Enhancing language learning for dyslexic learners: Integrating text-to-speech AI in CALL

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Abstract

This paper presents the development and adaptation of the Cipher game, a digital language learning resource adapted for dyslexic learners using text-to-speech (TTS) Artificial Intelligence (AI) technology. Modifications to the original Irish Cipher game include simplified texts, adjusted game rules, and AI-generated audio for instructions, vocabulary, and sentences. These elements reduce cognitive load and enhance comprehension, aligning with the needs of dyslexic students. The TTS technology used produces clear, game-appropriate speech, facilitating a more engaging and supportive learning experience. This paper provides a comprehensive overview of the design and development process of the dyslexia-focused Cipher game. It highlights the potential benefits of incorporating advanced AI technologies in educational tools for learners with reading difficulties. Future research is necessary to empirically evaluate the efficacy of this tool in real-world settings, involving dyslexic learners in the testing phase. This paper contributes to the ongoing discourse on leveraging technology to promote inclusive education and support diverse learner needs in CALL environments.

Keywords: CALL; text-to-speech; dyslexia; digital game-based language learning.

1. Introduction

This paper delves into the integration of TTS AI in Computer-Assisted Language Learning (CALL) resources, specifically tailored for dyslexic learners. Focusing on the adaptation of the Irish CALL resource, Cipher: Faoi Gheasa (Xu et al, 2023), for an English context, our research explores the transformative potential of digital game-based language learning to address the unique challenges faced by dyslexic individuals in reading and language acquisition. In the field of CALL, by attending to specific language needs, our research emphasises the imperative of infusing humanity into the interaction between humans and computers for all learners in the classroom. By leveraging the innovative application of TTS AI technology, we aim to create an inclusive and engaging language learning environment for dyslexic learners.

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2. Background

2.1. Dyslexia

Struggling readers is a term that is sometimes used to refer to those who encounter difficulties when trying to read text. However, this term looks at the deficit of the learner, rather than their abilities. For some people the term dyslexia means that language learning is problematic – dyslexia is about what learners cannot do and not what they can (Csizér et al., 2010; Eisenstein, 2010). Although more inclusive term is "those who need more support with reading", the terms dyslexia and dyslexic students will he used in this paper as they are more commonly used in the literature. Many readers who encounter difficulties with reading may be dyslexic, but there are many other potential causes of reading difficulties (Vellutino et al, 2004). Dyslexia is a learning disorder that involves issues with reading due to problems identifying speech sounds and learning how they relate to letters and words. Dyslexia is a spectrum and covers a range of reading abilities. Dyslexia is not related to intelligence and early interventions and support for dyslexic students can succeed in learning to read and write.

Reading is about understanding written texts and involves word recognition and comprehension. Pang et al (2003) note that early progress in reading depends on oral language development, that phonological and phonemic awareness are closely associated with reading ability and that vocabulary is crucial to reading comprehension. They report that readers make progress by reading more and that fluent readers read with accuracy, ease and understanding. People who can read, read for learning and for pleasure. However, for those who find reading difficult, they may find the process frustrating and miss out on learning opportunities. It is important to help learners to read so they can access information and knowledge held in the written word.

2.2. Dyslexia and CALL

Most of the CALL research is based on neurotypical adult English language learners (Ward, 2018). There is some focus on secondary school students (e.g. Macaro et al., 2012), but there is a limited focus on primary school learners (e.g. Ward, 2007). CALL research mainly focuses on L2 learners, but many CALL resources could also be helpful for L1 learners (e.g. dyslexic students). The term assistive technology in education is used to refer to the use of technology and tools to support learners. Assistive technology has been used to support dyslexic students in L1 reading and writing (Dawson et al., 2019). It is interesting to note that the first issue of Language Learning and Technology looked at language education and learning disabilities. (LeLoup, J. W., & Ponterio, 1997).

The pre-reader phase begins in infancy and will last until a child begins to actively learn to read. Researchers have reported on how technology can support pre-readers (Verwimp et al., 2023) and the importance of enjoyment for pre-readers (Vanden Bempt et al, 2022). Motivating and reaching all at-risk pre-readers to engage in reading programs can be achieved by making use of digital serious games. (Vanden Bempt, 2023). Vanden Bempt et al. (2021) note that technology can make a difference for pre-readers at cognitive risk for dyslexia (Dutch and Finnish). Beltrán et al. (2013) provide a good overview of inclusive language education and digital technologies (Beltrán et al., 2013) and Crombie (2013) reports on inclusive practice and technology in the dyslexia context. There are differing findings of the paper vs digital reading context with Støle et al. (2020) reporting that some students are better at reading on paper, while Schneps et al. (2013) note that e-readers can be helpful for those with dyslexia due to the short lines of text in e-readers. Overall there are indications of the benefit of digital technology in the dyslexia context, but more research is required (Bautista et al., 2023). Barzillai & Thomson (2018) advocate the need for a more nuanced understanding regarding the challenges and potential of digital environments and highlights the uniqueness of each child's digital reading experience. A is for App (Aisforapp, 2020) provides information on reading fluency apps for struggling readers in primary school. Liu et al. (2024) give an overview of the use of digital technologies to develop young children's language and literacy skills. Messer and Nash (2018) note the effectiveness of a computer-assisted reading intervention to address reading delays.

2.3. Orthographic transparency

Context is very important in language learning (Palfreyman, 2006). A core element of that is the language being studied. Language orthographic transparency has an impact on the ability of learners to read the language. Some languages are very transparent (e.g. Spanish and Finnish) and it is easy for learners to read and pronounce words in the language, even if they do not understand the words. A language like Dutch is slightly less transparent but learners can read the language with some guidance. Irish is less transparent than Dutch and it has unusual vowel (e.g. eadh which gives an 'a' sound) clusters and consonant clusters (e.g. bhf which gives a 'w' sound). English has an opaque orthography in which the relationships between letters and sounds are inconsistent with many exceptions, making English a significantly more challenging to the beginning reader than other more transparent alphabetic systems (Vellutino et al, 2004:17). Researchers have noted the impact of language orthographic transparency on reading and developmental dyslexia (Miles, 2000; Borleffs et al., 2019). According to Spenser (2000) there is evidence that English-speaking children who fail to acquire reading skills may fall into two distinct categories: those who would succeed in languages, other than English, that have greater orthographic consistency; and those who would still have problems even with perfect orthographic transparency.

2.4. Multidisciplinary CALL development

Often CALL research focuses on the impact of using off-the-shelf digital tools to enhance the language learning process (e.g. Messina Dahlberg & Bagga-Gupta, 2016). This is a sensible pragmatic approach as it means that others can learn how to effectively integrate available digital tools with their own students. Some of these digital tools are general digital tools (e.g. word processors and shared digital spaces), while others are designed with a pedagogical focus (e.g. Dizon, 2016). It is difficult to develop CALL resources from scratch as CALL development is challenging and requires a multidisciplinary team (Ward, 2015). Developing CALL resources for a specific cohort of learners is additionally challenging. There are often fewer tools available to help in the development process and there is a need to bring in additional expertise. For example, in the case of Less Commonly Taught Languages, there are fewer input resources available and it is difficult to find researchers with the necessary expertise to design and develop the CALL resource (Ward, 2007). In the case of L1 readers who need additional support, this means that the CALL development team needs the expertise of a dyslexia specialist, especially one who has experience in using, and is comfortable with digital tools. The dyslexia Cipher development team consists of a digital games expert, an Irish Natural Language Processing expert, a dyslexia expert and a CALL researcher.

2.5. Text-to-Speech

Text-to-Speech (TTS) tools convert digital text into audio. This can be helpful for language learning (Wood et al., 2018). In 2005, Handley (2005) noted that TTS tools were ready for use in CALL and TTS technologies have improved greatly since then. TTS can improve reading comprehension and word recognition and facilitate decoding (Keelor et al, 2020). It can also promote a more positive outlook on reading and increase time spent reading (Harvey et al, 2013). It can help students with disabilities stay at peer level in all of their subjects and improve self-esteem, motivation, and self-confidence. Diprossimo et al (2023) report on the benefits of vocabulary scaffolds for learners. However, using TTS tools and integrating them into reading support programmes can be challenging. Fälth and Selenius (2024) report that while teachers are supportive of the use of technology with their students, they lack awareness of what tools are available. Teachers need to acquire familiarity with the tools and how best to use them in order to have the self-confidence and competence to use the tools effectively with their students.

2.6. Cipher - A digital game based language learning app

The Cipher game, originally designed for Irish language learning, serves as the foundation for our adaptation to the English language. This digital game-based learning resource integrates vocabulary, reading, and writing components, rendering it a versatile and comprehensive platform for language acquisition tailored to learners of Irish. It is interesting to observe that the Cipher game for Irish was based on a game originally designed for English (Figure 1) (Xu & Chamberlain, 2020) and the current Cipher framework can now be used to develop resources for other languages and target-learner groups. Figure 2 shows the Irish version of Cipher for beginner learners of Irish, with a particular focus on primary school students (Xu et al., 2022). Note that the quantity and level of text is different between the original English version and the Irish version and the game vibe is also different.
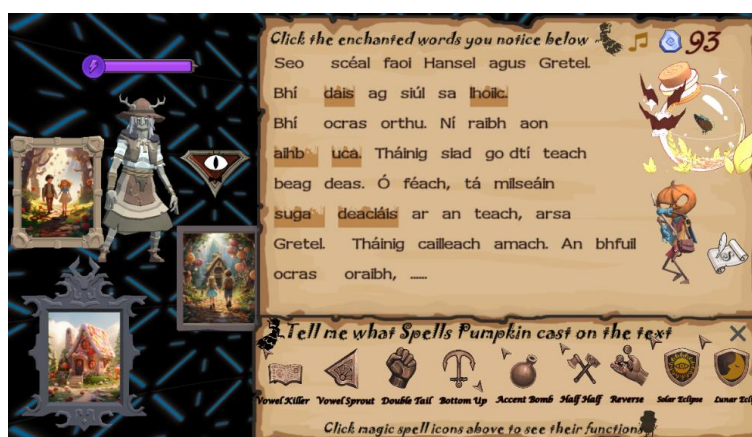

Figure 1. Original English language version

Figure 2: Irish Cipher

3. Methodology

This project focuses on L1 English-speaking primary school children, specifically those in the 3rd grade, who are struggling readers and have dyslexia. These learners face unique challenges in language acquisition, necessitating tailored educational interventions that use advanced technology to support their needs. The primary objective of this research is to develop a tool to explore the potential of digital game-based language learning, particularly through the use of the Cipher game, in facilitating text, audio and image based language learning for dyslexic students. This project aims to explore the intersection of games and language acquisition, promoting a more inclusive approach in CALL.

3.1. Design features and approach

The Cipher game retains all the features of the Irish Cipher. However, this version of the Cipher game incorporates several key design features tailored specifically for this context. In order to focus on L1 English, young dyslexic students, the game content is tailored to meet the specific requirements of primary school children with dyslexia. There was also a need to make some modifications to the game rules. They are slightly adjusted to suit learners with dyslexia, ensuring the game remains accessible and supportive. With regards to TTS integration, the game employs TTS technology with an engaging voice to aid comprehension and pronunciation. The audio is carefully selected to match the game's magical theme, using a witchy and mysterious voice that is clear and slow, enhancing the gameplay experience.

3.2. Simplified game content

To adapt the Irish CALL resource for the needs of dyslexic learners, a comprehensive redesign of language learning materials, including vocabulary, reading materials, and sentences, was undertaken. The text in the game was simplified to ensure accessibility, achieving a Flesch Kincaid reading score of Grade level of 1.8 (indicating a reading level of Grade 1) and a Gunning Fog score, which estimates the years of formal education a person need to be able to read a text of 3.7 (indicuating that it is suitable for very young readers). This simplification was crucial to make the text suitable for young dyslexic learners. The adjustments to the game rules included changes to the quality of text and the storyline. The amount of text on each page of the story in the game was reduced to lower the cognitive load on learners. The storyline was rewritten to be appropriate for the target audience, maintaining the magical theme of the game. There were also changes to the magic spells. In the game, magic spells encode words in specific ways, creating patterns that learners can decode. Some examples of these magic spells include Bomb Switch (this spell jumbles the letters B, D, and P in a word), Hidden Harmony (this spell removes the 'h' from combinations like ch, th, or sh in a word and Silent Eva (this spell removes the silent 'e' in a word). These magic spells were designed based on common errors made by dyslexic learners, helping them recognise and correct these patterns in a fun and engaging way. Figure 3 shows the adapted version of Cipher for dyslexic learners. Note that there is less text but the game vibe has been maintained.

Figure 3: Adapted version of Cipher for dyslexic learners

3.3. Audio instructions using Text-to-Speech technology

Another adaptation is the use of simplified instructions and audio support. All text instructions in the game were checked, simplified and paired with AI-generated audio. Vocabulary words and their explanations in the

vocabulary also included AI-generated audio to reinforce learning through multiple modalities. Each sentence in the sentence writing part of the game also includes AI-generated audio, providing auditory support.

By incorporating these design elements and approaches, the Cipher game aims to provide a supportive and engaging learning environment for dyslexic students, enhancing their language skills through innovative digital game-based language learning. Table 1 provides a summary of the adaptations for dyslexic learners.

4. Discussion

Before the availability of TTS technologies, human voices were used to provide audio support for pronunciation of written words and text. While this is highly desirable in a CALL application, budget and time restrictions have frequently made this impractical. More recently, AI TTS technologies have enabled the provision of this audio support in CALL Liakin et al., 2017). When high quality AI TTS technologies are available for the langage being studied, it can result in a more efficient and reliable approach to audio support for learners. It should be noted that high quality AI TTS tools are not available for all languages, however they are available for the most commonly taught languages (e.g. English, French and Spanish).

In this research we use AI TTS technology to produce high-quality speech to support learners playing the Cipher game. In addition to pronunciation support, it provides them with guidance on how to play the game. This additional audio support can help dyslexic learners channel their cognitive resources in a more effective way. It can enable them to focus on active text-based learning targets within the game and reduce the cognitive load associated with interpreting textual d gameplay instructions. This is quite innovative in the CALL context, and we believe that the integration of AI TTS will prove to be a valuable tool in creating an accessible and supportive learning environment.

It is important to consider diverse learner needs when designing CALL resources r and the integration of advanced technologies, like AI TTS, can help in this regard. The Cipher game was designed to be an engaging and fun experience for players.. In classroom tests, learners who have played the Irish version of Cipher have reported that the game is fun and engaging. However, due to logistical constraints, it has not been possible to date to test this app with dyslexic students. In future research, we aim to assess the impact of the game modifications and additional audio support with this student cohort to investigate its effectiveness in making CALL applications more accessible to learners with special needs.

Table 1: Adaptations for Dyslexic Learners

Feature	Change	Motivation
Target language	L1 young dyslexic students	Language must be at an appropriate level
Audio	Addition of TTS audio to the game	To enhance comprehension and aid pronunciation
Game rules	Adjusted for dyslexic students	Keep the game accessible and supportive
Quantity of text	Less text	Lower cognitive load on students
Storyline	Rewritten for target audience	Ensure storyline is relevant for students
Magic spells	Adapted to cover specific difficulties for	Help students with decoding

	dyslexic learners (e.g Bomb Switch, Hidden Harmony, Silent Eva)	
Instructions and audio support	Simplified instructions and additional audio support are provided	Keep game accessible and provide additional support

5. Conclusion

The aim of this project was to develop a version of the Cipher game with additional audio support for learners, particularly those with additional needs, including learners with dyslexia. Audio files can provide useful support for all learners, irrespective of whether they have a learning difficulty or not. These additional supports in Cipher include audio files for pronunciation as well as audio files for the instructions of how to play the game. In this application, AI TTS technology was used to generate the English language audio files for the game. This facilitated the efficient production of high-quality, clear, game-appropriate speech providing an engaging and supportive learning experience. It would not have been possible to produce these audio files to the same quality, consistency and low cost in such a short time frame without the use of AI. . Further research is necessary to empirically evaluate the efficacy of this tool in real-world settings, involving dyslexic learners in the testing phase. This paper outlines how technology can be leveraged to promote inclusive education and support diverse learner needs in CALL environments and CALL researchers are encouraged to consider the use of this technology in the development of their own CALL resources.

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