

Learner-Oriented Game Design: The Evolution of Cipher

Liang Xu¹, Jenny Thomson², Elaine Uí Dhonnchadha³, Monica Ward¹

¹ School of Computing, Dublin City University, Dublin, Ireland

² Human Communication Sciences, School of Allied Health Professions, Nursing and Midwifery, University of Sheffield, Sheffield, UK

³ Centre for Language and Communication Studies, Trinity College Dublin, Dublin, Ireland

liang.xu6@mail.dcu.ie, j.m.thomson@sheffield.ac.uk, uidhonne@tcd.ie, monica.ward@dcu.ie

Abstract—This paper explores the integration of a digital game, Cipher, into language learning. It emphasises the balance between maintaining a playful game approach and ensuring robust pedagogical foundations. Motivating learners, especially for endangered languages (in this case Irish), can be challenging, but digital game-based learning offers an effective solution. The game has evolved via a pragmatic, pedagogically informed, learner-oriented game design approach. The game includes key elements such as levels, power-ups, scoring system and life mechanism all of which are important in maintaining the game ethos, in challenging the player and maintaining interest and to avoid the chocolate-covered broccoli scenario. The game framework, derived from an existing model, is modular and designed to be language independent. This enables the game to be adapted to the local culture, language and context. Crucially, the co-creation process, involving feedback and insights from teachers and learners, has driven the game's refinement through multiple iterations, resulting in enhanced content and features. This semi-agile approach enabled the evolution of the game through various stages to the current iteration, featuring more appropriate texts, improved game components and planned enhancements including AI-generated audio, images, and other innovative features. Cipher serves as a valuable asset for low-resourced languages, fostering inclusivity by catering to individual learning speeds and diverse learner needs. This paper outlines an approach centred on reuse/repurpose, pragmatism, and co-creation, which holds promise for application across various other contexts.

Keywords—*Serious Games, Digital Game-Based Language Learning, Artificial Intelligence, Inclusive Design.*

I. INTRODUCTION

This paper traces the evolution of Cipher, a game where players uncover clues in texts, fostering ‘noticing’ and incidental language learning. Game design is intricate and the approach to developing and enhancing the game consists of several key elements: reuse and repurpose of existing resources, consideration of logistical and practical issues, pedagogical focus, curriculum alignment, which is underpinned by a co-creation and culturally responsive ethos. Given the complexities of game design, repurposing existing game resources for new educational contexts often proves feasible. The original Cipher game [1] targeted B2 (and higher) level English speakers, focusing on error detection in texts. The possibility of repurposing and adapting it into a game for learning a language (in this case Irish) led to the development of the initial version of Cipher: Faoi Gheasa¹. While successful (see Section III-A below), enhancements were necessary to bolster its pedagogical foundation, align it more closely with curriculum standards, and

improve the user experience. To achieve this, consulting with teachers and seeking feedback from both teachers and students regarding the game was crucial. Equally important was the adaptation of the game to local content and ensuring cultural responsiveness across language, context, and cultural nuances.

Cipher's overarching goal is to facilitate language learning. In this specific context, the game helps with the acquisition of the Irish language through ‘incidental’ learning while playing the game. In this game scenario, malevolent forces seek to sabotage myths and ancient tales, attempting to destroy the memory of culture and heritage. The villain achieves this by casting spells which disrupt the words, rendering the stories indecipherable. The aim of the game is to restore the stories and defeat the evil creature. This scenario lends itself well to the learning tasks of spelling, reading and vocabulary acquisition. The game incorporates spells targeting specific language errors (e.g. issues with accents or specific letter combinations), supplemented with imagery for vocabulary reinforcement. Additionally, tools were developed to measure text complexity, ensuring suitability for novices and false-beginners. Learner feedback has played a crucial role in the learner-oriented design process, contributing to the enhancement of the game, such as refined game components and integrating AI-generated audio and visual elements. This paper looks at the evolution of Cipher and outlines how a learner-oriented game design approach has worked well in the context of a low-resource language like Irish. It underscores the potential applicability of this approach across different learning environments, providing valuable insights for those considering similar strategies.

II. BACKGROUND

This paper focuses on Cipher, a digital game for Irish. However, the challenges encountered in Irish language education mirror those of other low-resource languages. They share a common requirement for digital language learning tools, including digital games, yet these resources are frequently inaccessible to them.

A. Irish Language Learning Context

Motivation is an important factor in successful language learning [2]. Resources, such as digital games, can boost motivation levels among students [3], a particularly vital aspect in low-resource language environments where even a few resources can greatly enhance the language learning experience. Irish orthography is not initially transparent to learners, including learners whose first language is English, which is the case for most learners in schools in Ireland. For example, the

¹ ‘Faoi gheasa’ means ‘Under a spell’

word ‘teach’ to a native English speaker refers to the act of imparting knowledge and is pronounced [ˈti:tʃ]. However, the word ‘teach’ in Irish means ‘house’ and is pronounced like ‘chock’ [tʃok]. Other orthographical issues can cause difficulties for language learners including word-initial mutation and its complex morphology. It is incorrectly assumed that students will automatically be able to read the language (based on their knowledge of English). This results in incorrect transfer from English, which in turn makes reading and learning the language more difficult. Common errors included ignoring accented vowels and a lack of understanding of what possible spelling combinations. Accents are important in Irish and change the pronunciation and meaning of words (compare ‘briste’ (trousers) with ‘briste’ (broken)). These difficulties result in students ‘giving up’ on getting the right spelling and not persevering when they make spelling mistakes, hindering their language learning progress.

Research in Second Language Acquisition (SLA) has enhanced the teaching of languages, particularly for some of the most commonly taught languages such as English and Spanish [4] but Irish sometimes misses out on some of the elements of language learning that contribute to the enjoyment of learning. Therefore, there's a pressing need for resources that enhance the enjoyment of learning Irish. In education systems across the world, many language teachers are either first language speakers, or have studied the language to an advanced level. However, in the Irish context most primary school teachers are not native speakers and often lack confidence in their ability to speak the language. Moreover, they have limited access to digital resources that can enrich the language learning experience, both in terms of effectiveness and enjoyment.

While some challenges mentioned above are specific to Irish, there are parallels between Irish and other low-resource languages in the language learning landscape. One obvious similarity is the dearth of pedagogically sound, curriculum-aligned digital resources, particularly language-focused digital games. Despite the demand, such games are difficult to build and the required resources (e.g. finance, time and skillsets) are often not available to low-resource language communities. To our knowledge, there are no curriculum-aligned digital games for Irish that are readily accessible for classroom use.

B. Reconnecting to the Spirit of Language

Research from other language communities (e.g., Cree language) indicates that endeavouring to reconnect with the spirit of the language can help learners in their learning journey [5]. While the level of connection may vary and many may lack enthusiasm for the language, Irish people recognise that their language is something unique and special and it is an important part of their cultural heritage. Given the complex socio-cultural context of the language in Ireland, providing learners with an opportunity to reconnect with the spirit of the language can be a helpful approach. For this reason, *Cipher: Faoi Gheasa* was adapted for Irish learners and in addition to international fairy tales, it focuses on incorporating Irish folklore and mythology into the game context.

C. Specific Learner Cohorts - Dyslexia

Another learner group who can benefit from the motivational aspects of game-based learning are students with reading difficulties such as dyslexia. Developmental dyslexia is a specific learning difficulty that impacts the accuracy and efficiency of word reading and spelling [6]. As the *Cipher* game demonstrates, immersion in stories can help bolster language skills, however children with dyslexia often avoid text-based tasks due to accumulated experiences of excessive effort and/or failure. Such avoidance can then lead to a vicious cycle of reduced academic achievement. In this project we adapt the *Cipher* game, to make it more accessible and appropriate for learners with text-based language difficulties, such as dyslexia. The most basic adaptations involve reducing the amount of text on each screen and carefully monitoring the readability of the text (both in the target story, as well as in the scene-setting and instructional supports). We also believe that the inclusion of specific spells in the game can be used as a tool to help dyslexic learners detect and correct spelling patterns commonly reported in dyslexic learners of English [7], such as difficulties with more complex vowel spellings (e.g. split vowel digraphs a-e, i-e), and confusion of consonants with similar articulatory and visual features (e.g. b, p, b). Text in the game that is not part of the active learning segments is augmented with Text to Speech (see section III-F below), so that understanding text instructions is not a barrier to gameplay.

D. Digital Game-Based Language Learning

Digital game-based language learning (DGBLL) offers a promising avenue for second language (L2) acquisition, with a recent meta-analysis revealing key insights [8]. Entertainment-focused games outperform those designed for L2 education, emphasising the importance of engagement and authenticity [8, 9]. Vocabulary acquisition is a highlight, but diverse game mechanics pose challenges in generalising outcomes [10, 11]. Educational games face hurdles in industry investment and player engagement, hindering success [8, 9]. Defining digital games is crucial for understanding their impact, distinguishing them from traditional learning software [8]. The shift from rote-based to context-based language learning, as discussed by [12], aligns with the transformative potential of games. Digital Educational Games show promise in supporting minority language learning but require enhancements to match the engagement of mainstream games [8]. Bridging the gap between entertainment and educational game design remains a challenge to maximising DGBLL's potential in language learning contexts.

E. Text-to-image AI

Text-to-image generation models (TTIG), such as DALL-E², have emerged as powerful tools in the visual arts and game design, allowing the creation of visual content from text descriptions or user-provided images [13]. These models, trained on massive datasets, enable the generation of high-quality images and have been embraced by the game industry [14]. They democratise image-making, enabling individuals without traditional artistic skills to produce visually appealing content [14]. However, concerns exist regarding biased content, copyright issues, and limitations such as the generation of

² <https://openai.com/dall-e-2>

predictable images and lack of personalisation [13, 14]. Despite these concerns, TTIG models are expected to impact the creative process across various visual art domains [14]. Initially the inclusion of imagery in the Cipher game seemed impossible given our limited budget and the lack of pre-existing suitable images. However, the advent of AI image generation means that it is possible to generate customised images at a reasonable cost. However, the process of generating suitable images still requires substantial time and effort. There were issues with generating suitable images of females as they tended to be either young and provocative or old and grotesque. Generating images with multiple story elements was also problematic. As noted by [15] there is a significant semantic gap between the text domain and the image domain. However, with perseverance and more varied and detailed prompts, it is possible to generate suitable imagery. AI systems such as Midjourney³, transform image generation for lower resourced languages where traditional methods of generating images would not be commercially viable.

F. Text-to-speech AI

Text-to-Speech Synthesis (TTS) is a transformative technology that converts written text into spoken language. The progression of TTS systems has witnessed steady development, shifting from initial mechanised or rule-based synthetic speech to end-to-end models providing a level of quality comparable to human speech [16, 17]. TTS has the potential to play important roles in CALL applications: as a reading machine, pronunciation model, and conversational partner [18]. Research [19] highlights its positive impact on vocabulary enhancement, reading comprehension, and fluency. TTS benefits learners, especially those with dyslexia, by triggering phonological awareness and reducing reading fatigue [19]. Despite the potential benefits, the suitability of TTS in CALL is yet to be universally accepted [18]. Research indicates its positive impact on language learning, reading abilities, and vocabulary enhancement [19], showcasing the need for further integration of TTS into diverse educational contexts.

III. GAME DESIGN

The game design for Cipher has undergone iterative development, incorporating feedback, learner needs, and advancements in technology. The design evolution can be categorised into several stages, each aimed at enhancing language learning, user experience, and inclusivity.

A. Stage 0 - Original Cipher

The original Cipher game [1] was developed to encourage people to identify errors in text. Text error detection is important for a variety of applications, e.g. spell checkers and optical character recognition (OCR). However, some correction algorithms do not perform well for complex errors and it is costly to employ humans to do the task. To solve the problem, the "game with a purpose" [20] concept was used to transform the task of error identification into a gamified experience. The text-based Cipher game targeted university students with English as a first/second language, spanning B1-C2 CEFR⁴ proficiency levels, encouraging them to play the game for

entertainment while making valuable annotations which locate text errors. The game mechanics involve encoding text with various ciphers, adding a cryptographic layer to the error identification process. Genuine errors, sourced from Kaggle's English common error lists, serve as distractors to enhance gameplay complexity. Players earn points for identifying errors or ciphers, contributing to data collection for further analysis. Positive player feedback and the observation that the game had the potential for language learning led to the exploration of Cipher's application in language education.

B. Stage 1 - Initial Adaptation: Proof of Concept

The Cipher game was adapted for Irish language learning by incorporating Irish language resources from textbooks and corpora [21]. Challenges arose due to the scarcity of Irish language resources such as suitable texts and lists of common errors for young learners. An initial list of common errors was assembled manually. A customised error noticing mechanism was developed to assist players in understanding and correcting errors which were randomly inserted into the texts. This version of the game targeted primary school students at A1-B1 CEFR levels. Initial feedback from an Irish-medium primary school highlighted the need for clearer instructions on how to play the game and the identification of real-world errors. Fig.1 displays a screenshot of Cipher in stage 0 (left) and stage 1 (right).



Fig. 1. Screenshots of Cipher in stage 0 and stage 1

C. Stage 2: Game Enhancements and Socio-Cultural Theory Incorporation

Based on feedback at the proof-of-concept stage we made several changes to the design. We dispensed with real-word errors and concentrated on extending the range of Irish-specific ciphers in the game. The socio-cultural theory of 'reconnecting to the spirit of indigenous languages' [5], was woven into the game's storyline and learning materials, leading to an emphasis on Irish mythology and common fairy tales. The narrative involves a magical world where evil spirits seek to obscure ancient mythological tales, connecting the game to Irish folklore and cultural heritage [22]. Key features added in this stage include:

- **Irish-specific ciphers and word gender highlighting:** New ciphers such as Accent bomb, Vowel sprout, Lunar eclipse, and Solar eclipse were added, enhancing language relevance (Fig. 2 bottom left). Noun gender was highlighted in the reading task using Irish Natural

³ <https://docs.midjourney.com/>

⁴ Common European Framework of Reference (CEFR) <https://www.coe.int/en/web/common-european-framework-reference-languages/table-1-cefr-3.3-common-reference-levels-global-scale>

Language Processing (NLP) tools [23]. See Fig. 2 top left and right.

- **Game tutorial:** the tutorial graphically demonstrates the ciphers and their effects on words, which helps players to better understand how the game works.
- **Power-ups:** these enable players to progress even with limited language proficiency, fostering a positive language exposure activity. See Fig. 2 bottom right.
- **Writing component:** a ‘complete the story’ feature was added to reinforce learning through active participation.
- **Adaptivity:** the gaming experience is tailored to the player by adjusting text difficulty based on player information and their game performance.

The game was tested in an English-medium school, focussing mainly on user experience [24]. Feedback showed that players liked the game but some found the texts and the ciphers difficult, and many found the free-form story completion element too challenging. Clearly, more support was needed for early-stage Irish learners. With this in mind we explored the potential of AI image generation to create context-specific visual aids to enhance learners' comprehension and engagement.



Fig. 2. Screenshots of Cipher in stage 3

D. Stage 3: AI Generated Image Incorporation

In this stage the incorporation of context-specific images into the game was a major innovation. We concentrated on developing content for two stories: a fairy tale and an Irish mythology tale. Each story ‘page’ contained one context-specific image. The sentence writing feature was temporarily removed due to player difficulties, and an alternative new sentence-based game element was designed. Key elements introduced in this stage include:

- **AI-generated images:** Enhancing visual appeal and contextual understanding, aligning with the theme of reconnecting with cultural roots. See Fig. 3 on the left.
- **Localisation:** Providing the user-interface in a choice of languages.
- **Enhanced game tutorial:** The game tutorial underwent additional improvements, incorporating animations to illustrate ciphers and gameplay.

We tested the enhancements in the same English-medium primary school and received mainly positive feedback on AI-generated images, with suggestions for enhanced gaming and

learning experiences [25].



Fig. 3. Screenshots of Cipher in stage 3 (left) and stage 5 (right)

E. Stage 4: Gaming and Learning Enhancement

This stage focused on refining the game's storyline and educational game components, through alignment with the primary school curriculum. A vocabulary learning element was introduced and the language learning materials were co-created with primary school teachers [25, 26] to ensure curriculum alignment. Immersive elements, such as game characters, animations and additional elements of Irish mythology, were introduced to connect various game tasks. Word gender highlighting was removed from the reading task based on user feedback but was retained in the vocabulary task. Key additions included:

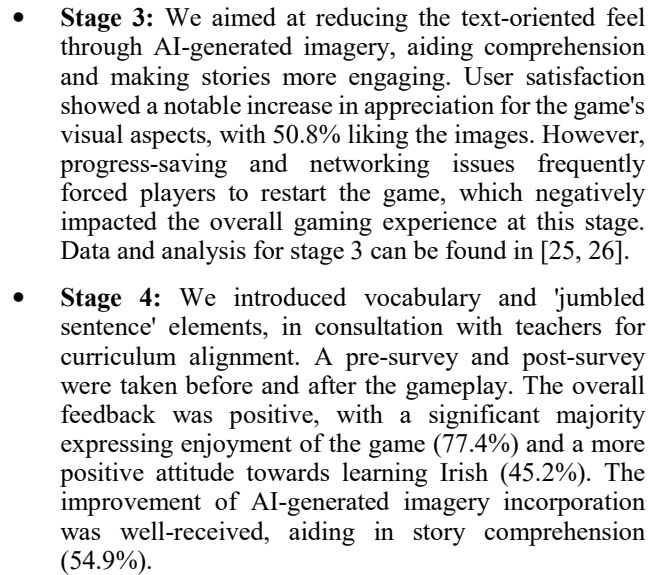
- **Characters:** The witch (player) with life points mechanism and the evil pumpkin (villain) to enrich the storyline and engage players.
- **Character life mechanism:** different from the existing scoring system in the game, the character life mechanism connects all the language-related tasks (vocabulary, reading and writing).
- **Storyline improvement:** A more immersive and interconnected narrative involving deciphering spells and saving mythical animals in the game world. A 3D animation was added to depict the game world at the beginning, which strengthens the theme of reconnecting to cultural roots. Refer to Fig. 4.
- **Sequenced AI-generated images:** Seamless integration of multiple AI generated images infused with game features on each story ‘page’, contributing to more positive learner reception. Fig. 3 on the right.
- **Addition of vocabulary task and enhancement of writing task:** Further gamifying educational aspects, enhancing the overall learning experience. See Fig. 5.

The latest feedback is positive with players enthusiastically engaging with the game and teachers noting the game's potential for increasing motivation and positivity towards Irish.

F. Stage 5: Language Independence and Inclusivity (ongoing)

From the project's inception, language independence was a consideration. The game was recently adapted for dyslexic learners in English, with strategic adjustments to language learning materials (less and easier text at the beginning) and game rules. Modifications were made to cater to the specific needs of dyslexic learners. Refer to Fig. 3 on the right. Key features added in this stage include:

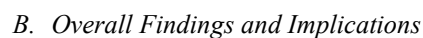
- through heightened motivation, and sustained high satisfaction (71.9%). For in-depth information on the data and feedback in stage 2, please refer to study [24].



Please refer to the Table 1 for a detailed overview of pre- and post- user satisfaction studies across all stages of the game.

TABLE I. CIPHER GAME USER SATISFACTION ACROSS STAGES

Question	Stage 2 Post (n=64, 2-week)	Stage 3 Post (n=169, 2-mth.)	Stage 4 Pre (n=44)	Stage 4 Post (n=31, 3-week)
Did you like playing the game?	46 (71.9%)	85 (50%)	N/A	24 (77.4%)
How do you feel about learning Irish (after playing the game?)	36 (56.3%)	63 (37.3%)	12 (27.3%)	14 (45.2%)
Do you think you learned anything while playing the game?	33 (51.6%)	59 (34.5%)	N/A	20 (64.5%)
What do you think about learning Irish through the game?	40 (62.5%)	81 (48.2%)	N/A	17 (54.9%)
Do you like the images in the story?	N/A	86 (50.8%)	N/A	17 (54.9%)
Do the images in the story help you understand the story?	N/A	46 (27.2%)	N/A	14 (45.2%)



High user satisfaction throughout its development phases underscores Cipher's capability to captivate learners attention, and successfully navigate the challenge of making educational

- Authorized licensed use limited to: DUBLIN CITY UNIVERSITY. Downloaded on December 05, 2025 at 18:11:25 UTC from IEEE Xplore. Restrictions apply.

content engaging without diminishing its educational value—a feat akin to avoiding the "chocolate-covered broccoli" scenario.

The insights gathered to date affirm the feasibility of integrating a digital game like Cipher within primary school settings. Several key features help to ensure that the process is successful. A shift from (old) laptops to more accessible tablets improved user experience. Ensuring that the game's content aligns with the curriculum and is tailored to the language proficiency levels of the target student cohort is crucial for its relevance and effectiveness. It can potentially transform the language learning experience, increase student engagement, and foster a positive disposition towards the language being studied.

Some of the challenges we encountered include the difficulty of adhering to the standard frameworks for evaluating the gameplay experience due to constraints such as limited gameplay sessions for children in the class and the impracticality of long surveys for this audience. Consequently, surveys were shortened to include a subset of questions from study [28] to fit the restricted time frames and retain the essence of user feedback, as detailed in our initial study [24].

V. CONCLUSION

Cipher's evolution showcases the power of digital games in language learning, particularly for less-resourced languages. With its learner-centred design, Cipher boosts motivation for language learning and strengthens cultural connections while bridging language learning technology and diverse linguistic and cultural backgrounds. The invaluable feedback from teachers and students has played a pivotal role in refining Cipher's usability and effectiveness, highlighting its capacity to motivate learners and cultivate positive attitudes toward language learning in educational settings. As Cipher evolves, it exemplifies the power of a learner-centred design approach in the realm of educational game development. The ongoing incorporation of pedagogical principles and technological advancements aims to increase its impact, positioning Cipher as a model for similar initiatives in other low-resource language contexts across diverse linguistic and cultural landscapes.

REFERENCES

- [1] L. Xu and Jon Chamberlain, "Cipher: a prototype game-with-a-purpose for detecting errors in text," In *Workshop on Games and Natural Language Processing*, Marseille, 2020, pp. 17-25.
- [2] Z. Dörnyei, "Attitudes, orientations, and motivations in language learning: Advances in theory, research, and applications," *Language learning*, vol. 53, no. S1 pp. 3-32, 2003.
- [3] F. Cornillie, S. L. Thorne, and P. Desmet, "ReCALL special issue: Digital games for language learning: challenges and opportunities: Editorial Digital games for language learning: from hype to insight?," *ReCALL*, vol. 24, no. 3 pp. 243-256, 2012.
- [4] R. Ellis, "Second language acquisition, teacher education and language pedagogy," *Language teaching*, vol. 43, no. 2, pp. 182-201, 2009.
- [5] K. Napier and L. Whiskeyjack, "wahkotowin: Reconnecting to the Spirit of nēhiyawēwin (Cree Language)," *Engaged Scholar Journal* vol. 7, no. 1, pp. 1-24, 2021.
- [6] J. Rose, "Identifying and teaching children and young people with dyslexia and literacy difficulties: An independent report," Department for Children, Schools and Families (DCSF), London, 2009.
- [7] J. Pedler, "Computer spellcheckers and dyslexics—A performance survey," *British Journal of Educational Technology*, vol. 32, no. 1, pp. 23-37, 2001.

- [8] D. H. Dixon, T. Dixon, and E. Jordan, "Second language (L2) gains through digital game-based language learning (DGBLL): A meta-analysis," *Language Learning & Technology*, vol. 26, Issue 1, pp. 1-25, 2022.
- [9] J. Reinhardt, "Gameful second and foreign language teaching and learning: Theory, research, and practice," Springer, 2018.
- [10] M. H. Chen, W. T. Tseng, and T. Y. Hsiao, "The effectiveness of digital game-based vocabulary learning: A framework-based view of meta-analysis," *British Journal of Educational Technology*, vol. 49, no. 1, pp. 69-77, 2018.
- [11] Y. L. Tsai, and C. C. Tsai, "Digital game-based second-language vocabulary learning and conditions of research designs: A meta-analysis study," *Computers & Education*, vol. 125, pp. 345-357, 2018.
- [12] B. H. Sørensen, and B. Meyer, "Serious Games in language learning and teaching—a theoretical perspective," In *DiGRA Conference*, 2007, pp. 559-566.
- [13] H. K. Ko, G. Park, H. Jeon, J. Jo, J. Kim, and J. Seo, "Large-scale text-to-image generation models for visual artists' creative works," In *Proceedings of the 28th International Conference on Intelligent User Interfaces*, Sydney, 2023, pp. 919-933.
- [14] V. Vimpari, "An Adapt-or-Die Type of Situation': Perception, Adoption, and Use of Text-To-Image-Generation AI by Game Industry Professionals," *arXiv preprint arXiv:2302.12601*, 2023.
- [15] M. Elasri, O. Elharrouss, S. Al-Maadeed, and H. Tairi, "Image Generation: A Review," *Neural Processing Letters*, vol. 54, no. 5, pp. 4609-4646, 2022.
- [16] Y. Wang, R. J. Skerry-Ryan, D. Stanton, Y. Wu, R. J. Weiss, N. Jaitly, Z. Yang et al., "Tacotron: A fully end-to-end text-to-speech synthesis model," *arXiv preprint arXiv:1703.10135* 164, 2017.
- [17] X. Tan, J. Chen, H. Liu, J. Cong, C. Zhang, Y. Liu, X. Wang et al., "NaturalSpeech: End-to-End Text-to-Speech Synthesis with Human-Level Quality," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 14, no. 8, 2015.
- [18] Z. Handley, "Is text-to-speech synthesis ready for use in computer-assisted language learning?," *Speech Communication*, vol. 51, no. 10, pp. 906-919, 2009.
- [19] Yi. C. Huang, and L. C. Liao, "A Study of Text-to-Speech (TTS) in Children's English Learning," *Teaching English with Technology*, vol. 15, no. 1, pp. 14-30, 2015.
- [20] L. Von Ahn, "Games with a purpose," *Computer*, vol. 39, no. 6, pp. 92-94, 2006.
- [21] L. Xu, M. Ward, E. Uí Dhonnchadha, "Cipher 2 An Printiseach Rúnda (The Secret Apprentice): A Language Game For Irish CALL," In *Irish Conference on Game-based Learning, Online*, 2021.
- [22] L. Xu, M. Ward, E. Uí Dhonnchadha, "Exploring the Synergies between Technology and Socio-Cultural Approaches in CALL for Less Commonly Taught languages," In *LTC'23, 10th Language & Technology Conference*, Poznan, 2023.
- [23] E. Uí Dhonnchadha and J. V. Genabith, "A Part-of-Speech tagger for Irish using finite state morphology and constraint grammar disambiguation," 2006.
- [24] L. Xu, E. Uí Dhonnchadha, and M. Ward, "User experience study of 'Cipher: Faoi Gheasa', a digital educational game for language learning and student engagement," In *Proceedings of the 2nd Workshop on Games Systems*, Athlone, 2022, pp. 5-8.
- [25] L. Xu, E. Uí Dhonnchadha, and M. Ward, "Harnessing the Power of Images in CALL: AI Image Generation for Context-Specific Visual Aids in Less Commonly Taught Languages," In *EUROCALL2023*, Reykjavík, 2023.
- [26] M. Ward, E. Uí Dhonnchadha, and M. Ward, "Co-creating CALL content - does it work? Goldilocks compromise or Cruella chaos?," In *EUROCALL2023*, Reykjavik, 2023.
- [27] J. S. Chall, "Stages of reading development," New York, NY: McGraw-Hill, 1983.
- [28] Bul, K. C., Franken, I. H., Van der Oord, S., Kato, P. M., Danckaerts et al., "Development and user satisfaction of 'Plan-It Commander,' a serious game for children with ADHD," *Games for Health Journal*, vol. 4, no. 6, pp. 502-512, 2015.