Use of Pervasive Tools to Help Students with Organisational Dyslexia

Clare Hooper[1]

[1] School of Electronics and Computer Science,
University of Southampton, SO17 1BJ, United Kingdom
cjh302@soton.ac.uk

Abstract. This report considers pervasive and mobile tools which might aid students with issues relating to organisational dyslexia, particularly those of memory, orientation and organisation. Relevant techniques and technologies are described, and social aspects are considered: these include forms of communication (synchronous vs asynchronous, text-based and non-text-based), types of learning and issues of learned helplessness. A high-level vision of a potential solution is presented, along with other paths for future work.

Acknowledgements. With thanks to Mark Weal for invaluable guidance and feedback.

1 Introduction

Between 4% and 10% of the population are affected by some form of dyslexia [24], which impacts on everyday and academic activities in various ways. This paper outlines the current technological landscape of tools for dyslexic students, and considers where future work might be focused.

A great deal of current work on dyslexia and technology considers interfaces, yet other impacts of dyslexia (on memory, orientation and organisation) have received less attention. Examples of these impacts include remembering which books to take to university each day, recalling which bus to get (from where and when), which building and room a lecture is in, and when coursework is due in.

First, this paper outlines what dyslexia and related conditions are, and common symptoms. People with dyslexia develop and use various coping techniques to 'keep up' with their peers and minimise the impact of their condition: the second section briefly explores these techniques. From here, this work considers existing technologies, which help or might help dyslexic students, particularly pervasive and mobile tools: two PDA-based student organisers are described. Next, communication is considered, including the impact of text-based interactions. The sixth section discusses learning, considering types of learning and mobile devices; scaffolding;

learning and technology; and Virtual Learning Environments (VLEs). An initial 'solution' is then outlined, before future work is set out and conclusions are given.

It should be noted that the term 'dyslexic' is used to refer to someone displaying common symptoms and difficulties associated with dyslexia, and not necessarily a student who has been explicitly statemented (assessed by an Educational Psychologist) as dyslexic.

2 What is Dyslexia?

This section outlines the symptoms of dyslexia, and two related conditions: dyspraxia and dyscalculia.

Dyslexia is a pattern of difficulties of which the most obvious are significant, persistent problems in the learning to read, write and spell. The following may also be affected: numeracy, motor skills, spoken language, information processing, memory and organisational skills. Pupils with dyslexia may be identified by their ability to demonstrate orally their conceptual understanding. There will be significant discrepancies in performance between the area of difficulty (e.g. literacy) and other skills. Dyslexia occurs across ability levels and socio-economic groupings.

(Partnership: Parents, Professionals and Pupils Fife Education Authority, 1996)

Dyslexia, along with other learning difficulties, has many symptoms that affect people across a continuous scale [43]. The most documented and supported symptom is that of literacy, with reading and spelling referred to as core problems. Other less documented and supported issues include memory, orientation and organisation [43]. Work has suggested that the most important aspects of dyslexia during university-style lectures are memory, speed of processing and multi-tasking [24]. During lectures, students might struggle to listen to the lecturer, remember what is being said, decide what to write down and actually make these notes. Other issues include dealing with non-regular meetings, recalling instructions, suggestions and arguments [45]. All of this affects results in individual, interpersonal and environmental stress, affecting study, relations with peers, and self-esteem.

Dyspraxia, a related condition, is an inability to plan and carry out sequences of coordinated movements to achieve an objective [11]. It is similar to the organisational inabilities of dyslexia, but with physical, rather than mental, constraints. Dyspraxic people find information from the senses and their integration to be poor, particularly in terms of balance and self in space. An estimated 1/12 of the population is dyspraxic.

Dyscalculia is a learning condition specific to understanding and manipulating numbers, acquiring arithmetic skills [29]. It is linked with dyslexia and dyspraxia. Problems arise with mathematics, time and measurement.

Overall, this spectrum of learning difficulties causes common issues, including self-image and confidence, social integration, academic needs, physical education needs and day-to-day organisational skills [11]. Although this paper focuses upon organisational aspects, the broader context of these symptoms is still relevant.

3 Techniques

Here, existing techniques to deal with dyslexia and like conditions are considered; this includes teaching methods, learning methods, and technology-specific learning methods. Techniques to create an effective e-learning system are also outlined, and media combinations are discussed.

Existing techniques which deal with dyslexia are not generally technology-based, although technology is sometimes used. Teaching methods include conveying information through [2]:

- Videos
- Colour
- Stories
- Handouts
- Worksheets
- Multiple-choice questions
- Mind maps (where ideas are noted and linked with lines)
- Cloze procedures (students supply missing words from a passage)

Dyslexic methods for learning and recording information include [28]:

- ‘Box and underline’ technique to understand essay questions
- Physical space (placing paper in different areas of a room according to the information represented)
- Colour (highlighting, or differentiating between notes, sources, prose to check and final prose)
- Bullet points
- Asking friends to check work

Systematic control of the work is essential [28], and frameworks can help: students are sometimes encouraged to use one A3 sheet to record whole essay plans. The sheet is a framework for the essay, encouraging student focus on an overall view.

Dyslexic methods which make use of technology include use of [28]:

- Text-to-speech
- Talking spell checkers/thesauruses
- A split screen for notes and prose
- Notes to self and audio triggers in Microsoft Word
- Cut and paste
- Speech recognition

It has been noted that e-learning can lack a vital ingredient of the learning process – fun [8]. Only a few of the techniques and artefacts discussed in this paper constitute e-learning, yet this is an important point. Suggestions for improving e-learning include:

- Allow the sharing of ideas
- Require regular fixed deliverables
- Support a healthy group dynamic
- Provide feedback
- Keep records
- Appoint a ‘cheerleader’ (a member of the core community who brings interesting questions, topical issues and other new material)

- Give rewards
- Keep to a narrow topic
- Utilise a good design

Another concern with software tools involves media combinations. Work has examined what combinations (e.g. text, text and audio, text and diagrams) work best for computer-aided assessments [4]. Interestingly, the work concluded that although it seemed that use of combinations made misreading or misunderstanding of questions less likely, time taken and overall performance were not affected according to the media combinations used. The study did not include sufficient dyslexic participants to compare differences between those students and non-dyslexic students; additionally, dyslexic students perceived increased usefulness of the combinations.

4 Technology

This section considers relevant software and hardware, before discussing two PDA-based student organiser systems.
It has been noted that existing technology for those with Special Educational Needs (SEN) is largely limited to aids for memory, reading, writing and arithmetic [43]. Organisational aids appear to be few and far between.

4.1 Software

Much existing software concerns itself with HCI-related issues: making content, colour and layout accessible to dyslexic (and standard) users [3] [9] [13]. A key finding is that different configurations suit different users. Visual aids such as the magnifying tool ScreenRuler [40] exist, whilst other tools include text-to-speech software such as BrowseAloud [32] and SpeakOUT [41]. Study skills software includes Nessy BrainBooster [36], and mindmapping software targeted at dyslexic users includes Mindfull [35] and MindGenius [12]. Some of this software can be of use to the non-dyslexic student. Broader tools include 'life skills' software, supporting users in certain areas, such as time and simple sequences [39], shopping, travel, banking etc. [37] and spelling, cooking and use-by dates [38]. These three examples are not designed to support the dyslexic student, but someone with heavy organisational dyslexia might benefit from such support.

The Mobile Learning Engine [22] is an Austrian technology, a learning environment tailored to suit the limitations of mobile phones: small screens, differing input methods, low processing power and differing operating systems. The MLE affords images, links, audio/video playback, various types of question (checkbox, order, cloze, graphical) and a help system.

The MLE uses MILOs (Mobile Interactive Learning Objects) [17], which are structured similarly to LOs (Learning Objects). Differences are in the presentation and volume of information: small mobile phone screens prompt heavier usage of multimedia (figures, pictures, video, audio).

There has been discussion of microportals [20], systems for use with mobile phones. Design considers web browser type and device characteristics (resolution, colour depth, input style, etc),. The are extensible, so adding a new device involves a database update and adding a line of code to detect that device type. It is possible that these might be used to represent information to dyslexic students.

4.2 Hardware

Smartphones combine telephone functionality with that of a PDA, and allow the installation of additional applications. Current relevant examples of usage (beyond the MLE above) are limited. Text input methods vary widely: Figure 1 demonstrates the same key layout on three different phones [17]:

Fig. 1. The same key layout on the Nokia 3660, Siemens SX1 and Nokia 6600 [17].

The SMS Multi Tap system provides text input. The key marked with the letter is pressed one or more times; to select two letters on the same key (e.g. 'a' then 'b'), users must wait for (or kill) a time-out [17]. Alternative input methods on PDA-like smartphones and PDAs include the pen-based Graffiti system, which simplifies Roman capital letters to one stroke, and scaled-down soft QWERTY keyboards, which may be attached. All three methods are easy to learn, and yield between 8 and 30 WPM (Words Per Minute). Comparatively, normal keyboard use averages 65WPM, and speech recognition 39WPM [19]. A solution which allows note-taking should consider achievable WPM.

Voice input is standard for any form of telephone: dictaphone functionality might well be of use to dyslexic students, although it is not suitable for lectures.

Smartphone OSs include Symbian, Palm OS, Windows Mobile, BREW, and Linux. Although there are no formal standards, Java and XML are ubiquitous.

PDAs may also be considered. Again, OSs vary (including Palm OS, Windows Mobile, RIM for the BlackBerry, various Linux, Symbian OS). Java and XML are widely used. PDA issues include remembering to charge them (loss of charge means loss of data and software), synchronisation, connectivity and physical storage. Previous work designing PDA applications suggests that flat menus, single column layouts, and simple navigation aid the end user [16].

Various forms of wireless connectivity are available, including Bluetooth, infrared and WiFi. Each variety has different strengths and weaknesses, relating to cost, bandwidth, latency etc. Choice of device is best left to individual users.

Few papers appear to study dyslexic uses of mobile devices, although it would appear that the constraints of these (small screens requiring that information is given over several channels, and with a low proportion of text) suit issues of dyslexia. Three examples of technical help children are:

1) AlphaSmart: a portable system with a fullsize keyboard and LCD screen, running limited software. The devices are large, easy to use and robust. However, the £219 system is designed to remain within the school [1].
2) Reading Pen: Oxford Edition. This scans printed words, displaying and speaking the words aloud. It contains definitions to 240,000 words, acting as a portable dictionary [10]. This is ideal for students whom have difficulty with large words. However, it is not robust, and may be cumbersome to use. It costs £169.
3) Franklin Collins Dictionary and Thesaurus [34] defines 170,000 words, with 150,000 synonyms and antonyms. The device sells for around £25.

Line readers, such as the £25 Visual Tracking Magnification Line Reader [42], exist. The magnifier is partially shaded to mask glare, and is designed to help dyslexic people as well as those with visual difficulties.

Various m-learning systems exist, including the PDA-based MAPS (Memory Aiding Prompting System), part of the CLever (Cognitive Levers) project [5]. This system prompts its charges to perform particular tasks (e.g. catching a bus), using visual and audio cues. Although MAPS addresses issues which can be relevant in the context of organisation dyslexia, it is focused elsewhere, ignoring dyslexic issues such as multimodality, note-taking in lectures and co-ordinating university resources.

PDAs usage in schools can be highly successful [27], although Perry's work did not consider dyslexic students. Tasks included beaming information between users, reading ebooks, diary functions, note-taking, creating documents, web browsing, taking measurements, and field trips. Much of this functionality is relevant to university-level study. Additionally, dyslexic students find PDAs to be an extremely valuable resource [33]: advantages include portability, legible note-making and reminders/calendar functions; disadvantages include being unable to make diagrams or mindmaps, and losing charge and data.

4.3 Similar Systems

It has been suggested that although PDAs may boost motivation and responsibility, and help organisation and learning, no published studies relate to 16 - 24 years olds who are disengaged or with literacy needs [30]. Nonetheless, several PDA-based student organisers exist [15] [7], although neither explored the dyslexic perspective. The first system included timetable and module information, but lacked collaboration and mapping tools; issued include a lack of clarity about ownership. Trials were limited, with 12 students each being given one task to perform with the system.

The second system underwent more comprehensive testing, with 17 students each given a PDA for one year. Software included:

- time manager (teaching periods and deadlines)
- course manager (course materials)
- communication centre (email, IM, contacts)
- two mapping tools (visual map of notes and documents)

Features included a 'today' screen (timetable information) and course navigation by module. Course material was in PowerPoint and eBook formats, optimised for a small screen, and allowed annotation, saving and sharing. The students were told to use the system for study and leisure, and to add any software they wanted.
Evaluation was conducted using questionnaires, focus groups, videos and log books. Negative points included device size/weight, low memory (64MB), and the issue of losing software if batteries emptied. The back-up process was found to be slow and unreliable, and a fold-away keyboard was desired. The students found the concept mapping tools difficult to learn, and disliked that the tools saved to non-exportable formats. However, students found the timetable, web access, IM and email positive. Over time, usage of course content and mapping tools declined, but this may reflect high levels of project work. Students remarked that the course materials were very useful for learning. It was suggested that it was easier to retrieve content online, not through synchronisation, and noted that much content was not optimised for the tool, and so was hard to read. Additionally, timetable information was not provided consistently, nor was content standardised.

5. Forms of Communication

Various approaches to CMC (Computer-Mediated Communications) exist. Learning is a fundamentally asynchronous activity, which may go on during any spare moment of time: this allows use of asynchronous communications methods.
Asynchronous non-text-based communications are not considered, because within the educational context (and outside the context of art), non-text-based communications appear to be limited to lectures, seminars and meetings – all synchronous occurrences.

5.1 Synchronous (Real-time) Text-based CMC

Various forms of real-time, text-based CMC have evolved. These incorporate Instant Messaging (IM), and include:

- MUDs (Multi-User Dungeons), multi-player games including IM chat rooms
- MOOs (MUD Object Oriented), where users may use OO programming to create new rooms and objects or alter interfaces
- MUSHes (Multi-User Shared Hack), more socially-focused. Again, coding may edit the MUSH world
- MUVEs (Multi-User Virtual Environments) [21]. Users simultaneously access virtual architectures to learn/interact with digital artefacts (may incorporate graphical and audio artefacts)

These systems provide a generally negative experience for dyslexic students [45], largely because there is no time to process and exchange information. Many dyslexic props exist (Section 3, Section 4), yet issues of multi-tasking and speed of processing remain. The core use of IM does not allow an easy workaround for these issues. (Internet Relay Chat presents similar issues.)

5.2 Synchronous Non-text-based CMC

Examples include Skype, based on VoIP technology. Such systems have not been tested in this context, but it appears likely that dyslexic students would perform more comfortably and competently than when using IM-based systems, as literacy issues become irrelevant. Issues common to standard face-to-face discussion (e.g. recalling agreed meeting dates or deadlines) would remain.

5.3 Asynchronous Text-based CMC

These include forums and wikis, which do not update in real-time, and allow greater depth of thought in replies. Use of blogs for teaching has recently been considered [44]. Asynchronous communication seems better suited to dyslexic users, and encourages deeper reflection, considered arguments and use of references.

6 Learning

This section discusses types of learning, scaffolding, technologies which support learning and Virtual Learning Environments.

6.1 Types of Learning

Types of learning include [25]:

- Behaviourist: learning as a change in the learners' actions
- Constructivist: learners construct new ideas
- Situated: learning in an authentic context and culture
- Collaborative: learning through social interaction
- Informal and lifelong: learning outside a dedicated learning environment and formal curriculum

Mobile devices are suited to many kinds of learning [25], as they are portable (allowing situated learning) and social (allowing collaborative learning and information exchange). Content may be tailored to encourage the desired type of learning.

Given the presence of individuals or groups engaged in learning, any place can become an ad hoc learning space. A solution should allow for abrupt stops and starts of learning (e.g. a user learning as they wait at a bus stop and halting on the bus' arrival).

Inclusion is an important facet of learning, and is an aim of the CLever project [5]. Inclusion is an overall approach taken by organisations and institutions, whereby procedures and processes are designed to be available to and usable by all personnel, regardless of physical or mental requirements.

6.2 Living or Learning?

Tools may be aids for living, or for learning. Tools for living are external artefacts that empower human beings to do things that they could not do by themselves – examples include eyeglasses and hand calculators [5]. By contrast, tools for learning (‘scaffolding’ tools) help people learn a new skill, without remaining reliant upon the tool once learning is complete. For example, scaffolding may hide some of the complexities of a problem, so that students may remain focused on the big picture and achieve the main goal of the exercise [14].

Learned helplessness is the phenomenon whereby people become unnecessarily dependent upon a tool, using a learning tool as a living tool – for example, an over-reliance on calculators may result in someone not learning arithmetic, when they are entirely able in this area [5]. This issue may be examined further:

Some tools are ambiguous: for example, mindmapping software can teach the mindmapping technique for use with paper and a pen, but the user will still require an actual tool to follow the technique. Text-to-speech software might be used to help learn proof reading techniques, and a dictionary/thesaurus might teach a broader vocabulary. Yet these tools might also be used in the ‘living’ sense, with users coming back to them time and again. MAPS [5] is a learning tool, reducing the granularity of instruction as time passes: for example, it first tells its user each step required to reach a bus stop, but gradually fades information out, until it simply reminds the user: “Take the number 10 bus at 1205.” Scaffolding tools empower their users and increase their skills, yet living tools are sometimes required. For example, no one can ‘learn’ to magnify text without a magnificer, and dyslexic students cannot ‘learn’ to view standard pages in the colour shades which best suit them. The proposed possible solution for this area (Section 7) considers the issue of scaffolding.

6.3 Learning and Technology

Both technology and learning have undergone trends towards personalisation [31], which is advantageous for the dyslexic student. Various types of technology support learning [21]:

- Traditional technologies (interactive whiteboards, projectors)
- Virtual/immersive environments (multi-user environments, simulators, mixed reality systems)
- Mobile learning technologies (laptops, tablets, PDAs)
- Ambient learning technologies (enabling active, responsive environments that play a part in the learning process)
- Infrastructure/communication technologies (wireless networks, peer-to-peer software, Bluetooth)

A solution may draw on several of these – a mobile solution might communicate with ambient and virtual environments, using infrastructure technologies. It is highly unlikely that traditional technologies will be displaced by any solution.

E-learning might also be considered: e-learning is computer-based learning which supports interactivity beyond that provided by a single computer. As such, few of the above technologies are forms of e-learning, although mobile systems (allowing access to remote information) support this concept. Access to further resources and social interactions might make the learning process more efficient [8]. However, e-learning environments such as VLEs (Section 6.4) have a reputation for bad design [6]: e-learning offers advantageous aspects, yet cannot be blindly incorporated as 'a good thing'.

6.4 Virtual Learning Environments

A VLE is software which facilitates teaching by managing and presenting material to students via web pages. This affords distance-learning, available at any time [6]. Three types of VLE use have been suggested [26]:

- Content and support: printed/online prepared content, online support
- Wrap-around: mixture of prepared content and online collaborative learning (discussions, debates etc.)
- Integrated: mostly collaborative learning, learners determine most content

This reflects a spectrum of approaches, from minimum to maximum student input.

VLEs are often designed by non-educationalists, who possess a weak model of learning on which to base designs [6]. For example, IM might be used where asynchronous communications would be more appropriate (Section 5).

Cooper suggested various facets of effective VLEs [6], including:

- Simple interface
- Multimedia communication
- Multiple communication channels (e.g. public, private, synchronous, asynchronous, audio-visual, text...)
- Interface conveying the whole picture (a meaningful, high-level narrative)
- Creation of groups/information by students and tutors (empowering students)
- Social and academic interaction: an integration of personal and academic interchange

Wright outlined three areas of web-based learning and dyslexia [46]:

1) Impact: the system's effect. For example, enabling users to read notes before lectures empowers them; conversely, timed online exercises increase pressure and do not account for dyslexic learning styles. Dyslexic students may prefer anonymity in discussions and feel inhibited about synchronous chats (due to literacy issues).
2) Accessibility: customisability helps meet individual needs (e.g. reduced contrast is useful for dyslexic users, but not for the visually impaired).
3) Navigation: some dyslexic students are insecure, and want confidentiality. They don't want to log on to a system, as they may be mocked or forget passwords.

Design considerations include modes of learning, communications and web site aesthetics and accessibility: e.g. wrapping a simple, accessible page in a sophisticated page with a style sheet.

7 A Solution

Here, the high-level design of a potential solution is presented, based upon the information given. Appendix A summarises the tools and techniques outlined, and their advantages and disadvantages.

Certain non-technical questions must be considered before the design is implemented. These consider device ownership and funding. Are all dyslexic students eligible for funding to get a PDA? Will they buy them anyway? Can they afford to? It is unlikely that a student will own both a PDA and a smartphone, which is a reason to cater for both.

Figure 2 shows a system overview.

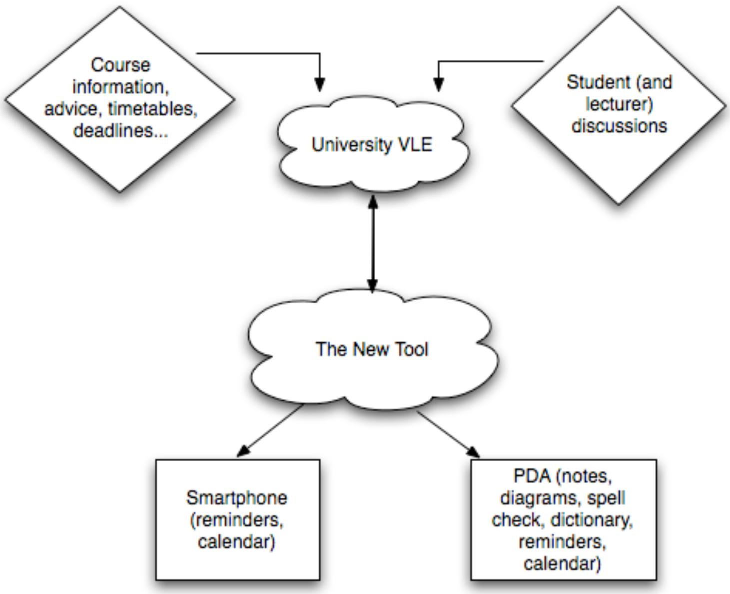

Fig. 2. A broad view of an initial solution.

Features include customisable reminders (vibrate, message, sound), and splitting coursework reminders into personalised sections (e.g. a student may decide to spend two weeks on research, with a reminder to plan essay structure at the end of this time). Reminders might also list which textbooks to take into university each day. The ability to make diagrams and mindmaps is a strong feature, as these techniques are rarely supported.

The solution integrates with VLEs and mobile devices. Communication with mobile devices might be achieved through use of the smartphone-compatible MLE. Simple use of Java and XML seems best, as this allows the system to support a wide range of hardware. Device choice is left to the user, because different people work in different ways. This means that the user chooses their PDA/smartphone, input technique and connectivity type. Achievable WPM depends upon the device and chosen input method.

A PDA is more suitable than a smartphone, as text and diagrammatic input is far simpler with PDAs, which also offer greater (and more suitable) processing power for this kind of application. However, smartphones can support a lightweight version of the system, focused not on note taking and other input, but upon succinct output. VLEs integration provides calendar information and deadline reminders.

The system can be IMS-compliant [18], built to open learning technology standards: this allows integration with tools such as Blackboard and WebCT. Many VLE choices exist (overall system choice; level of student interaction to encourage; communications supported; administrative decisions): VLE decisions are left to each organisation. Similarly, issues around providing positive e-learning experiences are beyond the scope of this work, at this time.

It has been noted that dyslexic students may not wish to log on to systems [46]: VLEs all require login, and this system requires login in order to discern, amongst other things, which information may be displayed. Reluctant students will already have coping mechanisms (from use of webmail, IM, forums, VLEs and other groupware), perhaps setting their devices to remember their details. It is possible that Wright over-estimates the importance of this issue to dyslexic people, or under-estimates the necessity of logging into systems. Future work might include gathering opinions and suggestions about this topic.

VLE linkage offers the opportunity to automatically gather timetables and deadlines. The system could link to specific coursework guidelines and general advice on study skills. Integration with existing university systems minimises development time, and creates no knock-on effects for standard VLE users.

The system aims to be simple and inclusive, by ensuring that the content is accessible and can be customised by individuals (e.g. offering stylesheets). Multimedia support (videos, colour) can help dyslexic students in particular. LOs and MILOs, through use of XML, allow appropriate presentation, which varies according to the device used. These objects also support multiple-choice questions, cloze procedures, and other dyslexic teaching techniques.

Asynchronous text-based communications appear to be best suited to this environment, not least as learning is an asynchronous activity: wikis, forums or blogs may be used. The system model assumes that this communication takes place on the VLE ('Student discussions').

The system supports various forms of learning, including constructivist (constructing ideas, prompted by content), situated (in context) and collaborative (discussion-based).

Scaffolding requires further investigation. Some mobile features support scaffolding: connectivity, context sensitive data and personalisation. Early user trials might investigate how the system is used: e.g. for diary functionality, reminders and communication (a living use), or for different types of learning (a learning use). This helps consider the scaffolding implications of the system.

The solution requires a change in the overall teaching approach. Lecturers will be required to maintain up-to-date coursework deadlines and advice, whilst students cannot afford to become entirely dependent upon the device: meetings may be arranged off-the-cuff, whilst the date of presentation-based assessments (traditionally allocated further into courses) might easily slip through the net of the VLE information.

8 Progressing the Design

Refining, implementing and testing the design presented represents a significant amount of future work. This section considers additional research considerations, which might progress in parallel to work on the system above.

Work might consider the affordances and constraints of handheld devices, in terms of functionality, methods of usage (both dyslexic and non-dyslexic) and HCI. Current trends suggest the convergence of PDAs and smartphones: further questions might relate to infrastructure standards (methods of connectivity – Bluetooth, WiFi, infrared etc.), cross-compatibility, and adherence to semantic standards. Looking further ahead, visions for the semantic grid suggest the spread of pervasive, PDA-like devices, boding well for systems such as this.

Other current work which may consider areas such as the Memories for Life project [23], where future artefacts might include lecture recordings, user prompts and other items of use to dyslexic students.

The system may useful to students with related SEN. The physical coordination needs of people with dyspraxia present a fresh set of usability issues, many of which relate to hardware. Those with dyscalculia might find particular value in personalised date formats (e.g. substituting "5pm 2/5" for "Five pm, on the second of May"), and the ability to check calculations. Further work might examine what other sets of users might find particular use in the system, and what adaptations would benefit these people.

9 Conclusions

This paper considers the use of pervasive technologies to help students with organisational aspects of dyslexia. Dyslexia itself consists of a spectrum of difficulties, which may cover several areas: the focus here is upon memory, orientation and organisation. Dyslexic students use a wide range of techniques (paper-based and computer-based) to cope with their condition: these techniques are described, as are relevant technologies. Two PDA-based student organiser systems are described. This paper considers forms of communication, and what is appropriate a) to a dyslexic student and b) in an educational context. Types of learning are discussed, as is learned helplessness, learning and technology and VLEs. A design is presented and additional paths for future research are suggested.

The system design attempts to incorporate the best of the tools and techniques discussed in this paper, as well as considering future aspects, such as PDA and smartphone ownership. A key point is the importance of customisability, which is supported by current web technologies such as stylesheets. Non-dyslexic students, as well as those with specific organisational needs, could effectively use this solution.

An important aspect is ensuring that relevant students are consulted and considered throughout any future work and prototype design. This area represents the boundaries between two areas of research: pervasive technologies and dyslexia assistance. Currently, research is strong in each separate area, yet work on the boundary – using pervasive technology to help dyslexic students – is sparse. This is a rich area, offering dyslexic, and indeed non-dyslexic, students the possibility of a new method of study.

References

1. AlphaSmart (2004) AlphaSmart UK Product Catalogue, AlphaSmart.
2. Bailey, M., Accessing the curriculum: procedures and study skills. In: Thomson, M. (ed.): Dyslexia Included – A Whole School Approach, David Fulton Publishers London (2003) 56-65
3. Banes, D., Seale, J., Accessibility and inclusivity in further and higher education: an overview. In: Phipps, L., Sutherland, A., Seale., J. (eds.): Access All Areas: disability, technology and learning, JISC York (2002) 1-5
4. Beacham, N., Media Combinations and Computer-Assisted Assessment: An Initial Study of Computer-Based Media Effects on Learners who have Dyslexia and Dyscalculia During Computer-Assisted Assessment Tests, Loughborough (August 2005)
5. Carmien, S., & Fischer, G., Tools for Living and Tools for Learning. In: Proceedings of the HCI International Conference (HCII) Las Vegas (July 2005)
6. Cooper B., Virtual learning environments: educational requirements versus educational provision – an age old problem, EdukaLibre project, Leeds, http://edukalibre.org/
7. Corlett, D., Sharples, M., Chan, T., Bull, S., A Mobile Learning Organiser for University Students. In: Journal of Computer Assisted Learning, Vol. 21 Issue 3 (June 2005)
8. Currin, L., Feelin' Groovy. In: eLearn Magazine, Vol. 2004 Issue 1, ACM Press New York (2004) 1
9. Dickinson, A., Gregor, P., Newell, A., Ongoing investigation of the ways in which some of the problems encountered by some dyslexics can be alleviated using computer techniques. In: Proceedings of the Fifth International ACM Conference on Assistive Technologies, ACM Press, Edinburgh, Scotland (2002) 97–103
10. Dyslexic.com (2004) A Buyer’s Guide: Helping dyslexic people make the most of their abilities
11. Flory, S., Dyslexia and dyspraxia. In: Thomson, M. (ed.): Dyslexia Included - A Whole School Approach, David Fulton Publishers London (2003) 66-81
12. Gael, MindGenius product range, 2006: http://www.mindgenius.com/
13. Gregor, P., Newell, A. F., An empirical investigation of ways in which some of the problems encountered by some dyslexics may be alleviated using computer techniques. In: Proceedings of the Fourth International ACM Conference on Assistive Technologies, ASSETS 2000, ACM Press (November 2000) 85-91

14. Hogan, K., Pressley, M. (eds.): Scaffolding student learning: Instructional approaches and issues. Cambridge, MA: Brookline Books (1997)
15. Holme, O., Sharples, M., Implementing a Student Learning Organiser on the Pocket PC Platform. In: Proceedings of MLEARN 2002: European Workshop on Mobile and Contextual Learning, Birmingham , UK (2002) 41-44
16. Holzinger, A., Errath, M., Designing Web-Applications for Mobile Computers: Experiences with Applications to Medicine. In: Stephandis, C., Stary, C. (eds.): User Interfaces for all. LNCS, Springer, Berlin, Heidelberg, New York (2004)
17. Holzinger, A., Nischelwitzer, A., Meisenberger, M., Mobile Phones as a Challenge for m-Learning: Examples for Mobile Interactive Learning Objects (MILOs). In Proceedings of: Third IEEE International Conference on Pervasive Computing and Communication (PerCom 05), Kauai Island (HI) (2005) 307-311
18. Innovation Adoption Learning (IMS) Global Learning Consortium, Inc., Specifications (2006) http://www.imsglobal.org/specifications.html
19. Johansen, A. S., Hansen, J. P., Augmentative and Alternative Communication: The Future of Text on the Move. In: Proceedings of 7th ERCIM Workshop “User Interfaces for all", Paris (Chantilly), France (October 2002) 367-386
20. Kadirire, J., Learning with mobile devices – a microportal design experience, Recent Research Developments in Learning Technologies (2005), Chelmsford, England
21. Lonsdale, P., Vavoula, G., Research into current technology that could be applied to the design of learning spaces. Report prepared for JISC project "eSpaces: Study on how innovative technologies are influencing the design of physical learning spaces in the post-16 sector" (2004)
22. Meisenberger, M., The making of MLE Mobile Learning Engine. http://drei.fh-joanneum.at/mle/docs/The%20making%20of.pdf, Project page: http://www.elibera.com/index.php?page=main_page_en (2004)
23. Memories for Life project, http://www.memoriesforlife.org/
24. Mortimore, T., Dyslexia, cognitive style and memory: Effect on study skills in HE?, Southampton (February 2006), http://www.ecs.soton.ac.uk/~cjh302/Mortimore.ppt
25. Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M., Literature Review in Mobile Technologies and Learning: Nesta Futurelab, Birmingham, UK (2004)
26. O'Leary, R., Ramsden, A., Virtual Learning Environments. In: Davies, P. (ed.): The Handbook for Economics Lecturers: Teaching, Economics LTSN (2002)
27. Perry, D., Handheld Computers (PDAs) in Schools. Becta ICT Research (2003)
28. Price, G., Creative solutions to making the technology work: three case studies of dyslexic writers in higher education. ALT-J, Research in Learning Technology, Vol. 14 Issue 1 (March 2006) 21-38
29. Shalev, R. S., Gross-Tsur, V., Developmental dyscalculia. Review article in: Pediatric Neurology, Vol. 24 (2001) 337-342

30. Savill-Smith, C., Kent, P., The use of palmtop computers for learning. A review of the literature, in British Journal of Educational Technology Vol. 36 No. 3 (2005) 567-568

31. Sharples, M., The design of personal mobile technologies for lifelong learning. In: Computers & Education, 34 (2000) 177-193

32. TechDis, Browse Aloud, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=191

33. TechDis, Case Studies, JISC, http://www.techdis.ac.uk/index.php?p=9_5_20050212091247_20061502040208

34. TechDis, Franklin Collins Dictionary Thesaurus DMQ-118, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=34

35. TechDis, Mindfull, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=307

36. TechDis, NessyBrainBooster, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=214

37. TechDis, Out And About – The Living Community, Life Skills Software, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=170

38. TechDis, Out And About 2 – Around The Home, Life Skills Software, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=171

39. TechDis, Out Of Order, Life Skills Software, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=169

40. TechDis, ScreenRuler, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=446

41. TechDis, SpeakOUT, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=197

42. TechDis, Visual Tracking Magnification Line Reader, Product Catalogue, 2006: http://www.techdis.ac.uk/index.php?p=3_1_1_1&disability=&technology=&id=177

43. Tindale, P., Wells, M., Wilson, M., Zhang, Q., Weal M., Facilitating Mainstream Inclusion of Children Presenting with Severe Dyslexia or Asperger's Syndrome

by Providing Technological Assistance to Aid the Organisational Aspects of Their Disabilities during Secondary Education. Southampton (May 2006), Project report

44. Walker, J., Assignments to help students learn how to blog (April 2006) http://jilltxt.net/?p=1670
45. Woodfine, B. P., Nunes, B., Wright, D. J., Constructivist eLearning and Dyslexia: Problems of Social Negotiation in Text-Based Synchronous Environments, University of Sheffield. In: Recent Research Developments in Learning Technologies (2005)
46. Wright, L., Stephenson, J., Issues around the use of WebCT in on-line learning for dyslexic students at the University of East London. In: Scholarship of Teaching and Learning Conference (2002)

Appendix A: Tools and Techniques (Summary)

Table 1. Summary of tools and techniques described in Section 3 and Section 4.

Tool/Technique	*Advantages*	*Disadvantages*
Techniques		
Various methods of conveying information (videos, colour, stories etc.)	Simple, effective, cheap	Can be difficult to find method best suited to each individual, and to reach entire audience
Various methods to record/use information (box and underline, colour, bulletpoints etc.)	Simple, effective, cheap	Can be difficult to find method best suited to each individual
Various methods using standard technology (text-to-speech, spell checkers, cut and paste etc.)	Standard (relatively cheap)	Computer required; lack of guidance; user may be over-whelmed with options (e.g. Microsoft Word offers split screens, notes, highlighting, etc.)
Various methods for enlivening e-learning solutions (idea sharing, healthy group dynamic, feedback, records etc.)	Cheap to follow, apart from initial good design	Issues of changing a culture; difficult to monitor progress – how to measure 'fun'?
Media combinations	Simple to implement, positive student feedback	Benefits are uncertain
Software		

MAPS		
Visual aids (HCI solutions - adjus layout, colour)	Much guidance; relatively simple to implement	
Visual aids (magnifying tools, e.g. ScreenRuler)	Very simple, cheap	
Text-to-speech (BrowseAloud, SpeakOUT)	Helps proof-reading and understanding	Slow; students may be self-conscious in public spaces
Study skills software (Nessy BrainBooster, Mindfull, MindGenius, other mindmapping software)	Broadens skills, introduces effective techniques	Issues matching suitable skills with the student
Lifeskills software (Out And About/Out Of Order series)	Support very needy students	Expensive, may not match students needs (particularly HCI issues: the software is not designed for dyslexic users)
Mobile Learning Engine	May be used anywhere; Java-based, therefore portable; leverages existing technology	Requires that students own a particular type of phone; little processor power; little screen space
Hardware		
Smartphones	Leverages existing technology; software (MLE) exists; possible use as a dictaphone	Requires that students own a particular type of phone; input methods vary
PDAs	Relatively cheap; robust; portable; can make legible notes; students enthusiastic; successful prior usage	Limited power and screen space; losing charge means lost data; difficult to make diagrams; dyslexic-specific studies not performed
AlphaSmart	Broad functionality; relatively cheap	Designed to remain within a school; inappropriate for university-level study
Reading Pen	Aids understanding	Not robust; costly; limited functionality
Dictionary/Thesaurus tools	Aids understanding and learning; relatively cheap	Limited functionality
Magnifiers	Very simple, cheap	