Mythology Meets Technology: Transforming a 2D Game into a Virtual Reality Journey for Language Reconnection

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***Abstract*— This paper explores the transformation of the 2D language learning game, Cipher, into a 3D Virtual Reality (VR) experience to enhance Irish language learning and reconnection. Despite the Irish language's official status, its use is limited in day-to-day life, necessitating innovative educational methods. The VR adaptation integrates sociocultural theory and elements of Irish folklore and mythology to create an immersive learning environment. A study with 20 participants from primary and secondary schools was undertaken to evaluate user satisfaction with the VR game. Preliminary results show that the VR version enhances engagement and motivation compared to the earlier 2D evaluations. This research demonstrates the potential of VR to create transformative educational and cultural experiences in language learning. Further research is required to investigate its impact on learning.**

I. Introduction

Sociocultural theory, widely recognised for its contributions to language acquisition, posits that language learning is deeply rooted in social interaction and cultural context [30]. This study leverages the sociocultural theory of language learning [1], emphasising the integration of cultural and historical contexts within the learning process. The language which is the focus of this study is Irish. Although, it is the first official language of Ireland it has a limited number of daily speakers. The Government of Ireland 20-year strategy for Irish [2], aims to increase daily usage of Irish, and calls for innovative approaches to language learning to increase engagement. However, the situation in primary schools presents challenges. Research highlights a noticeable disengagement with the Irish language among primary school students [31]. Dalton [32] emphasises the need for innovative strategies to reverse this decline in Irish language learning. There is a clear demand for fresh, engaging tools that not only facilitate language learning but also reignite student interest in Irish. This research is driven by the pressing need to develop such tools, utilising technology and cultural relevance to create a more engaging and effective language learning experience for Irish.

Cipher Faoi Gheasa [3] is a digital game set in a magical world (Fig. 1a), which uses gameplay mechanics to increase engagement and motivation and thereby encourage language learning. In this world, an evil spirit has cast spells on the stories and myths making them unreadable. The player must undo the spells to restore the stories (Fig. 1c). In preparation for this quest, the player must accumulate power by restoring the stone tablets (Fig. 1b). If the player runs out of power, they can be revived by completing the sentence task (Fig. 1d). By transforming the 2D version of the game into a VR environment, we aim to provide a more immersive, and culturally rich experience for learners. This VR adaptation not only focuses on learning but also on reconnecting learners with the culture of the Irish language, using folklore and mythology as key elements. The following sections will explore the background and context of the Irish language, the potential of VR in language learning, the theoretical framework of sociocultural theory, and the specific design and implementation of the VR version of Cipher.

Figure 1. Screenshots of 2D Cipher (from left to right: a) folklore scenes, b) vocabulary, c) reading and d) writing)

This study aims to demonstrate how VR technology can bridge the gap between theoretical approaches and practical applications, offering a novel strategy to promote the Irish language and other lesser resourced languages. The VR adaptation is particularly suited to enhancing the cultural and historical elements of Cipher, thanks to the VR interaction loop, which includes sensory feedback (visual, audio, haptic) and movement-based interaction (e.g., hand tracking), creating a fully immersive experience for learners [34].

II. Background

Irish is one of the official languages of Ireland (along with English and Irish Sign Language), however the number of speakers who use it as a primary language of daily communication is less than 2% of the population [4]. Irish is a compulsory language in schools in Ireland but there are very few digital resources for teaching and learning the language. The development of Computer Assisted Language Learning (CALL) resources for any language is difficult, and is even more difficult for less resourced languages like Irish [5]. Some limited resources do exist (e.g., abair.ie), but are underused and not widely known. There is a need for more CALL resources for Irish, including VR resources, with more research into their integration in the classroom and their effectiveness in supporting the curriculum.

Virtual reality (VR) has emerged as a promising tool for enhancing language learning [6] and cultural awareness [7]. VR offers immersive experiences that can create meaningful contexts for language use and could be beneficial for Irish. Previous research [8] explores the use of three-dimensional virtual environments (3DVEs) in primary schools, focusing on task-based language learning. They found that 3DVEs could re-energise Irish language learning by providing authentic language communities and facilitating meaningful communication. Another study [9] investigates the impact of VR on adult learners' situated identity in learning Irish. Findings indicate that the intervention reduces anxiety levels and fosters a sense of belonging among Irish learners by allowing them to interact with native-speaking avatars in a virtual community of practice. The study also highlighted the educational value of VR, demonstrating its potential to create a believable reality and positively influence learners' attitudes towards the Irish language community. The study also incorporated sociocultural theory, specifically situated learning, into its methodology.

Sociocultural theory [1, 10] is a learning theory that emphasises the importance of social interactions, cultural and historical context in the learning process. Sociocultural theory posits that learning occurs through social interactions within a community of practice. VR environments can simulate these social contexts, making them ideal for language learning [9]. Interaction is not just a helpful condition but an essential force for learning [11], a notion that underpins VR's potential in language education. In our implementation of VR, we provide both physical (retrieve letters and rearrange them in 3D space) and mental (vocabulary word puzzles) interaction. These activities combined with the powerful 3D visual imagery means that the words are more firmly anchored in the player's memory, as interacting with the physical world leads to greater engagement and more active learning [35].

In the context of indigenous languages, the sociocultural theory of reconnecting to the spirit of a language underscores the deep relationship between language, culture, and identity. Previous research [12] elucidates this concept through work with the Cree language. This approach is particularly relevant for indigenous languages, many of which face extinction as younger generations become less motivated to learn them [13]. In this study, we apply this theory to the Irish language, leveraging the immersive potential of VR to create an engaging and interactive learning environment. The integration of Irish folklore and mythology into the VR game Cipher: Faoi Gheasa [3] aims to reconnect learners with the cultural and historical essence of Irish. By integrating language learning with its cultural context, we foster a heightened sense of cultural awareness among learners. Through VR, we aim to provide a space where learners can engage with the Irish language in a way that is both deeply meaningful and transformative, promoting not just language learning but a connection to the cultural heritage of Ireland.

It has long been recognised that motivation is an important factor in successful language learning. Study [14] hypothesised that learner motivation is an important factor in second language (L2) acquisition. They proposed two types of motivation: *instrumental* motivation (inspired by a desire for practical and financial gain) and *integrative* motivation (inspired by positive feelings towards the speaker community), both of which fall under *extrinsic* motivation. *Intrinsic* motivation stems from the inherent enjoyment or interest in an activity, independent of external rewards or punishments. In the case of a minority L2 language such as Irish where most learners have the global language English as their first language (L1), integrative motivation for acquiring Irish is of greater importance than instrumental motivation. For successful L2 acquisition in such circumstances, it is important to encourage positive feelings towards Irish language and culture. The game content focuses on stories from Irish mythology and folklore, and the VR environment creates a magical and immersive mythological world. Mythological stories and heroes have enduring appeal for both adults and children. The popular and successful Marvel Cinematic Universe films [15] draw heavily on Norse mythology, and the popular and successful Percy Jackson and the Olympians [16, 17] book series draws heavily on Greek mythology. Cipher VR in a similar vein taps into the magical and heroic world of Irish mythology. We hope that this exciting and heroic world will entice learners from all backgrounds to (re)connect with

the Irish language and culture, which will strengthen integrative motivation, i.e. a willingness to be part of a community of speakers with a sustained interest in the Irish language and culture, as this is an important factor in successful L2 language acquisition and transmission. In this research, sociocultural theory encourages intrinsic and integrative motivation by reconnecting learners with Irish culture and heritage, while game rewards addresses extrinsic motivation, encouraging sustained engagement.

Digital Game-Based Language Learning (DGBLL) represents a progressive and captivating method for facilitating L2 acquisition by harnessing the engaging nature of digital games. This innovative approach integrates educational content within game environments, enabling language learning as a secondary outcome of gameplay [18]. DGBLL offers a promising avenue for L2 acquisition as they can provide engagement and authenticity [18, 20] and enhance vocabulary acquisition [18]. The overall effectiveness of digital games on L2 development showed a medium positive effect [18]. However, the diversity in game mechanics poses challenges in generalising outcomes across different game types [21, 22]. VR content development and implementation can be complex and time-consuming, requiring substantial resources and expertise, and deployment requires the availability of VR headsets. Despite these challenges, VR has the potential to revolutionise education by providing immersive, interactive, and personalised learning experiences, making it a highly promising tool [6]. It is worth mentioning that Virtual World Language Learning (VWLL) and DGBLL, while related, differ primarily in their goal orientation. VWLL environments (e.g. [8]), are open-ended and emphasise social interaction and constructivist learning without specific objectives. In contrast, DGBLL integrates clear goals and narratives within the game design, making in-game objectives intrinsic to the gameplay [27]. Children prefer more game-like environments with clear tasks and goals [8], making DGBLL a more suitable option especially for school children. However, unlike previous studies in Irish context that utilises the social interaction aspect of sociocultural theory, this study leverages the theory to explore how embedding Irish cultural and historical elements into the learning environment can increase engagement thus improving language learning. The VR version of Cipher immerses players in Irish mythology and folklore, encouraging learners to reconnect with the cultural context of the language through gameplay.

III. Game Design

The Cipher Game, originally designed for detecting errors in English text, underwent several iterations before evolving into an Irish language learning game. The initial design of Cipher [24] was grounded in the concept of games-with-a-purpose and crowdsourcing. The Cipher engine was enhanced to support the creation of games in Irish, utilising DGBLL and AI technologies (e.g., Natural Language Processing, Text-to-Image Generation, and Text-to-Speech Synthesis) [3], leading to the development of Cipher: Faoi Gheasa. The game, Cipher: Faoi Gheasa, is set in a magical world influenced by traditional Irish mythology, folklore and fairy tales. In the game players are required to find enchanted words (encoded words) within various narratives integrated with engaging game elements. The game's storyline involves an evil spirit casting spells on ancient legends. Game elements such as spells, power-ups, and ancient spirits transform traditional language tasks into engaging game challenges. Fig. 1 shows some screenshots of Cipher at this stage. Up to this point, the game has been operating on tablet devices rather than in VR headsets. Further details about 2D Cipher can be found in study [3].

This study focuses on the incorporation of Irish folklore and mythology to enhance the game's cultural relevance and appeal. As previously discussed, DGBLL has proven to be an effective method for encouraging language learners. Beyond DGBLL, VR provides powerful tools to deepen language connection through its interactivity and immersive nature. Research shows that VR can boost cultural awareness and learner engagement [7, 19]. By harnessing VR's immersive and interactive features, Cipher VR seeks to transform how learners engage with the Irish language, helping to renew or initiate interest in it through the concept of "reconnecting to the spirit of the language" [12].

The Cipher VR game builds on the existing game Cipher: Faoi Gheasa [3], enhancing interaction and immersion while ensuring continuity in the user experience for those familiar with the 2D version. In addition, the game narrator's introduction to the VR game world enables players who have not seen the 2D version of the game to quickly orient themselves to the tasks and challenges that are presented. The transition to the VR version of Cipher: Faoi Gheasa represents an important step in leveraging immersive technology to enhance the theory of reconnecting to the spirit of language. The VR version, focusing solely on the Irish folklore story "The Salmon of Knowledge", follows the same game mechanics (i.e., solving language-related puzzles in order to undo magic spells) of the Cipher game but in a richly immersive environment. In the VR adaptation, the focus narrows to a culturally rich story, the Salmon of Knowledge, which is about Fionn Mac Cumhaill, who gains all the knowledge of the universe by unintentionally tasting the salmon that had consumed magic hazelnuts from the Well of Wisdom. The VR environment mirrors the story descriptions, creating a 3D setting for the narrative.

Players interact directly with objects in the VR world using their hands, enhancing the immersive experience and making it accessible for young learners. In each scenario the player encounters a magic book with an enchanted word. For instance, in the first scenario, the 'Reverse' spell has been used to enchant the word, therefore the player must reverse 'liacso' to give 'oscail' (open). They use their hands to pick up letter cards from the table and arrange the scrambled letters into the correct form of the word (Fig. 2a left), thereby undoing the Reverse spell, unlocking a gate (Fig. 2a right), and learning that 'oscail' means 'open'. It is not necessary to be familiar with the word 'oscail' as each type of spell guides the player to the correct spelling of the word. Successful completion of each word puzzle triggers corresponding events that advance the narrative and reinforce language learning through context.

Special effects, animations, background music, sound effects and hand tracking engage players while playing Cipher, maximising the immersive experience provided by VR interaction loop. Importantly, the game is designed to be short, around ten minutes, to minimise the risk of cybersickness, a common concern in VR applications [7]. Hand-based

interaction simplifies the learning curve, making the game accessible to a wider audience, particularly younger learners. However, due to the focus on sociocultural aspect of the game, the intensity of learning has decreased considerably compared to the 2D Cipher game. By "intensity of learning", we refer to the frequency and depth of language tasks included in the gameplay. In this initial VR version, the number of learning tasks was reduced compared to the 2D version, as the focus was on building a culturally immersive environment. In this first iteration of the VR adaptation, we prioritised the integration of sociocultural elements, with plans to increase the other learning components in future iterations.

The game consists of several scenarios (see Figs. 2 to 5), each blending language learning with cultural storytelling:

Figure 2. Undo the 'Reverse' spell on the gate: in front of a gate, players restore 'liacso' to 'oscail' (open) to open a gate, marking the beginning of their adventure.

Figure 3. Undo the 'Botton Up' spell on trees: under a withered tree, players restore 'nranc' to 'crann' (tree), reviving the tree beside a river and linking it to the River Boyne, thus integrating the geographical and cultural context.

Figure 4. Undo the 'Accent Bomb' spell on the well: at a dimly-lit well, players restore 'bradan' to 'bradán' (salmon), clearing the water and enabling them to catch the salmon.

Figure 5. Undo the 'Vowel Sprout' spell on the fire: at a dead fire pit, players unscramble 'tíné' to 'tine' (fire), reigniting the fire to roast the salmon, a pivotal event in the folklore: Salmon of Knowledge.

For the technical implementation of Cipher VR, Unity3D and the Unity XR Toolkit were employed to create virtual reality (VR) scenarios and interaction was facilitated by the XR Interaction Toolkit. Using Unity's free assets, the game environment was constructed, including a mountainous background scene. Adapting the 2D game for VR required extensive technical adjustments in locomotion, user interface interaction, game object interaction. 3D games require more complex controls to navigate characters in three dimensions, posing challenges for novice players [25]. To address this, room-scale locomotion was implemented to let users physically move while in VR, with their movements mirrored in the virtual environment. This creates a more immersive experience, allowing natural exploration and interaction, as users' motions are seamlessly tracked and reflected in the virtual world. In our VR game, designed for schoolchildren, graphical user interfaces are essential for guiding the learning process [27]. They enable interaction through visual elements, such as text and feedback, which are triggered automatically when players complete specific actions, like placing a card in the correct position [28]. This structured approach ensures that the game advances only after correct tasks are performed, preventing random play. A magic book background serves as the canvas, enhancing both immersion and the educational experience.

Interaction with the virtual world is essential. For school-age children, we incorporated hand-tracking technology to allow players to intuitively place letters into designated sockets. Upon successfully completing a task, celebratory particle effects enhance the sense of achievement, while elements like the table and book magically shrink and disappear. This design ensures a smooth and engaging gameplay experience. The game progresses automatically, requiring no extra actions from the player, making it more intuitive and accessible for young users.

Figure 6. The XR Rig (left) and Hand Tracking (right).

IV. Experiment Design

The experiment design included both pre- and post-survey questions using a 5-point Likert scale to explore the gaming experience and sociocultural impact. We implemented shortened surveys, based on previous Cipher surveys, due to participant age [29]. Before engaging with the VR game, participants provided baseline data through a pre-test survey (e.g. school, familiarity with VR headsets and their attitudes towards learning Irish). Participants received clear and concise instructions prior to starting the VR game. Participants played the VR game which took approximately 10 minutes to complete. The game involved interacting with objects in the virtual world and solving puzzles by restoring words related to the Irish folklore story, "The Salmon of Knowledge". Following the gameplay, participants completed a post-test aimed at recording participants' reactions to the VR game and possible shifts in participants' motivation, engagement, and connection to the Irish language and culture. We compared the results of the VR post-test with the results of the post-test for the previous 2D version of Cipher.

V. Results and Discussion

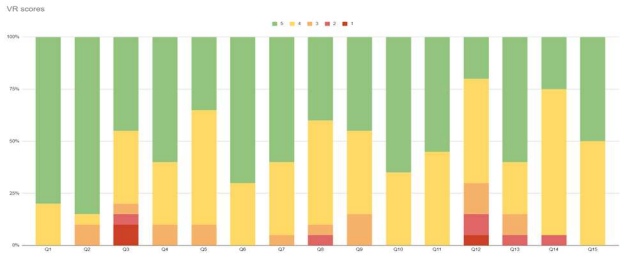

Figure 7. Bar charts showing Likert-scale responses (5-1, green to red, very positive to very negative) for questions Q1 to Q15 (left to right) in the post-game survey for the VR version of the Cipher game.

Survey questions:

Q1: Did you like the VR game?

Q2: How would you describe your experience of playing the VR game?

Q3: Do you already know the Irish folklore story in the VR game?

Q4: Do you think the VR game makes the Irish folklore story more interesting?

Q5: Do you think the VR game brings the Irish folklore story to life?

Q6: Do you think the VR game makes learning Irish more interesting?

Q7: Would you like to learn Irish through more folklore stories like this in VR?

Q8: Do you think the visual part of the VR game helps you understand the language better?

Q9: Do you feel motivated to learn Irish through the VR game?

Q10: What do you think about learning Irish through the VR game?

Q11: How would you compare learning or reading Irish through the VR game to normal classroom teaching?

Q12: Do you think you learned anything while playing the VR game?

Q13: Do you think the visual part of the VR game helps you pay better attention to the language challenge?

Q14: Did you find the VR game easy to play?

Q15: Would you recommend this VR game to your friends?

The study involved 20 participants—10 primary school students (aged 10–12) and 10 secondary school students (aged 13–17). The primary school students, all boys, had previously participated in a separate study involving the non-VR version of Cipher. The secondary school students were completely new to Cipher VR and comprised 4 boys and 6 girls. All participants played the VR game until completion, which took approximately 10 minutes. The primary school students had played the non-VR version in a previous study, where they engaged with the game once a week over a 5-week period, with each session lasting 30 minutes. Based on prior experiments, the non-VR version typically takes around two to three hours to complete the game content. The secondary school students played only the VR version, and this was their first exposure to the game. The primary school part of the study was conducted in educational settings, with students participating in a classroom provided for the purpose. However, as secondary schools were on break during the time of the experiment, the secondary school students were recruited through the researchers' network, and the VR test was conducted wherever was convenient.

Most of the survey data was composed of Likert-style responses on the scale from 1 to 5 and other questions were adapted to this scale. In Fig. 7, regarding the VR post survey there are five questions which every participant either answered positively (4) or very positively (5): Q1 – like the game, Q6 – makes Irish more interesting, Q10 – thoughts about Irish in a VR game, Q11 – comparison VR vs classroom and Q15 – recommend game. Of these, the strongest response was to the first question, where 80% of the 20 participants said that they very much liked playing the game. The less positive results were still quite strong, e.g. in Q12, 70% thought they learnt something while playing the VR game, with only 3 negative responses.

In terms of comparative analysis, the availability of statistical analysis on the data was limited by both the size (which can lead to a higher margin of error) and distribution of the data. Two comparisons were made: Table I) between the Cipher Faoi Gheasa 2D game and its VR equivalent, and Table II) between the primary and secondary school students that played the VR game. The main statistic analysed in the interpretation are the p-values for a two-tailed t-test on the Z scores for each comparison. The ten primary school participants who played the VR version of the game (Table I) are the same ten who feature in the 'Primary' row in Table II. Table I's highest mean (5.0) is the score from the number of participants who liked the VR game, as all said they liked it "Very much". The lowest mean value (3.30) is from those who played the non-VR game when asked if they would recommend the game to their friends, aligning with "Maybe".

TABLE I. A COMPARISON BETWEEN THE SURVEY RESPONSES TO THE VR AND NON-VR VERSIONS OF THE CIPHER GAME (V = VR, NV = NON-VR)

Question	Cond.	Size	Mean	SD	Results
Did you like the game?	V	10	5.00	4.00	Z = 0.95
	NV	23	3.70	2.58	p = 0.34
What do you think about learning Irish through the (VR) game?	V	10	4.90	3.52	Z = 0.94
	NV	23	3.70	3.07	p = 0.35
How would you compare learning or reading Irish through the (VR) game to normal classroom teaching?	V	10	4.70	2.76	Z = 0.58
	NV	23	4.04	3.50	p = 0.56
Do you think you learned anything while playing the (VR) game?	V	10	4.10	1.90	Z = 0.72
	NV	23	3.52	2.58	p = 0.47
Did you find the (VR) game easy to play?	V	10	4.20	2.10	Z = 1.16
	NV	23	3.35	1.50	p = 0.25
Would you recommend this (VR) game to your friends?	V	10	4.70	2.76	Z = 1.42
	NV	23	3.30	2.15	p = 0.15

TABLE II. A COMPARISON BETWEEN THE SURVEY RESPONSES OF PRIMARY AND SECONDARY SCHOOL STUDENTS TO THE VR VERSION (P = PRIMARY, S = SECONDARY)

Question	Cond.	Size	Mean	SD	Results
Did you like the VR game?	P	10	5.00	4.00	Z = 0.27
	S	10	4.60	2.53	p = 0.79
What do you think about learning Irish through the VR game?	P	10	4.90	3.52	Z = 0.36
	S	10	4.40	2.53	p = 0.72
How would you compare learning or reading Irish through the VR game to normal classroom teaching?	P	10	4.70	2.76	Z = 0.25
	S	10	4.40	2.53	p = 0.80
Do you think you learned anything while playing the (VR) game?	P	10	4.10	1.90	Z = 1.03
	S	10	3.30	1.55	p = 0.30
Did you find the (VR) game easy to play?	P	10	4.20	2.10	Z = 0.08
	S	10	4.10	3.52	p = 0.94
Would you recommend this (VR) game to your friends?	P	10	4.70	2.76	Z =0.32
	S	10	4.30	2.76	p = 0.75

The highest p-value, 0.56, indicates that the difference between VR and non-VR responses for that question is very small. Both mean values for that question are high (4.70 for VR and 4.04 for non-VR), suggesting that both the non-VR and VR games were favored over normal classroom teaching, with the VR game being only slightly more popular in this context than the non-VR game. This result highlights the need for innovative approaches like Cipher in educational settings for Irish language learning. The greatest difference comes from the final question, where participants were more likely to recommend the VR game to a friend rather than the non-VR game. The p-value of 0.15 is the lowest but fails to fall below the 0.05 significance level.

Table II's highest mean score is also (5.0). The lowest score, also 3.30, came from secondary school students when asked whether they thought they had learnt from the game, once again approximating to "Maybe". This question also had the greatest difference between the two groups, with a p-value of 0.3. Primary school students were more likely to say "Yes". This is probably because the level of Irish was appropriate for primary school but too easy for secondary school students who are less sure that they learned any Irish. The highest p-value here, and across the two tables occurs where the students were asked if they found the game easy to play, with both groups likely to respond with "Yes". While they cannot be taken to be statistically significant, the results indicate a few important points. Both games are preferred to the relatively same extent to normal classroom teaching, but the VR game was more likely to be recommended to a friend. Primary school students were more likely to feel they had learned from the game, which was expected since the learning content was aligned with the primary school curriculum. At this stage, we aimed to test the acceptance rate of the VR transformation, especially among secondary school students. The minimal differences (p-values over 0.05) between primary and secondary students across most questions in Table II suggest that the high level of user acceptance observed among primary students (also noted in prior experiments for Cipher [3, 29]) continues with secondary school students. Additionally, Both primary and secondary students found the VR games easy to play, even though 80% claimed they were not familiar with VR devices and 50% reported they had never played VR games.

In terms of the effect size (Cohen's d) between the Cipher and Cipher VR responses, four questions had a moderate effect size ("Did you like the game?", "What do you think about learning Irish through the game?", "Did you find the game easy to play?", and "Would you recommend this game to your friends?"). See Table I. This suggests that participants found the VR version more engaging compared to the non-VR version. When comparing primary and secondary school students' responses to the VR game, only one question ("Do you think you learned anything while playing the (VR) game?") showed a moderate effect size, which is expected as the learning materials were designed for primary school students. The study at this stage focuses on user acceptance, with future work aimed at enhancing the learning aspects of the VR game. All other questions in Table II had a small effect size.

VI. Limitations

We acknowledge the limitations of the small sample size, which may affect the ability to detect statistically significant differences between the 2D and VR versions of the game. We also acknowledge that the VR transformation covers only the first task, i.e. the vocabulary task, of Cipher Faoi Gheasa. The remaining tasks will be explored in future research based on user feedback. We recognise that a direct comparison of interaction paradigms between VR and non-VR games presents challenges and the study involving primary school students may be biased due to their prior experience with the non-VR version. However, it is important to note that our focus was not on comparing them in detail but rather on assessing how users, particularly secondary school students, responded to the VR format in its early stage of development. Our previous studies mainly focused on primary education settings and the non-VR version. This is our first attempt to transition to both VR and a secondary education setting. Future studies could incorporate a more detailed assessment of participants' language proficiency to better explore the VR game's effect on learners with varying levels of expertise. An analysis by gender could also be considered in future research.

Another limitation is the use of non-standard questionnaires, as observed in our initial study with the non-VR version [29]. We are aware of standard questionnaires that evaluate specific aspects such as engagement, usability, immersion, motivation in learning, and cognitive load. However, due to the age of the primary school participants, standard surveys proved lengthy and impractical in prior experiments, given the tight schedule in primary education settings and the participants' limited patience for extended questionnaires. Additionally, these questionnaires may not cover specific questions we are particularly interested in, especially within the Irish context, such as "How would you compare learning or reading Irish through the game to normal classroom teaching?" Future studies could focus on evaluating specific aspects (e.g., engagement and learning) of the VR game within secondary education settings where participants may have a higher acceptance for extended questionnaires and more complex assessments.

While the VR version of the game demonstrated its feasibility in real-world settings with minimal instruction, technical limitations were noted, including the short game duration, which was designed to prevent cybersickness, through limited exposure to the game content. Areas for improvement remain, such as providing more extensive gameplay and mitigating any potential Hawthorne effect (the novelty factor). For example, extending gameplay sessions and exploring the benefits of longer or more frequent sessions, possibly with breaks to reduce cybersickness, could be valuable.

To draw more robust conclusions, future studies should involve larger sample sizes, extended interaction times with additional content, and more diverse educational settings to better assess the VR game's effectiveness in different contexts. There is a notable scarcity of research on the use of VR in the context of Irish language learning. This gap in research on the use of VR in the context of Irish language learning highlights the need for further research to build a comprehensive understanding of VR's potential in this field. Future iterations could focus on expanding content and addressing these limitations and increase its scalability and accessibility.

VII. Conclusion

The primary objective of transitioning Cipher from a 2D to a 3D VR format was to evaluate the feasibility of adapting 2D concepts to a 3D VR environment and it also widened the reach of the game from primary school students to secondary school students and adult learners. The technical complexities of developing a VR version were significant but manageable, with many 2D elements successfully enhanced in the VR context. Transitioning from 2D to VR involved major design and technical modifications. This process preserved core educational objectives while enhancing the immersive experience, providing valuable insights for similar future projects. From a storytelling perspective, the VR environment allowed for a more creative and immersive experience. Cipher VR was designed as a special, impactful experience, distinct from the daily-use 2D version. There were a lot more '*wow - this is great*' type comments from players of the VR version. While the players enjoyed the 2D version and wanted more, the VR version was considered as something special. One post-primary school student said, "*It would be a treat, not something you would play all the time, but something you would look forward to playing*". Other elements worth mentioning are the ease of use of the game, the ability to play the game in a classroom setting and positive anecdotal feedback from educators. Despite its limitations, the work on the VR version of Cipher indicates that it is possible to imbue the game with cultural aspects and to tap into reconnecting to the spirit of the language by harnessing the lasting appeal of mythological tales and folklore and this can impact positively on participants interest in Irish folklore. The study demonstrates that short, well-designed VR experiences can effectively complement traditional learning methods, enhancing language learning through immersive, culturally rich narratives. Future research should explore the long-term impacts and expand content to further integrate educational and cultural elements.

The transition of Cipher from 2D to VR successfully enhanced the immersive experience, integrated sociocultural elements, and broadened the game's audience. However, the pilot study's limitations—such as the small sample size, brief gameplay duration, and the early stage of the VR version—may have impacted the results. Future research will aim to address these limitations by expanding the sample size, increasing interaction time, and further refining the game to provide a more comprehensive assessment of its impact on language learning.

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