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Enhancing human-centric CALL through AI innovations

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Abstract

This paper explores the integration of Artificial Intelligence (AI) into Computer-Assisted Language Learning (CALL) to create a more engaging and supportive educational experience. This study delves into the utilisation of Natural Language Processing (NLP), AI image generation and text-to-speech (TTS) technologies to enhance the game-like elements of CALL resources. Drawing from recent experiments, the paper discusses the iterative improvements made to the Cipher game (Xu et al., 2024), shedding light on the positive impact of AI on both user experience and learning outcomes.The integration of NLP, AI image generation and TTS AI in CALL resources, as exemplified by the Cipher game, demonstrates their effectiveness in creating engaging and inclusive language learning experiences. These technologies not only improve productivity but also cater to the needs of learners with diverse requirements. This paper advocates for further exploration and implementation of AI in CALL to promote humanity, interactivity, and accessibility in language education.

Keywords: *CALL; Artificial Intelligence; digital game-based language learning.*

1. Introduction

In recent years, the role of AI in educational technology has become increasingly significant, including in the field of CALL. The intersection of AI and CALL holds immense potential for transforming language learning experiences. This paper delves into the incorporation of AI, specifically Natural Language Processing (NLP), AI image generation and TTS synthesis, to foster more human-centric and inclusive CALL resources. While these technologies have been used in CALL resources before, they have become increasingly more powerful and accessible to developers to use and integrate into CALL resources. This paper provides an outline of these AI technologies and how they can be used in CALL development.

2. Background

A comprehensive explanation of AI is outside the scope of this paper and this section provides an overview of AI, along with a short explanation of AI, false dawns in relation to AI and the use of AI in CALL. It provides a short summary of Natural Language Processing, AI image generation and TTS systems and their role in CAL.

2.1. General overview of Artificial Intelligence

Since the public release of ChatGPT 3.0 in November 2022, the general public has become more aware of the existence of Generative AI (GenAI) tools and their usage. Those not previously familiar with AI tools in general and GenAI tools in particular were amazed at what they could do. In educational settings, particularly in Higher Education, there were initial concerns in relation to academic integrity, as there were fears that students would use the GenAI tools to do their assignments for them (Sullivan et al., 2023). Although this continues to be a concern, there are potential benefits for integrating AI into teaching and learning (Grassini, 2023). While AI can be used in a variety of ways, directly as a general tool to support learning, this paper focuses on leveraging AI tools in the development of CALL resources.

There is no singular definition of AI, but it can be defined as the use of computer technology to simulate human intelligence and problem-solving capabilities (Wang, 2019). The general public has gained most of its perceptions from films and books, which can sometimes give the idea that AI robots can 'think' or 'feel'. However, this is not true with the current state of AI development and it may then become a philosophical question if it is even possible for a non-human to 'think' and 'feel'. Generative AI (GenAI) is AI used to generate resources (e.g. text, audio, video) in response to prompts and queries. ChatGPT was the first GenAI tool that the general public became aware of, but it is not the only one and certainly not the first one. AI has been around for a very long time since the early days of computing, and even before than in a non-computing form (Muthukrishnan et al., 2020). Over the years, elements of AI have had different names (e.g. expert systems, intelligent systems) and sub-fields of AI have their own specific names.

When computing technology became available in the 1940s and 1950s, there was great hope that AI could be harnessed to carry out difficult tasks and there were some initial successes from the 1950s to 1970s (Haenlein & Kaplan, 2019). However, there were many difficulties including computing power and finance issues. In the 1980s, there was a brief flurry of activity in AI, but it is mainly since the late 1990s and early 2000s that AI has really become more common and used outside the lab environment. Tasks that could only be performed in specialised computer labs, can now be performed by the general public on a daily basis. For example, many people use a spelling and grammar checker when using a word processor, yet they are unaware that it is AI that is powering the checker - they can use it seamlessly without thinking about the technology behind it.

AI has been used in CALL for many years. The use of AI in CALL has often been referred to as Intelligent CALL (ICALL). It has been used with written learner language in spell checkers, grammar checkers including systems for automatic writing evaluation, and Intelligent Language Tutoring Systems (ILTSs) (Heift, 2017). It has also been used to enhance reading, listening, and speaking (Woo & Choi, 2021). In more recent years, Natural Language Processing (NLP) and TTS tools have been used in CALL resources.

2.2. Natural Language Processing and CALL

Natural Language Processing (NLP) is the use of computing technologies to process human language. NLP tools and technologies include text and speech processing, morphological analysers and automatic text summarisation. Many language learners currently use NLP-embedded tools for writing (e.g., spelling and grammar checkers (Ferris et al., 2013). NLP tools have the potential to enhance the development of CALL resources and also enhance their power (Ward, 2017; Ward, 2019). However, there have been difficulties in using NLP in CALL over the years. One fundamental issue is the cross-disciplinary nature of the integration - it can be challenging for NLP researchers to work with learners and CALL researchers to work with NLP technologies that they may not understand. NLP researchers focus on the technical aspects of NLP, while pedagogy is the main focus for CALL researchers. Furthermore, NPL tools are not designed for language learning activities and it can be difficult to adapt them for language learning purposes (Antoniadis et al, 2013). Other challenges, such as CALL development difficulties (Goewin-Jones, 2015), integration (Heift & Schulze, 2007), financial constraints and the difficulties in building a multidisciplinary team, are also an issue (Ward, 2015).

2.3. Artificial Intelligence images and CALL

Images have the power to help contextual written texts and can make CALL resources more visually appealing (Schroeder et al., 2011). AI image generation is complex and requires input parameters or conditions (prompts) to generate an image based on what it has learnt based on previous images it has seen (training images). AI image generators can generate images of things real or imaginary. Some benefits of AI image generators include time-saving, cost efficiencies, the ability to customise images, scalability, consistency and accessibility (especially for those who lack design or artistic skills) (Vimpari et al, 2023). However, there are also issues with AI generators. There are ethical concerns around the use of images used to train the generators and whether or not there are copyright issues, the impact on artists and designers, the generation of inappropriate images and the use of tools to create deep fake images (Vimpari et al, 2023). AI generated images have become very realistic in recent years. There is a phenomenon with AI images and virtual humans called the uncanny valley. This is where images or virtual humans appear real but there is something 'different' about them and this can cause an uncomfortable sensation in the viewer. Recent AI tools (e.g. MidJourney and Dall-E) can generate images that are very realistic, with less of the uncanny valley effect. However, there are still residues of this in the images, but sometimes viewers have to look hard to find 'strange' elements. One area that AI images struggle with is human hands and their rendering of hands is sometimes 'weird'. The prompts provided to AI image generators are key to successful generation of images. It can be difficult to get the AI generators to generate similar images for a sequence of pictures. While AI image generators have been around since the 1970s, it is only in recent years that they have become available, usable and (financially) accessible to the general public.

2.4. Text-to-Speech and CALL

Text-to-Speech (TTS) is a technology that reads digital text aloud. It converts words into their audio equivalent. TTS technology has been used to aid blind and visually impaired people to 'read' digital text. In the early days of TTS, the technology was clunky and only available for a limited number of languages, particularly English, but today the technology works really well and is available for many languages (Pratap, 2024). TTS tools can also be used to help others with reading difficulties. This includes those with dyslexia (particularly if they do not have auditory processing issues as well) and other reading difficultie. TTS tools can be integrated into devices, accessed via the web and in specialised apps. They can be used to support students with reading difficulties, in conjunction with their usual school supports (Keelor et al., 2023) In terms of language learning, TTS can also be helpful to learners (e.g., Cardoso et al., 2015), especially if they are unfamiliar with the L2 writing system. It can be used to help in pronunciation (Fouz-González, 2015).

3. Methodology

3.1. Context

Cipher is a Digital Game-Based Language Learning (DGBLL) application that asks players to find words that have been put under a spell by an evil character. There are different types of spells and the player has to spot a given number of words under a spell and identify the spell to progress through the game. The initial version of Cipher was developed in English and was subsequently adopted for Irish for beginners (Xu et al, 2024). The initial Irish version of Cipher was played successfully by primary school students (see Figure 1), but there was room for improvement in terms of the language content, visual appeal and accessibility for students. With this in mind, three AI technologie were used to enhance Cipher: NLP, AI images and TTS.

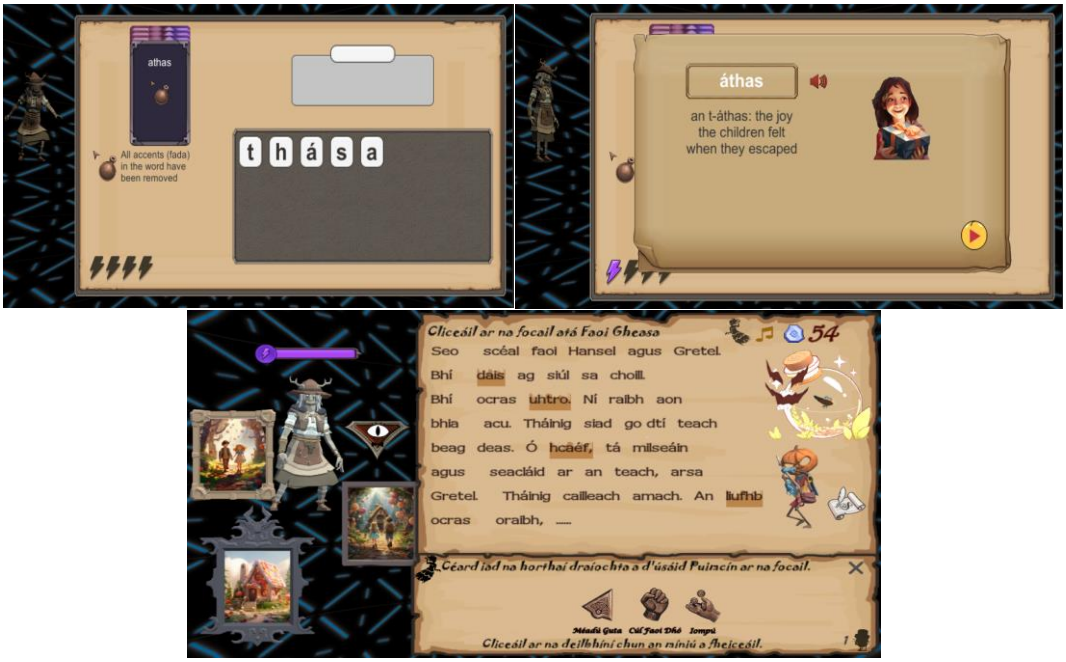

Figure 1. Screenshots of Cipher

3.2. NLP in Cipher

NLP tools are used in several ways in Cipher. NLP tools were used to check for spelling and grammatical correctness, a Part-of-Speech (POS) tagger was used to determine the lexical complexity of the learner texts and a POS tool was used to provide XML formatted POS tagged text to Cipher. It is important to ensure that the texts presented to the players have no spelling or grammatical errors (apart from the spells introduced by the evil spirit) and an NLP tool was used to check for correctness.

In CALL resources, it is really important that the language used is at the correct level for the learner (Hashemi, & Aziznezhad, 2011). For the most commonly taught language, there are many tools available to check the difficulty of a piece of text (Benjamin, 2012). These tools consider lexical complexity, grammatical complexity, sentence length and other features. In the case of Irish, these tools are not available and there was a need to develop tools to ensure that the texts in Cipher were at the correct level of difficulty for learners. The NLP text level analyser tool for Irish involves lexical analysis, grammatical analysis and frequency analysis. Moreover, Irish text classification using Large Language Models was also investigated (Mc Cahill et al, 2024).

The evil spirit in Cipher can choose which category of words to put under a spell. It is important that certain word categories (e.g. proper nouns) are not put under a spell. A POS tagger for Irish (Uí Dhonnchadha and van Genabith, 2006) provides XML formatted POS tagged text to the Cipher engine so it can choose to highlight particular parts of speech. This POS information is important for differentiating noun gender in Irish (i.e. masculine and feminine nouns) and it enables the Cipher game to display masculine nouns in blue and feminine nouns in red in the Cipher game.

Initially, there were plans to use a POS tagger to analyse texts produced by learners. However, the texts produced by players to get extra points when they ran out of points were at a very basic level and could not be used for this purpose. Some of the texts were in English and others were not full sentences. In order to support learners, later versions of Cipher allowed the players to gain points by joining word bricks together to make a sentence in Irish. This word brick approach had been used successfully before (Purgina et al., 2017) and it worked well in this context also.

3.3. AI images in Cipher

Our initial exploration of AI image generation in the Cipher game (Xu et al., 2023) revealed promising results. While AI was quicker than human efforts in terms of image creation, human intervention and iterative refinement were necessary. Building on this foundation, subsequent developments have seamlessly integrated AI-generated images into the game, presenting three sequential images per page aligned with the storyline. This evolution not only enhances comprehension but also transforms these images into interactive game components. It was important to ensure that the images were appropriate and consistent. The approach was to use a slightly cartoon like, rather than aim for realistic images. The aim was to stay aligned with the overall look and feel of the Cipher game.

Figure 2. AI-generated images in Cipher

3.4. Text-to-speech in Cipher

A notable addition to the Cipher game is the implementation of TTS AI, designed to assist learners, particularly those with dyslexia. This AI synthesised voice enhances the game's storytelling element, and ensures that learners with textual reading difficulties can fully access instructional and motivational game support. While the Cipher game is designed to be simple and easy to use for learners, sometimes there may be a need to provide extra support. The addition of audio support can help learners play the game independently and not rely on the help of the teacher or another student.

TTS was also used to support the vocabulary learning element of Cipher. abair.ie is a TTS tool specifically designed for Irish and can generate audio files in three different dialects of Irish and at different speeds. abair.ie was used to generate the audio files for each of the vocabulary words. Irish orthography is not transparent and it can be difficult for learners to decipher the correct pronunciation of Irish words (Hickey & Stenson, 2011). It is essential for learners to know how to pronounce words correctly as part of the language acquisition process.

3.5. Description of testing

The testing of the enhanced version of Cipher took place in two English-medium primary schools in Ireland. There were three cohorts - cohort 1 and cohort 2 were from an all-boys primary school. The participants were between 10 and 12 years of age and had learnt Irish orally and aurally for five years, and Irish reading and writing for three years. The learners played the game on tablets, generally individually, but sometimes in pairs. Cohort 1 played the game for 10 weeks, while cohort 2 played the game for five weeks. Each session lasted around 30 minutes, including the time for setting up and exiting the game. The students could play the game at their own pace and generally played with teacher or CALL researcher assistance, but it was available if required. Cohort 3 was an all-girls school and participant ages ranged from 10 to 12. These students played the game for three weeks for 1 hour at a time. The differences in number and length of sessions was due to timetabling issues with the classes in the schools.

There were various elements assessed as part of the Cipher evaluation process with the students. These included the usability of the game, the learning effects and students' opinions on the game itself. A double baseline approach was used to test the learning effects (Üstün-Yavuz, 2024). This paper focuses on the impact of NLP, AI images and TTS in Cipher.

4. Results, Discussion and Limitations

4.1. NLP and Cipher

The integration of NLP tools in the Cipher game proved to be effective in ensuring that the texts presented to learners were at the appropriate difficulty level. The use of NLP in text analysis facilitated the classification and adaptation of texts according to the linguistic proficiency of the learners. By analysing lexical, grammatical, and discourse features, the system ensured that texts were neither too challenging nor too simple, maintaining learner engagement and motivation. NLP tools were instrumental in providing XML-formatted POS-tagged texts, which were used to highlight grammatical features such as noun gender, enhancing the pedagogical value of the game. This adaptation of NLP tools is crucial for less-resourced languages like Irish, where pre-existing educational resources are limited. Overall, the approach of incorporating NLP into Cipher not only worked effectively but also provided a scalable model for other low-resourced languages, ensuring texts are pedagogically sound and appropriately challenging for learners.

4.2. AI and images

We were able to generate images that aligned well with the Cipher stories. There was a lot of trial and error and it was difficult to generate consistent images. There was also the issue of strange images, as well as images that were inappropriate (e.g. the use of the word witch meant some images of horrible women were produced or an adult themed 'witch' was generated). Comparing the outcomes of the earlier study with the recent experiment showcases noteworthy improvements. The further integration of AI-generated images and resolved issues related to game progress has led to a more positive reception from learners. In the recent experiment, out of 31 survey responses, 57% expressed a positive inclination towards the story images, surpassing the 51% recorded in the previous study (Xu et al., 2023). Regarding comprehension, 45% of respondents perceived the story images as facilitative, marking a notable increase from the earlier 27%.

Table 1: Comparitve results for Cipher with AI images

	Previous version with AI images	Recent version with AI images
Do you like the images in the story?	51%	57%
Do the images in the story help you understand the story?	27%	45%

4.3. Text-to-Speech (TTS)

TTS technology, i.e. elevenlabs.io, was used to generate the audio files for Cipher's English interface Help features. This ensured consistency and clarity of pronunciation throughout the game. It was also advantageous for the Cipher team to be able to use Irish TTS abair.ie to generate the Irish audio files. This ensured that the audio files were correct and consistent, and did not rely on the need to have a native speaker available to record the words. This level of accuracy and consistency is particularly important for novice and young, inexperienced learners. The students across cohorts 1 and 2 reported that while they liked the audio (48%), only 26% said that the audio helped them play the game. For cohort 3, only 21% liked the audio and also only 21% said it helped them play the game. The TTS tool generated words in English with a UK Received Pronunciation (RP) accent which is different to English with an Irish accent, (one student has heard to say "*I do not like the woman's voice it is annoying*"). This illustrates the importance of software localisation, and in future versions of Cipher we intend to add an Irish accent as a choice for the mainly Irish users of the game.

4.4. Discussion

CALL researchers aim to integrate new technologies into the language learning process. However, due to the difficulties in doing so, they often only choose one technology for new CALL resources (O'Brien et al., 2020). For instance,they may choose to use NLP techniques to ensure that the texts are correct and at the right level for learners. They may use AI generated images to make the game more interesting and engaging for learners. They may use TTS to provide audio guidance and pronunciation support for learners. The Cipher DGBLL app combines all three AI technologies in a pedagogically informed manner to create an engaging learning resource for students. It would not have been possible to choose suitable texts objectively and check their correctness without NLP tools. It would not have been possible to have suitable images in the app without the use of an AI image generator. It would have been possible, but much more challenging, to provide audio files in English and Irish for the app without the use of TTS tools.

This approach could be used by other CALL researchers. There may be suitable NLP tools available for the language of study, particularly if it is a well-resource language. If NLP tools are not available, rudimentary NLP tools could be developed using standard features (e.g. sentence length and lexical complexity). AI image generators are commonly available and can generate a wide range of images, independent of context. TTS tools may be available for the language of study and more will become available in the future, particularly as Generative AI tools increase their range of languages covered. The utilisation of some AI tools have a steeper learning curve than others (e.g. AI image generators), but the AI tools outlined in this paper have all contributed to enhancing the Cipher game and should be considered by CALL researchers looking to enhance their portfolio of CALL resources.

4.5. Limitations

There are several limitations of the current study, including cohort size, duration of testing and survey size. The game was only tested in two schools so there is a need for further research with a larger cohort of students. The students in cohort 1 played the game for 10 weeks, cohort 2 for five weeks and cohort 3 for three weeks (but for a longer duration per session). It would be preferable to test Cipher over a longer period of time, but it is challenging to test CALL resources in primary schools, especially when the CALL team are not primary school teachers in the schools in question. Student surveys can provide valuable information, particularly if there are many probing questions. However, due to the age of the student participants, it was necessary to limit the number of questions asked in the surveys. This meant that it was difficult to do a deep dive into specific aspects of the game e.g. images and audio components. Further research is required to carry out a more detailed analysis of these components.

5. Conclusion

The objective of this research was to explore the use of three AI technologies (Natural Language Processing (NLP), AI image generation and text-to-speech (TTS) technologies) to enhance the game-like elements of CALL resources. AI technologies can enhance CALL resources, but they can be difficult to integrate in a pedagogically sound manner into such resources. The NLP tools helped to ensure the quality of the texts, the AI generated images made the stories more engaging and the TTS made the game more accessible to learners of different abilities. These results demonstrate that by using AI resources in a focused manner, they can be used to improve CALL resources for learners by enhancing the user experience and the learning outcomes. These technologies improved productivity in terms of CALL development. CALL researchers are encouraged to explore these technologies and use them where feasible in their own CALL resources. Future research will continue to explore and enhance the integration of these technologies in CALL to promote humanity, interactivity, and accessibility in language education.

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