publisher Y Book 1 through 3.

While other interactive learning materials were available at this intermediate school and full primary school, the sets of material from these two publishers were the only digital resources available or intended for *learning through reading*. It would seem, from the nature of the other materials available, that the unlisted CD-ROMs that were also available were intended for *learning through interaction, exploration, and game play*, rather than learning through reading. E-Books in *EPUB* or other similar contemporary formatting were not available at either school at the time of this survey.

Both series of digital books critiqued are readily available to the students of this intermediate school, and, according to the librarian, are used by all age groups attending the school. The CD-ROMs are not used within the classroom curriculum; instead, they are used by the students within the library environment, during class-library-visits and at lunch time or after school. The CD-ROMs from Publisher X are also used within *Reading Assistance*, *Remedial Reading* and *Special Education* programs within the school.

The books have been analyzed on a Windows XP, Service Pack 2, based PC laptop with a screen resolution of 1680 x 1050 dpi, 32bit color, on the built-in LCD monitor, sized 15.5in widescreen.

Measurements were taken within the running application, using *JR Ruler Pro* version 3.0, a Shareware Windows based tool. (Spadix Software, 2004) All measurements are quoted in pixels.

Results

Books Reviewed

The software from Publisher Y contained one fictional illustrated story per CD-ROM, while the software from Publisher X contained many stories per CD-ROM and are a combination of both fiction and non fiction writing for young people.

The CD-ROMs reviewed for this Paper are as follows.

Table 1: Publication Information & Reading Ages

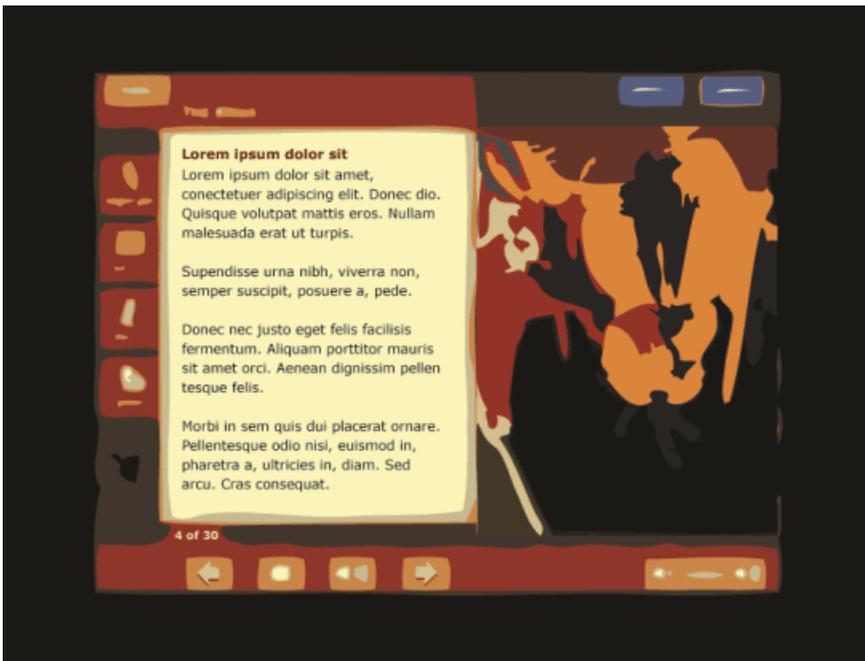| Publisher	Book	Age Range Quoted	Publication Date
Publisher X	PX B1	9 and 14 years (noun frequency level)	2006
Publisher X	PX B2	8 and 13 years (noun frequency level)	2003
Publisher X	PX B3	7.5 and 12 years (noun frequency level)	2002
Publisher Y	PY B1	3 - 7 years	1994
Publisher Y	PY B1	3 - 7 years	1993
Publisher Y	PY B3	3 - 7 years	1994

Figure 1: Artistic Interpretation of PX B1

Figure 2: Artistic Interpretation of PY B1

Reading Ages

The suitability of the tested material for particular age groups was suggested by the publishers, as shown in Table 1 above. Publisher X quoted age ranges specifically for each article and story within the CD-ROM; these age ranges were quoted as *noun frequency levels* . Publisher Y quoted a single age range on its packaging. The age ranges commensurate with the articles and stories of each application are noted in the table above.

It is well established, that there are trends in developmental changes in eye movements during reading. In 1922, Buswell, according to Rayner (1998), discussed how increases in reading skill resulted in improved eye movements for reading as indicated by decreases to fixation duration, saccade length increases and decreases to the number of fixations required, all occurring while frequency of regressions decrease. Rayner (1998), further discusses the 1991 research of McConkie et al, who examined children's eye movement behaviour and found that compared to adults, the children had more variability in their eye movement patterns. Interestingly, McConkie's research also showed that children, in their first year of reading, did show the same landing position patterns as adults who commonly saccade to fixations in the middle of a word.

Typographic Deconstruction

Typographic particulars for each CD-ROM are shown in Table 2 below.

Table 2: Typographic Deconstruction

CD- Rom	Type Size	Type Style	Line Height	Line Length	Lines / Page	Left Margin (min)	Right Margin (min)
PX B1	12 px	Sans Serif	25 px	298 px (~40 CPL)	5 - 18	19 px	45 px
PX B2	13 px	Sans Serif	30 px	385 px (~55 CPL)	4 - 13	41 px	41 px
PX B3	12 px	Sans Serif	30 px	344 px (~45 CPL)	5 - 12	52 px	46 px
PY B1	12 px	Serif	15 px	380 px (~50 CPL)	1 - 5	33 px	5 px
PY B2	13 px	Serif	22 px	280 px (~30 CPL)	1 - 9	25 px	6 px
PY B3	17 px	Slab Serif	22 px	424 px (~35 CPL)	1 - 5	62 px	21 px

Type Size

The type size, as measured using *JR Ruler Pro* (Spadix Software, 2003), is shown in column 1 of Table 2 above. Column 2 holds information regarding the typeface used within each application. Column 3 indicates the line height as measured, using *JR Ruler Pro* (Spadix Software, 2003). The line height was measured from the baseline of the second line of a page to the baseline of the first line of a page. The approximate line length appears in Column 4. Line length was measured by counting the number of characters on the longest line visible in the book. This line was then also measured, using *JR Ruler Pro*. Column 5 lists the minimum and maximum number of lines which appeared on a page. Columns 6 & 7 indicate the minimum left and right margins, as measured against the closest edge or closest significant graphical detail. This measurement was again taken, using *JR Ruler Pro*.

Ascenders, Descenders and x-height

In the literature, very little is agreed regarding how the human eye, brain and cognitive system analyses and recognizes words during reading. It would appear that the contemporary debate is whether a human reader recognizes particular objects holistically (an entire word) or by its parts (the individual letters that make up this word). Neither theory has fully explained the complex task of recognizing letters and words, nor the processing of this visual information for meaning, and the sub second time that this takes. There seems to be significant yet disputable empirical evidence to support either argument.

The stronger of the two arguments appears to be that of part-based, letter recognition. Larson (2004), a reading psychologist working for Microsoft Corporation, suggests that research evidence in cognitive psychology, indicates that letters within the word are used to recognize the word. Pelli et al. (2003), indicate that letter and word recognition studies,

typically pre-suppose a series of stages in the recognition process; detection and identification of features, followed by identification of the letters, then identification of the word.

Features are perceived to be recognizable and identifiable parts of the word or letters. Therefore, features could be the letters themselves, or, in fact, features or parts of those letters, such as letter shape, or ascender or descender information. This systematic, part-based recognition system follows the Gestalt psychology theory, that the whole cannot be evaluated separate from its parts. (Pelli, Burns, Farell, & Moore-Page, 2006) This hierarchical, feature based, recognition system, relies on the detection of "good parts", which are nameable and functional components or objects whose contours can be analyzed and identified. Letters, therefore, are good parts which are both functional and nameable. (Martelli, Majaj, & Pelli, 2005; Pelli, Burns, Farell, & Moore-Page, 2001; Pelli, Farell, & Moore-Page, 2003)

The process of letter recognition is assumed to be a pattern-based or pattern-matching process. This works by the extraction of the distinctive features of the information to be processed. These features are then used by an un-described decision process to categorize the stimulus. The individual features of the letters may be treated as "bundles of features" and processed individually or wholly, as letter-wholes. A word is therefore, processed as a series of "feature bundles". (Wheeler, 1970)

The letter recognition theory seems incongruent with the word shape theory discussed by typographers Eric Spiekermann and E.M. Ginger (2003) and reading psychologist Paul Saenger (1997). This word shape theory supposes words are read as complete units. This theory is suggested by Larson (2004), to date back to James Cattell in 1886, who Larson states was the first psychologist to propose this model of reading recognition. Thus, instead of seeing the letters as the units used in the template or pattern recognition process, it is believed that the entire word is used. It is further believed, by some, that the ascenders and descenders of the letters, assist in creating an envelope-shape or outline of the word, which is then used in the pattern recognition process. (Spiekermann & Ginger, 2003)

The main supporting evidence for the word shape based recognition theory, is the *Word Superiority Effect* theory. This states that letters are more easily recognised when within the context of a meaningful word, than when the letter is viewed alone. (Wheeler, 1970) This is disputed, however, by Pelli et al. (2003) and Larson (2004). They suggest that this phenomenon is to do with letter sequence and resulting shape recognition, rather than word shape recognition. Larson explains that the word superiority effect is due to the recognition of familiar letter sequences and not to the recognition of entire word shapes.

With these two theories in mind, it would seem that for young readers letters with clearly identifiable and somewhat extended ascenders and descenders will assist with reading, as well as letter and word identification and processing. Longer ascenders and descenders are referenced by Watts & Nisbet (1974), as helping to distinguish letterforms and wordforms. This is because the eye is believed to read along the x-height of the letterform. Thus, the ascenders and descenders give a distinctive shape to the letter and the word.

Although not measured, it was observed by this researcher that, ascenders and descenders are not especially long for the typeface choices of any of the material reviewed. This is possibly due to the choice in each software to make use of typefaces with (what this researcher considers) large x-heights. The typeface chosen for PX B2, appeared to have the best combined x-height with long ascenders and descenders. The rest of the testing material has reasonably generous ascenders, though most lack long descenders.

Tracking & Word Spacing

Stanley Morison writes in the introduction of *A Psychological Study of Typography*, "Spacing, in fact, is more important than choice of size or design of type" (Burt, 1959, p. ix). *Line spacing*, the space between lines, affects the ability for the eye to traverse successive lines of type with ease. The space between individual letters, *letter spacing, tracking or kerning*, affects the ease with which letters can be identified and in turn, the ease of recognition of words. The space between words, *word spacing*, affects successful transition from fixation to fixation, while the space between lines, affects the ability of the eye to navigate correctly from the end of one line to the beginning of a new line. For these reasons, we must carefully assess our spacing decisions when approaching a typographic layout, particularly that for children.

Walker (2005), states that children in her studies with printed text spacing, discussed tight letter, word and line spacing as being seemingly more difficult or confusing to read. This was often due to the children perceiving the size of the type to be smaller and harder to comprehend. From a motivational point of view, taking care not to set type overly tight, may therefore, assist with children's reading and comprehension.

Letter spacing is of great importance to reading, particularly if the pattern matching, part-based letter recognition theory, discussed previously in this paper holds true. If a reader recognizes and processes visual textual information in this way, then the relative space of letters and letter groups is of significant consideration.

Crowding is the phenomenon of letters being tracked too closely. This results in meaning being difficult to ascertain from the letter combination. It also causes confusion, through tight spacing and shape adjustments. This may also result in a slowing of the reading rates for experienced readers. A letter surrounded by other letters, when seen in the periphery or para-fovea, is much harder to identify than a single letter (Hess, Dakin, & Kapoor, 2000). It is thought that "crowding may determine the visual span and thus reading rate" (Pelli, Burns, Farell, & Moore-Page, 2006, p. 18).

Word spaces appear to be important for reading English, as they make it clear to the reader where a given word begins and ends (Rayner, Fischer, & Pollatsek, 1998). This is also because it is believed that these spaces are used as one of the systems to program up-coming saccadic movements (Epelboim, Booth, Ashkenazy, Taleghani, & Steinman, 1997).

Tracking in the reviewed material tends to be relatively tight for each application reviewed. This is made even tighter by the two CD-ROMs that use a stroke on the type. This has the effect of merging letterforms into glyphs which appear to become single forms and shapes; individual letters were difficult to distinguish. This also creates completely outlined words which are difficult to decipher easily.

Word spacing is relatively tight for all of the books investigated. The two exceptions seem to be PY B2 and PY B3, both of which have the largest word spacing at approximately 10 pixels, compared to approximately 5 pixels across all other material reviewed.

Sentence spacing is used generously by the Publisher X CD-ROMs where double word spacing, or *French Spacing*, is used at the end of a sentence.

Page Structure

Document or page structure is an important consideration within the presentation of any form of information. Documents intended for use and navigation by a young reader are no exception and perhaps it could be argued must be more cautiously considered by designers to facilitate good reading practices and highly functional and usable documents. Document structure is required, as much to lead the eye and guide the reading direction of the young user, as it is to ensure that distraction is not caused by poor layout, hierarchy or information placement.

The page structure of the material from Publisher X is well refined and consistent. Text appears in a left hand column with a consistent left hand margin and vertical position of the first line of text, while images appear in a contained right hand column. The Publisher Y material is a little less regularly structured. The CD-ROMs set type blocks on top of image areas, the left hand margin of the text block is positioned differently from page to page, as is the vertical position of the first line of text. The text block appears at both the top and bottom of pages.

PY B2, for example, has two different page layouts, one with a still image and type over top of the image intended for reading silently, and one where an animated image sits to one side, or above a block of text which is highlighted as the narrator reads. The child cannot choose to read silently the pages that contain animation; these are narrated and highlighted as read and once completed, the application automatically moves to the next page of the story. Automated page turns also impede the ability for the young reader to re-read a page without narration.

Margin & Padding

Margins are particularly useful in reading consecutive text, as these allow for guiding the eye, while giving visual barriers to the information space and the surrounding information. Margins are important when text abuts illustrations or the edges of books or monitors. Burt (1959) suggests that narrow margins produce visual fatigue. He continues, stating that when type is set too close to the edge of a printed page, a young reader will often follow the type right off the page. However, he concludes that for adult readers, large margins prove mostly aesthetic in value.

Burt (1959) suggests the two side margins should occupy approximately 1/3 of the printed page width. This size should then be increased as leading is increased. He continues, that for children, margins should be wider still. For the very young child, Burt suggests, lines end with the end of a phrase or sentence, thus leaving ragged margins on the right.

In the material reviewed, margin and padding around text blocks is often very tight. The Publisher X CD-ROMs do not have text on top of images and allow for 19 – 52 pixels of space to the left of the text block and 40 – 46 pixels of space to the right of text blocks. This is important for easy reading of the text block, particularly when images are set for full column-bleed are used, such as for PX B1 in Figure 1 above.

PX B1, for example could have benefited from larger margins and padding because of this dominant image found on the right hand side. The smaller margins used in the remaining two CD-ROMs from Publisher X were however considered appropriate due to the less dominant images used within these stories.

The margin and padding around text blocks is often much too small for the Publisher Y CD-ROMs. The text is often placed over complex images. In some instances, text to the right of the block has only 5 pixels of padding or margin before a complex part of the image begins. This can be reviewed in Figure 2 above.

Placement of Navigational Elements and Images

Complexity on screen has a negative effect on children's preferences and can impact children's choice of reading material. For this reason, careful consideration of layout, navigation and division of text and image will benefit young users. With screen based reading material the need for extra navigational information which would not be present in a printed document become apparent. Margin and padding around text which considers not only image distance but navigational elements is also of consideration in children's on-screen reading material.

Navigation elements used within the Publisher Y CD-ROMs are positioned carefully off to the bottom corners. This can be seen in Figure 2 above. This poses no issue of interfering with the text. Buttons used within some of the Publisher X CD-ROMs, could potentially cause issues for readability because of their close proximity to the type blocks. This is the case for PX B1 as indicated in Figure 1 above, where large, dominant buttons are within 19 pixels of the right hand side of the text block and in PX B2 and PX B3, large buttons are also within 20 pixels of the last baseline of text blocks.

Text is placed over complex image areas with the Publisher Y CD-ROMs. This causes reading issues because of the complexity of the area behind the text being read. Images in the Publisher Y CD-ROMs are animated and make reading or concentrating on the text, difficult at times. Text is segregated from image for the Publisher X CD-ROMs, though images are placed very close to text at times and due to the size and placement of image, this could cause distraction for the reader.

Colour Deconstruction

Colour particulars for each application are shown in Table 3.

Table 3: Colour Deconstruction

CD-ROM	Type	Background	Stroke	Highlight
PX B1	Black	Parchment	No	Orange Fill
PX B2	Black	Parchment	No	Red Fill
PX B3	Black	Parchment	No	Red Fill
PY B1	Black	Image	Yes	Blue Stroke with Black Fill
PY B2	White	Black & Image	No	Orange Fill
PY B3	Black	Image	Yes	Yellow Stroke Green Stroke

Column 1 of Table 3 above, indicates the fill color of the text for each application. Column 2 describes the background over which text is placed. Whether a stroke color around the text is used is detailed in Column 3. How text is highlighted for narration or on roll over, is described in Column 4. In Column 4, 'fill' indicates a text-fill-color change, while 'stroke' indicates a text-stroke-color change.

Colour is of particular interest in typographic presentation as indicated by Vanderschantz et al (2010) who discussed evidence that color combinations in children's on-screen reading material can affect children's' ability to comprehend text. This is supported by research conducted with text in print and with adults (Bix, 2002; Fukuzumi, Yamazaki, Kamijo, & Hayashi, 1998; Hill & Scharff, 1997).

Narration & Word Highlighting

Narration is used in both publishers' material. Narration could not be turned off for the Publisher Y CD-ROMs and the text is read before readers can read it silently on their own. For PY B2, parts of the text could not be read through silently by readers after they are read by the narrator, because they appeared during animated intervals between pages. Narration is an optional experience for the Publisher X CD-ROMs and users are required to click the line of text, or the button labeled with a speaker icon, if they wish to have text narrated.

In both sets of testing material, when text is narrated, the text is highlighted. This is indicated by use of either a change in text-fill-color, or text-stroke-color, or text-fill-color and text-stroke-color.

Findings

The Publisher X CD-ROMs appear to handle spacing concerns better than the Publisher Y CD-ROMs. This is perhaps due to the more recent production of this material, or perhaps because this material is designed and intended for use within the New Zealand education curriculum and thus is intended for use as a classroom based learning tool rather than a home based learning tool.

Type being highlighted as narrated, may assist with very young children following along with reading. Both narration and highlighting may prove distracting for the older, more competent reader. Narration and highlighting may interrupt children from being able to read the story by themselves or at their own pace. Narration and highlighted text should be an option which is chosen by the user. Rather, than an automatic assumption, as made by the Publisher Y material. Publisher X did well to allow for narration as a user specified device.

While interaction or learning through play is not discussed in detail above, there appears to have been consideration of this in the CD-ROMs developed by each publisher. The level of interaction and learning through play, presented in the Publisher Y CD-ROMs, might facilitate further learning through interaction and exploration. Where reading comprehension is intended, facilitating learning through interaction and play must not be at the expense of learning through reading. Interactivity in the Publisher Y CD-ROMs, allow for experimentation and investigation, however, opportunities are lacking for further learning through this interaction and animation. Perhaps a better use of interaction for learning opportunities, rather than simply for play and humor, would benefit these applications. It could be fair to

suggest, that the interaction and animation in the Publisher Y material could possibly serve a motivational factor for the child.

The two publishers have designed their work with quite different target markets in mind. Publisher Y material is targeted at 3 – 7 year old children, while, the Publisher X CD-ROMs are targeted at 7 – 14 year old children. This perhaps, explains the level of interaction and learning through play, intended by the Publisher Y materials. This may also be the reason for the narration before silent reading, which appears to be the practice of the Publisher Y materials.

In the CD-ROMs investigated, when type is printed over the top of an illustration or graduated-color background, the type is often perceivably very difficult to read or differentiate because of color similarities and visual complexity.

Padding, margins and space around text blocks, are not well considered by either publisher. Interactive elements, animations and illustrations are often too close to type blocks, distracting the eye of the reader in both sets of CD-ROMs reviewed.

Line spacing is overly tight for the Publisher Y applications; it is better considered in the Publisher X CD-ROMs but is still not consistent from application to application. Both publishers do well to present text blocks with line lengths, allowing for suitable amounts of text to each line. Line lengths are such that whole-thoughts and significant sentence-parts are present in each line. This is successful in ensuring that a suitable portion of the sentence, phrase or notion is covered in each line as suggested by Watts & Nisbet (1974).

The Publisher X use of double spacing (also known as *French Spacing*) between sentences may prove useful for children's reading because the ends of sentences are clearly marked. This is a desktop publishing tradition, dating back to typewriters with mono-spaced typefaces and letter spacing. However, this practice, is frowned upon for adults in current typesetting. The availability of proportional typefaces alleviates the need to mark the end of a sentence differently from the space between words. The use of double spacing after a sentence may prove beneficial to children's reading.

The age range quoted for the Publisher Y material was 3 – 7 years, while, the Publisher X material is aimed at children 7 – 14 years. Interestingly, the Publisher X use of typography appears more suited to the age group quoted and perhaps for a younger age group, also. This is due to the use of large space in terms of padding, leading, and word space. The Publisher Y material uses comparably very small type and tight leading which may not be particularly suitable for children in the lower age group quoted.

Discussion

The publication date of the material reviewed in this paper calls into question the way in which this may be critiqued. Interactive technology and visual display unit technology have clearly advanced since 1993. This writer feels that this investigation retains merit because this material was the breadth of material available for children's learning through reading in more than 1 school at the time of investigation. Studies that consider material produced more recently, including that in contemporary file formats such as the EPUB, will extend the knowledge in this area and this paper will form an opportunity to compare and contrast findings.

Conclusions

It would appear that careful consideration of spacing in terms of padding, margin, and line spacing, will assist with improving the CD-ROMs reviewed in this investigation. Consideration of children's eye movements and how typographic information can be designed or presented to aid children's reading, learning and comprehension is required in future digital books as well as other forms of material designed for children's on-screen use.

As discussed, issues relating to spacing have been recurring themes in the literature. Spacing, in terms of margins; between text blocks and image; spacing between lines; spacing between words and spacing between letters will all assist with children's reading. Spacing considerations play an important role in assisting with the correct and efficient eye movements for continuous reading. Eye movements during reading can be both positively and negatively affected by decisions made by typographers and designers. For this reason, the consideration of typography, spacing and leading the eye, is important in improving the design of these on-screen materials.

Should learning through reading be the intended purpose of these CD-ROMs, the analysis above indicates clearly that improvements to this material could be made for the benefit of children's reading.

The Publisher X CD-ROMs treat type in such a way that it should prove usable and approachable by its intended target market. This material carefully uses liberal line spacing; generous word and sentence spacing; a clear and readable typeface and type blocks which are separated from image and navigation elements. The Publisher Y CD-ROMs do not appear to do this as effectively as the Publisher X material. Type in the Publisher Y material is presented over complex images; does not use significant line or word spacing and often suffers very little padding around text blocks and around letters and words because of the use of colored strokes on text.

The Publisher Y digital books are quoted as catering to a much younger target market than the Publisher X digital books, thus, eye movement control should be more carefully considered by Publisher Y through more effective use of padding and margin around text blocks in order to avoid distraction. Simplification of typeface choice and removal of colored-strokes from type will also assist correct identification and interpretation of words and letters, while increased line spacing may also assist in ensuring that a young reader will be sure to remain on the line intended, rather than slipping to lines above or below.

Although, the Publisher X material is considered an improvement over the Publisher Y material, there is still room for enhancement. This Publisher X material quotes a very broad age range on some of its CD-ROMs, thus, it would seem that consideration of further typographic refinements might assist in ensuring that the reading material is suitable for the younger bracket of the reading age suggested (7 years old). Due to the use of dominant images and navigational devices, padding and margin around text blocks could be increased to ensure young readers do not become distracted. Typeface choices could make use of longer ascenders and descenders. Tracking and word spacing could be made somewhat more generous.

Use of animation, narration, sound and other interactive elements in on-screen reading material for children, might prove useful in engaging multiple learning styles and encouraging and motivating young learners. However, these devices must be used appropriately in order to add meaning or secondary opportunities for learning through multiple senses. When interaction, sound and animation are used solely for humor or entertainment, the learning may

be hindered. Use of animation and narration could be better used in the material tested. If reading is the intended method for learning when using these CD-ROMs, then these types of interactive devices should not be active until a user initiates them.

The findings of this paper should prove useful in developing future studies of children's on-screen learning material, therefore also ensuring the advancement of research in this area. These findings should also prove influential in developing material for children's on-screen learning, whether this be digital books, CD-ROM books, Enhanced E-Books, or web-based reading material. Consideration of these typographic adjustments will assist children's comprehension by creating applications or E-Books which are approachable and enjoyable for young readers. Children will be assured of effective and successful reading of the material, because they will not become distracted by material which does not add value or meaning. The reading of the material will be eased by ensuring that letters, words and lines of text are correctly identifiable and efficiently usable. Importantly, enjoyment would be improved through success, accomplishment and achievement in the reading process for the young learner due to minimization of visual features that may distract effective or efficient eye movements.

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About the Author

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Nicholas' area of research focus has been in childrens' on-screen reading. These investigations have specifically looked into how typographic spacing could best affect childrens' eye movements during reading. This area of exploration saw him graduate with a Masters in Computer Graphic Design from Whanganui School of Design, New Zealand in 2007. Nicholas is a lecturer in Computer Graphic design at the University of Waikato in New Zealand. As a central part of his teaching and research at the University of Waikato Nicholas pursues his interests in typography for children as well as socially responsible graphic design and graphic design education.

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