Computer-Assisted Language Learning (CALL) for Dyslexic Students

Cara Nicole Greene

School of Computing, National Centre for Language Technology, Dublin City University, Ireland.
cgreene@computing.dcu.ie

Abstract. This paper outlines the analysis, design, development, deployment and evaluation stages of Computer-Assisted Language Learning (CALL) software aimed at dyslexic learners. CALL is traditionally aimed at second language acquisition. The research presented here is different because the target group are students with first language difficulties. Dyslexia is a specific learning disorder, which affects roughly eight percent of the population in Ireland [5]. This research identifies the lack of support for dyslexic teenagers in Irish secondary schools and establishes their particular needs. The paper describes CALL courseware development in progress, which aims to aid the reading, organisation and exam skills of dyslexic students through the use of online authentic Junior Certificate history curriculum texts. The final evaluation phase of the project will assess the efficacy of the software and investigate the question of whether dedicated software can improve the reading skills of teenage dyslexic students at word, sentence and text level.

1 Introduction

This paper identifies a lack of learning support for dyslexic teenagers in Irish secondary schools and provides a basis for catering to their needs through the use of curriculum-focused CALL comprehension software. Section 2 briefly introduces the state-of-the-art in research and application for dyslexic students. Section 3 discusses the research and methodological approach adopted. Section 4 presents the findings from the Analysis Phase of my research. Section 5 presents the Design phase output. Section 6 discusses future plans. This is followed by the conclusion and references.

2 State-of-the-Art in R&D and Application

Teaching experience and teacher and student surveys carried out within this research point to three main categories of tool-technology that are being used by dyslexic students in Irish schools: (I) general-purpose ICT tools (e.g. word processors), (II) generic speech processing tools (e.g. text-to-speech) and (III) special needs-focused tools (e.g. speech-recognition), which are usually expensive.

In some Irish secondary schools, probably as a result of a lack of funding, CALL materials for special needs primary school children are being used as a stopgap for young teenagers with learning difficulties because the linguistic content (lack of complexity) is deemed appropriate. However, the drawback to these materials is that the content is not age-appropriate for a teenager.

Tools that allow students to access text are most often used in secondary schools as opposed to dedicated CALL systems. Dragon Dictate [3] is a speech recognition system, which allows students to dictate a text, but it takes a long time to train the system to a student's voice and therefore it is often not very practical. Kurzweil [3] allows a student to scan in texts. However, both tools are very expensive and most schools do not have continuous access to them.

To date, there has not been much dedicated research and development in curriculum-focused design or development for dyslexic students. For example, Elkind et al. [4] report on the usefulness of text-to-speech systems to improve reading comprehension of students with dyslexia but their paper is more focused on the area of generic educational tools to help access text rather than providing a focused CALL environment. The Kar2ouche Shakespeare range [6] provides programs that present text and audio from Shakespeare's plays with the complete character set and a variety of backgrounds, props and sound effects. Some of these plays are options on the Junior Certificate English curriculum in Ireland.

3 Research and Methodological Approach

The research presented in this paper describes curriculum-focused comprehension software based on the Junior Cert history curriculum and popular texts, which uses authentic texts to give dyslexic teenagers more practise with the vocabulary they need in exams and socially. The research follows Colpaert's [1] Research-Based Research-Orientated (RBRO) design model as the theoretical basis underlying the overall research methodology. This model, which is a working hypothesis for pedagogy-driven, research-orientated development, takes as input all the facts, principles and requirements that the developer must take into account before starting to develop the application.

Colpaert's design methodology has its basis in the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model grounded in the Waterfall model from Software Engineering [10]. This 'waterfall' model has successive and verifiable stages. Each step yields an output, which then serves as input for the next engineering phase. The idea is that each step is separate so that, for example, the design phase is reusable for other platforms because it is code-free.

Colpaert's Analysis phase entails gathering all possible information about relevant epistemological, empirical, actorial, contextual, technological, feasibility-related, and perceptive aspects, facts, findings, principles, and considerations that must be taken into account for the Design and subsequent phases.

Design is considered to be a working hypothesis, which can be verified and validated (or adjusted) after each implementation and evaluation. Each iteration of the design, implementation and evaluation loops leads to new working

hypotheses. This process is the so-called engineering loop. The RBRO design model is divided into three stages: conceptualisation, specification and prototyping. Conceptualisation involves the identification of personas (learner-types from Analysis phase), the hypothesisation of practical goals, the formulation of scenarios, and the description of system tasks. Specification describes the back-end and the front-end. Prototyping is testing of the system and involves formative evaluation.

As the Design phase is quite comprehensive, this makes the Development phase easier. Development does not involve more design issues but is simply the execution of a plan conceived in the Design phase. In this way, educators play a more significant role in the CALL engineering process in the code-free Analysis and Design phases. Development involves a thorough testing process. The requirements set out in the Analysis and Design phases should guarantee an efficient deployment of the developed system during the Implementation phase into the targeted learning and teaching environment.

The Evaluation phase of Colpaert's model uses summative (after the Implementation stage) evaluation. Only after Implementation and Evaluation does the model call for a new working hypothesis for new versions or new applications, which will be developed based on extensive user feedback.

4 Analysis Phase Findings

This section discusses the research tasks carried out and the results established under the Analysis phase of Colpaert's model. The Analysis phase covers a literature review, needs analysis and matching CALL functionalities against dyslexic needs analysis.

4.1 Literature Review

The literature review consisted of a thorough analysis of each area relating to the research including existing courseware (see Section 2 for details), special education, government policy, curriculum analysis using Computational Linguistic (CL) technologies, Human-Computer Interaction (HCI) and usability issues, with the main focus on Computer-Assisted Language Learning (CALL) literature and Dyslexia.

CALL software is language-learning software (e.g., web-based, CD-Rom, interactive) that has lessons and exercises designed and developed for the particular needs of a target language learner group. CALL is a means of aiding the work done in the classroom by the teacher and can also be a means of independently learning a language. The literature review also involved a review of CALL design and development in both first and second language areas.

The word dyslexia is derived from the Greek 'dys' (meaning poor or inadequate) and 'lexis' (words or language). The word dyslexia therefore means 'difficulty with words'. The causes and characteristics of dyslexia were investigated, as well as the needs and difficulties of dyslexic students. Research in the area of dyslexia and software design for dyslexia was also reviewed.

4.2 Needs Analysis

The needs analysis of dyslexic teenagers was carried out through teaching experience, training with the Dyslexia Association of Ireland (DAI) and survey questionnaires of dyslexic teenagers and teachers. This research helped to identify the needs of dyslexic students and the learner types.

Needs analysis was carried out during teaching experience as a learning support and English as a Foreign Language (EFL) teacher (2002-03) in a secondary school. This teaching experience helped identify dyslexic student difficulties, needs and preferences. Professional dyslexia training with the DAI was an important component informing needs analysis e.g. ethical issues such as student privacy.

Learner types provide the 'personas' in Colpaert's [1] RBRO model. Learner-types were identified based on research into special education, dyslexia and discussions with the DAI. Feedback from the teacher, student and tutor surveys helped to identify these learner-types. Previous learning support teaching experience with students with learning difficulties and dyslexia proved valuable.

Survey questionnaires were carried out with special needs teachers (21 participants), dyslexia tutors (15 participants) and dyslexic teenagers (32 participants). The aim of the questionnaires was to investigate:

- What (if any) software/ICT tools students and teachers used for schoolwork?
- What type of software/tool teachers and students would like?
- Which features would be most beneficial and useful in this software/tool?

The results from the surveys show that the majority of special needs teachers and dyslexic students in schools use general-purpose ICT tools for their schoolwork as opposed to dedicated systems. Respondents said much of the software for dyslexic students is aimed at younger students and therefore not age-appropriate. Details of the ICT materials used in schools and current research in the area can be found in Section 2. The most often asked for (yet non-existent) software/tool from the surveys was comprehension software working with *authentic* texts. Respondents (teachers, tutors and students) pointed to dyslexic students' need for a new way to access the curriculum and to gain experience with exam and every-day language.

Respondents were presented with many features that can potentially be integrated into such a system. Table 1 in section 4.3, entitled "Key Features for Dyslexia-Focused CALL Software" shows the features chosen, how many respondents chose that feature and their reason from a dyslexic student need point of view. These results have been matched against how the CALL system could integrate this feature.

4.3 Matching CALL Functionalities against Dyslexic Needs Analysis

This section takes the information gathered in my Analysis phase (following Colpaert's [1] model), which includes student needs, teacher needs, the survey questionnaire results and the review of CALL and related disciplines and puts them

together in preparation for the Design phase of the model. Table 1 shows the key features for curriculum-focused comprehension software for dyslexic teenagers and how CALL software can cater to the needs of these students.

Table 1. Key Features for Dyslexia-Focused CALL Software

Feature	Who	Why	CALL?
Present text in digestible chunks	85% of learning support (LS) teachers	Short term memory and sequencing difficulties	Dyslexia-focused design and layout
Pictures, audio, video, TTS systems	96% of students & 100% of LS teachers	Poor symbol-sound meaning, grapheme phoneme linking	Multi-modal activities (audio & video)
Manipulate text like word processor	95% of LS teachers & 93% tutors	Defective fine motor skills, energy	Mind map, click & drag capabilities
Language quizzes & games	100% of students, 90% LS teachers, 100% tutors	Thinking in pictures, ADD, concentration	Colour, graphics, kinaesthetic features
Manual text summarisation	73% of dyslexia tutors	Organisation, STM, thinking in pictures	Multi-modal capabilities
Automatic text summarisation	26% of dyslexia tutors	Organisation, STM, thinking in pictures	Multi-modal capabilities
Authentic texts	93% of tutors	Need real texts	Exam materials
Memory games	46% of tutors	STM, sequencing	Multi-modal games

Due to Short-Term Memory (STM) and sequencing difficulties, students can lose their way in comprehension texts because they are not retaining important facts and therefore do not fully understand the text. CALL courseware's multi-modal capabilities can present a text in small digestible chunks. STM and defective phonological and visual access problems can make retaining grapheme-phoneme links difficult. CALL technology can strengthen the symbol-sound-meaning link with constant audio-visual revision because a student can click on a word and hear what it sounds like as often as they like.

CALL can address defective fine motor skills because it allows the student to manipulate text easily, summarise their work automatically and manually in mind-maps with pictures and record their voice instead of typing. This will also address organisation difficulties. CALL can address the problem of Attention Deficit Disorder (ADD). Many tasks that other students take for granted are difficult for dyslexic students due to the energy required to do it. Evidence from brain imaging suggests that while children with dyslexia do not activate the left hemisphere (language centre) in the brain as much when reading as non-dyslexic readers [9], they use five times of the overall brain area as non-dyslexic readers while performing a simple language task [8]. Students can lose interest and become frustrated reading a text. CALL programs can use colour, graphics, sound and kinaesthetic features to utilise multi-sensory paths to organisation and retrieval [12] rather than being restricted to the textual and linear format of textbooks. Games and quizzes can be integrated easily to give the student a new and interesting way of accessing the curriculum.

4.4 Curriculum Analysis using CL Technologies

The content for my web-based CALL comprehension tool for dyslexic teenage students is provided by authentic texts from the History Junior Certificate curriculum. The content was determined in discussions with the DAI. Dyslexic students find the language in the history curriculum particularly difficult. These texts are online exam papers and online research samples of the History curriculum textbooks. This integrates the software with the curriculum in a blended CALL scenario and increases the reference of the software to students. Taggers, morphological analysis and pattern matching are used to analyse the text that students read to find words and patterns that dyslexic students find difficult, before the texts are presented to the students. Frequency lists are used to highlight words that occur repeatedly in these history texts e.g. 'archaeologist'. 'Hard words' and nouns that occur frequently in the history syllabus are stored in a XML database, which has associated pictures, audio files, and videos if appropriate. 'Hard words' are words of length >6, irregular phoneme-grapheme matching e.g. ph, words containing pre/suffixes, words that can be easily misinterpreted (p, b, d, q can all be seen as the same shape). There are also authentic popular texts such as texts from online teen magazines and online newspapers for the private newsgroup and pin board sections of the system.

The students will be able to avail of text-to-speech (TTS) systems (Talking Dictionary 8 [11] and Logox WebSpeech [7] and a summarisation system, Copernic Summariser [2]. These systems will be adapted to be used in my interactive environment so that students can access the text fully. Talking Dictionary 8 [11] is used because it is based on the Wordnet 2.1 [13] database and contains over 250,000 words together with audio information. Wordnet will provide synonyms/antonyms etc. in the multi-modal database and these words are also available in the Talking Dictionary.

5 Design Phase Findings

This section discusses the research tasks carried out under the Design phase following Colpaert's model and the associated findings and results.

5.1 Conceptualisation Results

Conceptualisation involved the identification of personas (learner-types from Analysis phase), the hypothesisation of practical goals, the formulation of scenarios, and the description of system tasks. Personas are types of users with common goals that have been identified in the Analysis phase. An example of one persona is 'John: John has an exemption from Irish. He avoids reading out loud in class and becomes annoyed and aggressive if pushed into reading'. Practical target goals for these personas were identified, such as improving reading skills, motivation, organisation and presentation skills. Scenarios were drawn up as to how personas will use the CALL tool. System tasks were described, which involved planning out exactly what each module in the system is going to do.

5.2 Specification Results

Specification entails the design of the back-end and the front-end of the system. The back-end of the system describes the system structure in terms of components and their interaction. The front-end describes what the students will see and how they interact with the system.

Front-End of the System The student logs into the system and they can go into history work, schoolwork/student newsgroups or schoolwork/student pin boards. When the student enters the history section the appropriate level of texts, decided by the teacher/tutor, are displayed. Each text will be presented in small digestible chunks (including text, recorded voice, pictures, video) to ease the load on the student's STM. Students will be able to click on words to hear them and access extra material: audio, text, video, antonyms, and synonyms. The student will be able to work on the texts and associated exercises at their own pace. The constant audio-visual revision will strengthen the symbol-sound-meaning (grapheme-phoneme) link for the students. The student will be able to manually summarise the text by clicking-and-dragging words from the text, and pictures and related content from the database of history nouns into a mind-map area for themselves, as well as record oral summaries. The teacher or tutor will have a login so that they can see students progress throughout the system.

Back-End of the System The back-end consists of the XML database that contains all the information for the comprehension texts and related information. The system has two main areas: schoolwork and a student area. The system modules are all separate to allow content to be added easily. The small texts that students receive have already been pre-processed in the Analysis phase and are stored in an XML database with associated video, audio and text. Further information can be found in Section 4.4.

5.3 Prototyping Results

The purpose of prototyping is to test discrete functionalities. Prototyping involves testing sections and versions of the software on a number of different people: fellow developers, teachers and finally when the product is ready, the students, for the implementation and evaluation cycle. Functionalities such as the XML database, summarisation and text-to-speech have been tested.

6 Future Plans Development, Deployment, Evaluation

Formative evaluation of discrete functions within the system is under way. The prototype is being developed at the moment. The software will then be deployed with students who receive after-school dyslexia tutoring to help them with their school and exam work. This first cycle of implementation and summative evaluation will provide student and teacher feedback, which will feed back into the

design phase and create new hypotheses for further development. These changes will then be implemented and further summative evaluation carried out.

7 Conclusion

The paper provides a background to research and development in the area of learning software for teenage dyslexic students. My research identifies and focuses on the lack of support for dyslexic teenagers in Irish secondary schools and establishes the particular needs of this age group. The paper describes CALL courseware development in progress. The software aims to aid the reading, organisation and exam skills of dyslexic students through the use of online authentic Junior Certificate History curriculum texts. The final evaluation phase of the project will assess the efficacy of the software and help answer the question of whether dedicated software can improve the reading skills of teenage dyslexic students at word, sentence and text level.

References

1. Colpaert, J.: Design of Online Interactive Language Courseware: Conceptualization, Specification and Prototyping. Research into the impact of linguistic-didactic functionality on software architecture. PhD thesis, University of Antwerp, Belgium (2004)
2. Copernic Summariser: Copernic Summariser. Available at http://www.copernic-.com (2005)
3. Edtech: Edtech Educational Software. Available at http://www.edtech.ie (2005)
4. Elkind, J., Cohen, K., Murray, C.: Using Computer-Based Readers to Improve Reading Comprehension of Students with Dyslexia. Annals of Dyslexia, v43. (1993) 238–259
5. Holden, L.: Dealing with Dyslexia. Provided by the Irish Times. Available at http-://skoool.ie/skoool/parents.asp?id=2912 (2004)
6. Kar2ouche: Kar2ouche Romeo and Juliet. Available at http://www.immersiveeducation.com (2006)
7. Logox Webspeech: Logox Webspeech. Available at http://www.webspeech.de/index2.php (2003)
8. Richards, T., Dager, S., Corina, D., Serafini, S., Heide, A., Steury, K., Strauss, W., Hayes, C., Abbott, R., Craft, S., Shaw, D., Posse, S., Berninger, V.: Dyslexic Children Have Abnormal Brain Lactate Response to Reading-Related Language Tasks. American Journal of Neuroradiology, 20. (1999) 1393–1398
9. Serafini S, Steury K, Richards T, D, Abbott R, SR, Berninger V.: Comparison of fMRI and PEPSI during language processing in children. Magn Reson Med, 45. (2001) 217–225
10. Sommerville, I.: Software Engineering. Harlow, Essex, England, New York: Pearson /Addison Wesley. 7th Edition, 2004
11. Talking Dictionary 8: Talking Dictionary 8. Available at http://www-.brothersoft.com (2003)
12. Wahl, R.: The Role of Computers in Teaching EFL to Dyslexic Students. ETNI. Available at http://www.etni.org.il/etninews/paper.htm (1996)
13. Wordnet 2.1: Available at http://wordnet.princeton.edu/obtain (2005)