DYSLEXIA AND LEARNING COMPUTER PROGRAMMING

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ABSTRACT

This paper describes work done in generating guidelines for the development of computer science teaching materials, accessible through virtual learning environments (VLEs), aimed at addressing the needs of students with dyslexia. A review of existing guidelines and standards is made with respect to the particular needs of this group. A mapping of the features of dyslexia to the tasks involved in writing a computer program is developed. Preliminary evidence from the wider dyslexia community, particularly those with experience of computer programming, is presented to both support the mapping and draw out other important issues. The results of a preliminary interview with a member of the client group are presented. Finally, the intended direction of the project is developed in the light of these findings.

Keywords

dyslexia, computer programming, virtual learning environments

1. INTRODUCTION

This paper describes the results generated from an on-going LTSN-ICS Development Fund project, entitled *Impact of Learning Disability on the Study of Computing*. This paper reflects the work carried out on this project and its proposed development.

Leeds Metropolitan University (LMU) is a large (37000 students) university of applied learning, with a policy of widening access to higher education. A concomitant effect of its widening access policy is a relatively problematic retention rate, especially amongst students with a learning disability.

This project seeks to investigate the impact of learning disabilities on students who are following a course of study in the computing curriculum. In the first instance it will focus on issues surrounding dyslexia and computer programming.

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2. DEVELOPMENT OF GUIDELINES

2.1 Accessibility Guidelines

Many VLEs, including WebCT, the VLE implementation adopted by LMU, are web-based. As such, accessibility guidelines covering the provision of software, electronic based teaching materials and web-based resources are all applicable. As a first step in the development of any guidelines, therefore, a survey of the existing standards and guidelines was made and assessed in the context of the group in question.

There are three principal standard providers:

- IMS Global [5], have developed guidelines for accessible learning applications;
- the World Wide Web Consortium's (W3C) Web Accessibility Intuitive (WAI) has developed Web Content Accessibility Guidelines 1.0 [13];
- United States accessibility law, Section 508 [2] provides standards of accessibility of electronic products, including software and web resources.

Sloan provides a more detailed treatment of creating accessible e-learning content, including automatic validation tools [7]. Witt and McDermott also consider SENDA-compliance of web sites in further and higher education [7].

In addition to these more formal standards, there are many bodies that endorse them. Some of these bodies provide additional advice or guidance on how to achieve accessibility, notably:

- WebCT describes how it conforms to the standards [12] and provides advice to course designers on how these standards can be met when generating material.
- TechDis [10] describes seven precepts of usability and accessibility as well as describing the issues around each type of disability.

This list is far from exhaustive, but shows that accessibility and the web is quite rightly an important and well-documented issue.

2.2 Applying the Guidelines to Dyslexia

We are interested in the guidelines that may be particularly beneficial to computer science students with dyslexia. However, we also argue that all users will benefit from clear, transportable and accessible web pages. Following the *offshoot argument* [3], by catering for dyslexic students, non-dyslexic students may also benefit. Germane, recurrent themes that emerged from the standards and guidelines described above were:

- Allow the user to control the font sizes and styles, and colours of the background and text [5]. Serif fonts can be problematic for dyslexic users [6] and some combinations of contrasting colours can aid the reading of text (Draffan in [7]). Such preferences are individual so cannot easily be catered for by the author, although it may be possible to cater for them to some extent at least by allowing the end user to configure the default interface. In a web context the use of Cascading Style Sheets may be used to facilitate this [13].
- Design pages so that they can be read by assistive technology [2, 5]. A person with dyslexia may use a screen reader in order to hear elements or large bodies of text. This circumvents the requirement of reading and provides the same information in a more accessible channel (Beacham in [7]).
- Allow the user to turn off any animated or timed elements [5, 13]. Blinking or scrolling text could be difficult to read and any assumed timing in presented text could be inaccurate for someone having difficulty reading the text or who is taking longer to digest the information. Animated elements that are not textual may simply be distracting, making reading any text difficult [13].
- Use consistent layouts and formats. This reduces cognitive overload and allows the content to be the focus of attention [5, 13].
- Clear structuring of the text into left justified paragraphs [10].
- Provide context and orientation information [13].
- Avoid strongly coloured or patterned backgrounds, as these can effectively obscure the text [5].
- Use clear and concise language and easy to understand graphical cues [10].
- Front-load the information [13], since giving as much orientation and content information at the beginning of any section as possible can be helpful. This enables the user to understand what they are reading and why without committing themselves to a costly time reading and the danger of losing the thread.
- Use judicious white space so the text does not appear cluttered [10].
- Place hyperlinks at the end of a piece of text instead of scattered throughout. [5].
- Provide a brief description of where a link will lead and why it is there prior to the link [5].

We argue that all these measures would be of benefit to dyslexic users and also other users in general, improving the clarity of the page and allowing the user to focus on content.

3. MAPPING DYSLEXIA AND COMPUTER PROGRAMMING

The discussion so far has focussed on the general provision of e-learning material for students with dyslexia. In fact, we argue that the points apply equally to any web or electronic content for general use. In order to focus more specifically on the issues of particular importance for this project (i.e. the impact of dyslexia on computer programming), the skills required to be a computer programmer were matched by the authors to the features of dyslexia.

3.1 Features of Dyslexia

Dyslexia is commonly defined as a mismatch in intelligence and language ability [1]. The diagnostic tests vary with the age of the subject and the perspective of the assessor, who is usually an educational psychologist [4]. The expression of dyslexia in each individual is also very varied; consequently the resulting profiles are very individual. The common theme however is to gain a profile of general intelligence and language ability and identify a discrepancy. The indicators of dyslexia are [4]:

- poor handwriting;
- poor spelling;
- poor reading;
- poor composition and writing skills;
- poor short term memory;
- poor organisation.

These are generally skills associated with processing sequenced symbolic information, typically designated left-brain activities.

Brain scanning images support the idea that people with dyslexia lack distributed automatic processing of languages and consequently expend a great deal of energy in the frontal, strategic parts of the brain, compensating for this [8].

3.2 Disability and Difference

It was felt that there was a danger that the research might emphasise merely the problems and that the exercise might become overly negative. An alternative model of dyslexia to special learning disability is to see it as an alternative learning style. This moves the perception of dyslexia from that of a disability to that of a difference [11].

Dyslexics have a difficulty in processing sequenced symbolic information, which is very much a leftbrained activity. This is a disadvantage in a society that predominantly processes information and more importantly educates in this way. The other side of this coin is that dyslexics may be stronger at [4]:

- visualisation,
- spatial awareness,
- creativity,
- lateral thinking.

These are typically designated right-brained activities.

Whilst this does not in any way take away from the difficulties dyslexic students may have faced throughout their education, these may be abilities that are advantageous in particular situations, compensating for some difficulties.

Although this model of dyslexia is probably an oversimplification (as is the translation of abilities to dominant hemispheres of the brain), it does allow a more rounded view of the issues and perhaps a more empowering and positive model to present to the subjects. The right and left brain labels will be used in this paper as a short hand for the associated skills.

3.3 Process of Programming

The steps involved in the design or problem-solving cycle can be summarised as follows [9]:

- recognition of a need;
- problem definition;
- synthesis;
- analysis;
- implementation;
- evaluation.

The particular steps may have specific programming connotations associated with them:

- *synthesis* involves conceiving what is required of the whole program, class, method, at different scales of the program;
- *analysis* involves what individual classes, methods or code will be required to create the whole functionality, again at different scales of the program;
- *implementation* involves coding and correction until the program both compiles and functions in the expected manner;
- *evaluation* involves the testing, and user trialing of the program and may engender further refinements or even a re-conceptualisation of the problem.

As this model of the process makes clear, the generation of a computer program and its subsequent correcting and testing require a great deal of logical and organisational skills combined with a precise expression of syntax and variable names.

3.4 Interaction

From the above it may be seen that the general design and problem-solving tasks involved in programming require the right-brained skills, which may be strong in dyslexic programmers. However, the more specific programming skills, especially those associated with generating and correcting code, require skills associated with the left brain. Additionally synthesis, looking at the program as a whole and how the elements interact seems a holistic activity, associated with right brain activities. The skills required in analysis are also associated with left brain activities.

The matrix in figure 1 was generated by considering tasks involved at each stage of the programming process and how the features of dyslexia may affect them. This model requires validating with the experiences of computer programmers with

Key to Interactions	
✔	Strong Positive
✓	Positive
	None
×	Negative
✖	Strong Negative

Features of Dyslexia		Steps Involved in Generating a Computer Program: Recognition of Need	Problem Definition	Synthesis	Analysis	Implementation	Evaluation
Negative	Handwriting						
Negative	Spelling					✖ Variables	
Negative	Reading						
Negative	Writing						
Negative	Short Term Memory			×	×	✖ Changes	× Tracking
Negative	Organisation			×	×	✖ Structure	× Planning
Positive	Spatial Awareness						
Positive	Visualisation	✔	✔	✔			✓
Positive	Creativity	✔	✔	✓			✓
Positive	Lateral Thinking	✔	✔	✓			✓

Figure 1: Matrix of Interactions between the Features of Dyslexia and the Process of Programming

dyslexia.

4. Preliminary Evidence

4.1 The Source

The mapping exercise so far has developed a hypothetical model (figure 1) in order to focus on the issues of the project. This will be used as part of the interviewing procedure during the needs assessment. In order to solicit relevant opinions on the issues associated with the project in general, and to empirically study the hypothetical model in particular, a request for information about people's experience with programming was posted on an e-mail forum that dealt with issues of dyslexia. There were replies from five correspondents (A-E) from this request and an additional relevant message (F) was posted prior to the inquiry. Comments from these sources will now be used to support the mapping process and identify any emerging issues.

4.2 Support of the Mapping

The correspondents all seem to prefer the problem definition and synthesis stages:

“The parts that I mainly enjoy is the initial thinking through the problem and structuring the problem and how to tackle it.” Correspondent A, a postgraduate student, self-taught scientific programmer.

“I have no problems designing systems, thinking up algorithms and such.” Correspondent B, a postgraduate computer science student.

Visualisation plays an important role in these stages:

“Programmers tend to be visual problem solvers.” Correspondent D, a professional programmer.

“It is definitely an advantage to be able to visualise a problem.” Correspondent E, a professional programmer.

Difficulties seem to occur during the implementation stage, where spelling and short-term memory become an issue:

“Variable names sometimes cause problems as I don’t remember how I have spelt them each time. I often get problems with putting loops inside out or in the wrong order. The other and perhaps the main problem is trying to remember what things need doing in the program” Correspondent A.

These and the other comments all broadly support, we argue, the model postulated.

4.3 Emerging Issues

One of the issues that emerged was the importance of the tools that were used to assist programming:

“I find the coloured code editors really helpful.” Correspondent A.

“Syntax coloring is heaven.” Correspondent B.

The choices however are very individual:

“Things I've found that helped: Visual development environments”, Correspondent D.

“I prefer working in console mode (Linux) less distractions from other things on the screen => less errors.” Correspondent B.

4.4 Dyslexia as a Boon to Programming

Interestingly, all the respondents were very positive about programming with dyslexia, most recognised the issues and problems they faced but overall saw dyslexia as an aid to their programming.

“I think in the nature of programming attracts the abilities that dyslexic people have…” Correspondent A.

“… I think Dyslexics benefit from their ability to *picture* things, which gives an advantage to all things Computer…” Correspondent C, an attorney and senior executive in the software industry.

“Bar the inconvenience of more syntax errors, silly slips and omissions, I'm very happy to be dyslexic when programming.” Correspondent D

“Dyslexia and programming has both disadvantages and advantages!” Correspondent E.

Some even recommended it as a career for people with dyslexia:

“CS is indeed a good vocation for dyslexic people”, Correspondent B.

“Programming is an arena where dyslexics can really flourish, … I would always advise a dyslexic to look at programming as a possible vocation…” Correspondent D.

Correspondent F, an ICT consultant reports of someone:

“… who was assessed … as 'severely dyslexic'. She is now … a senior programming consultant with her own company … in her working group of seven people, six are severely dyslexic”.

4.5 Caveat

It has to be stated that these views are not necessarily representative of the community of programmers with dyslexia at large. There are many levels of self-selection in this extremely convenience led sampling:

- People electing to join such a forum may be better disposed to their dyslexia.
- Those that have not been drawn to programming or gave up very quickly may not have responded.

- Those who responded may be prompted to do so because they do feel positive about computing and dyslexia.

Nevertheless, we believe that the fact that these views were expressed is worthy of note, and that their contribution is very valuable.

5. PRELIMINARY INTERVIEW

As part of the needs assessment, a number of dyslexic students will be interviewed. A preliminary interview was conducted with a student, prior to the finalisation of the structured focused interviews.

Interviewee M, a final year multimedia student, confirmed that the most immediate impact of dyslexia on his programming was associated with memory and spelling. He found it hard to remember details of the code and its ordering. He also found that getting the case of variables correct and mixing up letters in long variable names was problematic.

He found that coloured syntax and predictive typing features embedded in Integrated Development Environments were a great help.

Unlike the correspondents, he did not view his dyslexia having any compensation.

His principal concern was not programming but learning either in lectures or from textbooks. He preferred to attend lectures as he found seeing and hearing the information more effective than reading it from notes or a book. He advocated either filming or recording lectures, as this made use of preferred communication channels and also facilitated reviewing more difficult aspects of the lecture.

6. SUMMARY AND FURTHER WORK

The above discussion ignores the auxiliary skills that are also required in order to learn how to program different languages, algorithms or conceptions. These skills may well need to be considered in the remainder of the project. As was seen in the preliminary interview, the delivery of teaching materials was an important issue.

The positive response of the correspondents suggests that far from looking at dyslexia as a problem in this field, it may actually have beneficial consequences. Indeed, it may also be beneficial to dyslexic computer science students to be made aware of these positive views. This may have the benefit of providing added impetus to overcome initial problems when learning to program. It appears that programming may be an arena where they can exploit their strengths, circumvent their weaknesses and even be empowered to create their own Assistive Technologies.

To quote from Correspondent D:

“Make your own tools!!! Voice recognition, spell checking, data storage, visual modeling. These functionalities are all at your disposal as a programmer, and they're all useful to a dyslexic. If you need to be reminded to do things, want to store/call phone numbers by voice command, make your own contact management system that suits you!”

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8. REFERENCES

[1] British Dyslexics, *What is Dyslexia*, Web Site. http://www.dyslexia.uk.com/

[2] Center for IT Accommodation (CITA), *Section 508 Standards*, Web Site. http://www.section508.gov/ (1998).

[3] Edwards, A. D. N., *Extra-ordinary Human-Computer Interaction, Interfaces for Users with Disabilities*, Cambridge University Press (1995).

[4] Hammond, J. and Hercules, F., *Understanding Dyslexia*, Web Site. http://www.shefc.ac.uk/-content/library/dyslexia.html

[5] IMS Global Learning Consortium, *IMS Guidelines for Developing Accessible Learning Applications, Version 1.0*, Web Site. http://www.imsglobal.org/accessibility/index.cfm (2002).

[6] Parker, A., *Fonts for Dyslexics*, Dyslexic.com, Web Page. http://www.dyslexic.com/sassoon.htm (2001).

[7] Phipps, L., Sutherland, A. and Seale, J., *Access All Areas: disability, technology and learning*, Association for Learning and Teaching (ALT), JISC, TechDis http://www.techdis.ac.uk/-accessallareas/AAA.pdf (2002).

[8] Rose, D. and Dalton, B., Using Technology to Individualize Reading Instruction, Block, C. C., Gambrell, L. B. and Pressley, M. (eds), *Improving comprehension instruction: Rethinking research, theory, and classroom practice*, San Francisco, Jossey Bass Publishers, (2002).

[9] Shingley, J. E. and Mitchell, L. D., *Mechanical Engineering Design*, New York, McGraw-Hill (1993).

[10] Technologies for those with Disabilities and/or Special Needs (TechDis), *Web Accessibility & Usability Resource*, Web Site. http://www.techdis.ac.uk/seven/

[11] Turner, J. and Wooden, K., *The Turner/Wooden Method*, Web Site. http://www.dyslexiavictoria.com/

[12] WebCT Inc., *WebCT Accessibility*, Web Page. http://www.webct.com/products/viewpage?name=products_accessibility (2001).

[13] World Wide Web Consortium (W3C), *Technical Reports and Publications*, Web Site. http://www.w3.org/TR/