MULTIFUNK:
Bringing computer-supported reading one step further

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April 2002

Norsk Regnesentral
ANVENDT DATAFORSKNING

Rapport/Report

Tittel/Title:
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Dato/Date: April
År/Year: 2002
ISBN: 82-539-0491-6
Publikasjonsnr.: 983
Publication no.:

Forfatter/Author:
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Sammendrag/Abstract:

This is a paper presenting the Multifunk project. It also gives an extensive review of related research. Multifunk is a collaboration between three partners:

- Aschehoug Education
- Department of Special Needs Education, University of Oslo
- Norwegian Computing Center

The research focus in Multifunk is how to use computers to support and improve dyslexic students' reading and writing performance. More than 10% of the population is estimated to experience substantial difficulties. The results from the project and subsequent software development will hopefully contribute to improved reading skills and sense of mastery. We propose to offer *personalised text formatting according to individual profiles* when reading screen texts. A prototype has been developed that illustrates this functionality, and preliminary studies using the prototype indicate improved reading performance among poor readers. We also propose to use *speech synthesis* in order to give auditive support to the reading process. Improved reading will be of importance both to the students' motivation and the overall learning outcome. It is vital that the digitalisation of the primary schools is done in a way that is helpful to students with learning difficulties and does not bring just another arena for shortcoming.

Emneord/Keywords: Computer assisted learning, reading on screen, reading disabilities, screen design, speech synthesis, dyslexia

Tilgjengelighet/Availability: Open

Prosjektnr./Project no.: 840003

Satsningsfelt/Research field: E-læring, multimedia

Antall sider/No. of pages: 11

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1 Introduction

Reading consists of two components; decoding and comprehension. Decoding refers to the technical skill that enables the reader to transform printed letters into recognised words as the basis for activation of meaning. Comprehension is a cognitive process that allows the reader to interpret the text, which includes thinking processes on higher levels. This basic concept of reading must be completed with an additional component; motivation. Motivation is crucial in all learning tasks. Literacy development depends on the students' interest in and understanding of what is to be learned. Students with reading difficulties often experience a rapid decline in motivation during the first few years at school.

Research shows that 15--20 % of the students in primary and secondary schools have problems in meeting the required level of literacy in today's society (Shaywitz and Shaywitz 1996, Snow et al. 1998, Catts and Kahmi 1999, Solheim and Tønnesen 1999). Other studies, however, show a substantially lower prevalence of reading problems. The estimates vary depending on the means of measure and criteria for defining a reading disability. The highest prevalence includes both students with specific reading impairment (dyslexia – unexpected difficulty learning to read despite intelligence, motivation and education) and more general reading problems (garden-variety-poor readers which is due to poor instruction, low intelligence etc.) even if the clear-cut distinction between the categories is no longer widely accepted.

At the onset of the 21th century the computer is increasingly being adopted as a relevant tool (and medium) for reading and writing. Both in Norway and internationally, the number of computers per student has increased over the last few years as well as the time spent working with them (Quale 2000). It is of great importance, however, to realise that the introduction of computer technology in schools implies both a risk and a possibility. If the special needs of students with literacy problems are not recognised and taken into account, the use of computers in classroom based project groups may well represent an additional hurdle instead of a compensatory asset.

The project has developed a *prototype* to support reading on screen for persons with reading disabilities. The basic functionalities offered in the first version are:
- personalised text formatting;
- auditive support using speech synthesis (single words, sentences and paragraphs).

The target group is students (primary and secondary school), but the software may be useful to adults with reading difficulties as well. In a future version functionality supporting writing and project work will be added. Our study has a twofold focus:
a. utilisation of the computer to help students with reading and writing difficulties to decode and comprehend, and

b. application of technology in such a way that these children are integrated in the computer-based activities in the classroom.

This paper has an emphasis on *how to use the computer to support central tasks involved in the three components of reading; decoding, comprehension and motivation*.

2 Decoding

2.1 Reading on screen

From research conducted over the past 20 years, we know that many factors influence reading texts on the computer screen. Reading long texts on screen is more tiring than in books, and one often turns to the printer to solve this problem. Another factor influencing the perceived difficulty of screen reading is computer workplace ergonomics and monitor placement (Ankrum 1999, Fostervold 1997).

A third factor is screen technology. Dillon (1992) gives a review of studies on reading on paper versus screen and concludes that the main difference in outcome between the two media is speed. With early screen technology, reading was actually found to be substantially slower than on paper, but research by Muter et al. (1991) indicates that improved computer screen technology has made reading efficiency on screen comparable with paper. Not all studies show the same results, and a study conducted at Ohio State University even suggests that reading a text on the computer screen may present an additional hurdle for less competent readers (Murphy 2000).

A fourth and well-known factor influencing text legibility on paper is typography. As for screen texts, typography still matters, but there are reasons to believe that screen typography must be seen as a separate issue. Early experiments did not show any improvements in reading performance related to textual formatting (Muter 1991). Muter's study did not isolate the single text formatting characteristics.

This has been done by Dyson et al. (1998, 2001), whose research suggest that line length influences reading speed and comprehension. Several researchers present overviews of factors that affect legibility of texts on computer screens (Walker 2000, Harrell 1999). Often mentioned factors are colour, font type and size, line length, line spacing, text structure and text justification. Harrell (1999 p. 453) claims that "the reader should be able to "adjust" screen design to his or her needs and desires in any number of ways…not only to satisfy idiosyncratic quirks but to "correct" screen design weakness".

2.2 Personalising text formatting

Computer texts may be formatted according to individual reading levels and personal preferences, a possibility the printed book does not offer.
Our prototype supports adaptation of font type, font size, line length, line spacing, word spacing, type colour and background colour. The choice of the typographical variables is based on the typographical tradition for print (Hallberg 1992) and on the works of Muter (1996), Harrell (1999), Walker (2000), and Dyson (2001) related to computer screen typography.

Six different font sizes are available in the prototype, and the reader may choose between the font types Arial (sans serif) and Times New Roman (serif). We have chosen two of the most common font types as there is evidence that both normal and poor readers seem to prefer fonts they are most exposed to (Hallberg 1994).
Line length is reported to be important by many researchers (Walker 2000, Dyson 2001), but there is only unsystematic knowledge on how line length affects disabled readers. In general, long lines tend to make the return sweep to the next line more difficult, while short lines make reading slower (Dyson 2001). The user of the prototype may choose between four different line lengths depending on reading level as well as actual window and screen size.

As for text justification, we have chosen to make all text left justified with a ragged right-hand margin. Hyphenation at the end of lines is not used as it makes reading more difficult and scrolling is used for navigation, even if paging has been proved by several researchers to be more efficient (Dyson 2001).

Since line spacing has been seen as an important factor for legibility (Walker 2000), the prototype has three optional levels of line spacing. Four levels of word spacing has been added (even though no research known to us mention this factor) to support students that need additional assistance in identifying word limits. Colour and contrast is considered important for dyslectic readers. We have chosen some of the colours that are suggested by associations for dyslexia (Dyslexia).

Each student can create her own individual profile, and subsequently all texts that the student chooses to read will be formatted according to her established profile, whether they are Web texts, scanned from ordinary text books or electronic text books. The profile can be changed at any time, e.g. when reading skills have improved.
A first tentative study focused on the effects of adapting the screen text to the readers' individual profile. The study was carried out in a Norwegian primary school with 8 nine year-old students, all below average readers. Reading performance was measured by speed and number of errors reading texts on screen and in books. The results indicate improved reading performance in both speed and accuracy for screen reading (Haugen 2001). The reasons could be increased motivation, improved legibility of the formatted text etc. Further

and more in depth studies are, however, necessary to show the real effect of reading individually adapted texts on the computer screen as compared to traditional text reading. Such studies will be carried out in the context of this research project over the next two years.

3 Comprehension: reading support using speech synthesis

Several researchers have recommended the use of speech synthesis to support decoding and comprehension in children with reading difficulties (Olofsson 1992, Wise 1997, VanDaal 2000, Lewin 2000). Wise et al. (1997) found that speech synthesis substantially improved the disabled reader's reading performance, and this has recently been confirmed by Lewin (2000). McKenna et al. (1997) claims that books with speech support make reading less frustrating, aid the development of decoding skills, improve fluency and provide considerable individual support, offering for instance repeated reading of whatever part of the text the student might want. Van Daal (1993) reports that the effect of speech feedback depends on how the system is used by the readers, for instance whether the reader chooses to listen to hard-to-read words or unselectively chooses to listen to a lot of words. The overall result is, however, positive. Olofsson (1992) states that the usefulness of speech support depends on factors like age and meta-cognitive ability. He found that the younger children (grade 4-5) and disabled readers appear to need training in the use of speech synthesis, while elder children (grade 6-7) acted in a more intuitive and independent way.

The mentioned research, except Olofsson's, is based on English beginner readers. Linguistic differences, as letter-sound correspondence, might present some differences to the usefulness of speech synthesis in different languages. Olofsson (1992) has studied speech synthesis to assist Swedish children, and his conclusions were positive. Due to language similarities, we believe that Olofsson's results can be transferred to the Norwegian case.

The prototype offers a "read-it-loud-to-me" functionality through speech synthesis. The student can choose to listen to words, sentences or paragraphs according to the individual needs. Olofsson (1992) states that co-occurrence of spoken and highlighted words may also have a direct positive effect on children's understanding of the letter–sound correspondence and help them to apply this knowledge in their reading. For comprehension purposes speech synthesis should be used at approximately normal speed, while speech synthesis for decoding purposes should be used at a slower speed.

Some researchers (Zellweger 2000) have chosen to use digitised speech to assist emergent readers, as they think speech synthesis technology is not of high enough quality (personal communication) for use with dyslexic children. When the main purpose of the speech support is to assist the decoding, i.e. the comprehension of the letter–sound correspondence, low quality of speech synthesis might clearly pose a problem. On the other hand, speech synthesis is more robust to unknown text. In our opinion digitised speech can

clearly be an alternative in some contexts since pronunciation of single sounds, which are limited in number, can be digitised and reused several times. We will consider integrating digitised speech with speech synthesis when it is more useful.

The speech synthesis functionality of the prototype has not been extensively tested. We have carried out some brief tests with teachers and children, observing that students had a very tolerant attitude towards the prototype's somewhat artificial and mechanical voice. The teachers, however, worried about the children "ending up speaking like that".

4 Motivation

Due to poor performance reading disabled students develop a negative attitude towards both reading and reading related tasks. Negative attitude/low motivation is related to attention, and attention provides the necessary focus needed for decoding and comprehension processes to result in successful reading. A relevant hypothesis is that if the prototype improves the reader's overall reading experience, this will in itself affect the motivation for further reading. Improved motivation may also come from being able to manipulate and personalise the text formatting and thus being in control of the reading tasks (van Daal 2000).

Speech synthesis supports comprehension, and provides for the poor reader a necessary distance to the laborious task of technical decoding and as such strengthens the communicative aspect of literacy. This may make the reading task more enjoyable, stimulate further reading, enhance a sense of mastery, and trigger more motivation. Underwood (2000) claims that the use of talking-books is in itself highly motivating.

5 Future development of the software

In a commercialised version, the following functionality will be added:

- reading support including speech synthesis of syllables, morphemes and word constituents;
- reading support through digital speech when more suitable than speech synthesis;
- spelling support adapted to students with reading and writing difficulties;
- word explanations adapted to the age of the target group.

The spelling support will not be a simple check that suggests (any) similar spellings. It will be designed to meet the special needs of people with poor writing skills. The software will have a database of errors commonly made by dyslexic persons and suggest the most probable spelling alternatives. It will also provide semantic information as to help the student reflect on which word she tries to write. A feedback mechanism will also be included to provide information on progress, reduction of errors etc.

A primary goal for the project is to identify which parts of the reading and writing process can be supported by technology and computer-based tools.
The second main question motivating our research is "how to apply the technology in such a way that students with reading and writing difficulties are integrated in the computer-based activities in the classroom?" The challenge is to design a tool that enhances reading, writing skills and promotes collaborative work, e.g. a tool that has both a compensatory ability and integrative power.

6 Conclusion

ICT can be used to improve the learning experience and performance of children with reading and writing difficulties. Today computers are an integral part of the daily life of many children, and we must ensure that the process of digitising the classrooms will be an asset for poor readers and writers.

Knowing that children with reading and writing difficulties are motivated by certain uses of computer technology, this must be exploited for the best of struggling readers. Research also suggests that students find writing on computers to be highly motivating (Daiute 2000), and that they produce texts of higher quality when using the computer in a real-life context.
We propose to use individual adaptation of text formatting when reading texts on the computer screen. Preliminary studies indicate improved reading performance for poor readers when reformatting the text individually. We also propose to use speech synthesis to support reading. Several researchers have shown improved reading either by the means of screen design and typography or by speech synthesis. We have integrated these two options to make an even better support for dyslexic children. In primary and secondary education in Norway there are a total of 50.000 students with reading and writing difficulties that could benefit from this tool.

7 References

Ankrum, D.(1999)*Visual ergonomics in the Office. Guidelines for monitor placement and lighting.* Occupational Health and Safety. 68, 7, pp 64-74. URL: http://www.office-ergo.com/setting.htm

Catts, H. and A. Kahmi (1999) *Language and Reading Disabilities*. Boston: Allyn and Bacon.

Daiute, C. (2000) Writing and Communication technologies. In Indrisano, R. and J. R. Squire (eds.): *Perspectives on Writing: Research, Theory, and Practice*. International Reading Association, 2000.

Dillon, A. (2000) Reading from paper versus screen: a critical review of the empirical literature. *Ergonomics, Vol 35, no 10*, pp 1297-1326.

Dyslexia, the gift. URL: http://dyslexia.com/

Dyson, M.C. and M. Haselgrove (2001) The influence of reading speed and line length on the effectiveness of reading from screen. *International Journal of Human Computer Studies Vol 54, no 4.*

Dyson, M.C. and G. J. Kipping (1998) Exploring the effect of layout on reading from screen. In Hersch, R.D; J André and H Brown (eds), *Electronic Documents, Artistic Imaging and Digital Typography*, Proceedings of EP'98 and RIDT'98 conferences. Berlin: Springer-Verlag, pp. 294-304.

Fostervold, K. I. and I. Lie (1997). The ecological viewpoint - a new ergonomic construct. In the *Proceedings of the Fifth International Scientific Conference on Work With Display Units*, Tokyo 1997. URL: http://www.human.waseda.ac.jp/~wwdu97/

Hallberg, Å. (1992). *Typografin och läsprocessen*. Spektras Handsboksserie.

Hallberg, Å. (1994). Vilken stil är mest lättläst? *Aktuell Grafisk Information no. 236*

Haugen, A. (2001). *Fra bok til skjerm - Fortidens læremiddel inn i nåtiden? En studie av lesesvake elevers lesing i bok og på dataskjerm*. Master Thesis, Department of Special Needs Education, University of Oslo.

Harrell, W. (1999). Effective Monitor Display Design. *International Journal of Instructional Media. Vol 26, no 4*, pp 447-458

Lewin, C. (2000). Exploring the effects of talking book software in UK primary classrooms. *Journal of Research in Reading. Vol 23, no. 2*, pp 149-157.

McKenna M.C., D. Reinking and L.D. Labbo. (1997) Using Talking Books with Reading-Disabled Students. *Reading and Writing Quarterly. 13(2)*, pp 185-190.

Multifunk web-page (2001). URL: http://www.nr.no/imedia/multifunk/

Murphy, P. K., J. Long, T. Holleran andE. Esterly (2000). *Persuasion online or on paper: A new take on an old issue*. URL: http://www. coe.ohio-state.edu/pkmurphy/Research/Presentations/

Muter, P. and P. Maurutto (1991). Reading and skimming from computer screens and books: The paperless office revisited? *Behaviour and Information Technology, 10,* pp 257-266.

Muter, P. (1996). Interface design and optimization of reading of continuous text. In: van Oostendorp, H. and S. de Mul, (eds.), *Cognitive aspects of electronic text processing*, 161-180. Norwood, N.J.: Ablex..

Olofsson, Å. (1992) Synthetic speech and computer aided reading for reading disabled children. *Reading and Writing: An Interdisciplinary Journal, 4*, pp 165-178.

Quale, A. (2000) Second Information Technology in Education Study, *SITES, Modul-1, Nasjonal rapport*, Norge. September 2000. URL: http://www.ils.uio.no/forskning/sites/

Solheim, R.G. and F.E. Tønnesen (1999) *Kartlegging av leseferdighet og lesevaner på 9. klassetrinn* Stavanger : Høgskolen i Stavanger, Senter for leseforsking

Underwood, J. M. D. (2000) A comparison of two types of computersupport for reading development. *Journal of reading research in reading Vol. 23-2.*

Van Daal, V.H.P. and P. Reitsma (1993) The use of speech feedback by normal and disabled readers in computer-based reading practice. *Reading and Writing, 5 (3),* pp 243-259.

Van Daal, V.H.P. and P. Reitsma (2000) Computer-Assisted learning to read and spell: results from two pilot studies. *Journal of Research in Reading. Vol 23, Issue 2*, pp. 181-193.

Walker, S and L. Reynolds (2000) Screen design for children's reading: some key issues. *Journal of Research in Reading. Vol 23, Issue 2*, pp. 224-234.

Wise, B., R. Olson and J. Ring. (1997) Teaching phonological awareness with and without the computer. In: Hulme, C. and M. Snowling (eds.), *Dyslexia: Biology, Cognition, and Intervention*. London: Whurr.

Zellweger, P. and J.D. Mackinlay. (2000) The Fluid Reading Primer: Animated Decoding Support for Emergent Readers. In *Proceedings of ED-MEDIA 2001*, Tampere, Finland.