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EDITED BY
Yu-Tung Kuo,
North Carolina Agricultural and Technical State University, United States

REVIEWED BY
Crusher Wong,
Hong Kong Baptist University, Hong Kong SAR, China
M. Shahid Anwar,
Gachon University, Republic of Korea

*CORRESPONDENCE
Vincent Reynaert
✉ vincent.reynaert@univ-catholille.fr

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Immersive poetry learning: a field study with middle school students

Vincent Reynaert[1,2]*, Jalal Possik[3], Catherine Demarey[4], Danny Kieken[3], Benoit Abert[5] and Benjamin De Witte[1,2]

[1]Anthropo-Lab, ETHICS EA7446, Lille Catholic University, Lille, France, [2]Piktura the School of Image, Roubaix, France, [3]ICL, Junia, Lille Catholic University, LITL, Lille, France, [4]PSyCOS, ETHICS EA7446, Lille Catholic University, Lille, France, [5]ALITHILA, University of Lille, Lille, France

Introduction: The field of poetry learning is currently facing significant challenges, primarily due to a lack of motivation and interest among students. This has resulted in educators encountering difficulties in identifying suitable educational alternatives. To address the latter issue, immersive learning has emerged as a potential solution, as it has been demonstrated to enhance motivation and learning outcomes in a multitude of fields.

Methods: In light of the aforementioned considerations, this field study seeks to examine the potential of virtual reality (VR) tools in enhancing the memorization of poetry by increasing the engagement of the participants. The study concentrated on the acquisition of a French poem by a group of middle school students. A virtual environment has been developed for this purpose, tailored to the poem in question. The experimental design included a pretest, segmented learning sessions, a posttest, and a retention test. To evaluate student engagement, both motivation and sense of presence were measured using Likert-scale questionnaires, while memorization performance was assessed through a scoring system based on recall accuracy.

Results: The findings reveal that the VR group demonstrated significantly higher motivation than the control group, with a mean difference of 12.626 on a 7-point Likert scale (six items), indicating that VR is a notably more effective tool for enhancing motivation in poetry learning than traditional methods. Additionally, the VR group reported a significantly stronger sense of presence, with a mean difference of 6.111 on the same questionnaire scale, further suggesting that VR enhances students' sense of immersion in the learning experience. These results indicate that students using VR exhibited higher levels of overall engagement than those in the control group.

Discussion: However, this increased engagement did not lead to improved memorization outcomes, as there was no significant difference in recall accuracy between the two groups. A potential explanation for this discrepancy is the "novelty effect" of VR, which may have distracted students from focusing fully on the memorization task. The implications of integrating VR in educational settings are thus discussed.

KEYWORDS

virtual reality, immersive learning, poetry, field study, middle school

1 Introduction

Learning poetry enhances the acquisition of elevated vocabulary and grammatical structures (Mulatsih, 2018). In this manner, poetry can serve as an efficacious instrument for the acquisition of a foreign language (Khatib, 2011; Zaiukova, 2022). Furthermore, research indicates that learning poetry can also facilitate the development of imagination (Hamington and Rosenow, 2019), assist in the acquisition of historical knowledge (Godsell, 2019), and enhance one's understanding of society (Simecek and Rumbold, 2016). Despite the evident advantages, students are becoming increasingly disinterested in learning poetry, perceiving it as outdated and irrelevant (Kangasharju et al., 2024). This is corroborated by teachers who report encountering difficulties in developing effective pedagogical approaches to teaching poetry (Sigvardsson, 2020). Additionally, the teaching of poetry is a time-consuming process, making it challenging to integrate into a comprehensive curriculum (Weaven and Clark, 2013). Taken together, these factors present a significant challenge to the effective teaching of poetry. To address this challenge, researchers continue to explore and test various learning methods with the goal of increasing students' motivation and consequently their learning outcomes. Efforts to enhance poetry learning are not new; for instance, as early as 1913, Lakenan (1913) compared the "whole" and "part" methods to improve the memorization of poetry. More recently, innovative approaches such as cooperative learning (Chemwei et al., 2005), collaborative multimodal writing (Guise and Friend, 2017), and the use of drawing (Richardson, 1990; Xie and Deng, 2023) have been trialed. In the current era of technological advancement, the potential of virtual and augmented reality (VR and AR) tools has garnered attention for addressing the challenges of teaching poetry. Indeed, the decreasing cost of head-mounted displays (HMD) and the increasing technological capabilities of these devices contribute to the proliferation of immersive learning (Hamilton et al., 2021).

Immersive learning provides learners with the opportunity to become fully immersed in the learning content. The technological degree of immersion provided by the device enables the learner to experience a sense of "presence," defined as the subjective feeling of being in the virtual environment. The sense of presence acts as a general affordance, thereby facilitating learning when using HMDs (Makransky and Petersen, 2021). Immersive learning has been extensively researched in numerous fields (Radianti et al., 2020; Wu et al., 2020; Ryan et al., 2022; Strojny and Dużmańska-Misiarczyk, 2023). Indeed, immersive devices (e.g., HMDs) afford the opportunity to travel easily to locations around the world (e.g., Greenland) (Makransky and Mayer, 2022) or inside inaccessible structures (e.g., human body cells) (Klingenberg et al., 2023). Furthermore, it provides the opportunity to practice high-risk procedures, such as surgical procedures (Khan and Lippert, 2022) or firefighting (Wheeler et al., 2024) without concern for the possibility of making mistakes or risking lives.

However, literature dealing with the learning of poetry and immersive devices is scarce. Studies have investigated the potential of VR and AR as a means of facilitating the comprehension of poetry using high or ancient languages (Ching, 2024; Makhenyane, 2024). Virtual reality has also been explored as a potential medium for the communication of poetry as this technology has the potential to enhance the expression of cultural and spiritual poetic elements (Li and Hao, 2023). Finally, some studies have examined the potential of these technologies to enhance learners' interest in poetry (Chao et al., 2021; Lam et al., 2023). The latter study sought to determine the effectiveness of a VR game in fostering engagement and interest with poetry and raising awareness about social issues among younger generations. To this end, the authors created a game inspired by a poem where players embark on a journey as a Cuban migrant. Similarly, Choi (2021) developed a video game with the objective of enhancing creativity among students, with the ultimate goal of improving their poetry writing abilities.

These studies underscore the significant potential of VR in poetry education, particularly in enhancing student engagement and comprehension. However, the application of VR in this field remains in its early developmental stages. Therefore, our study seeks to investigate how VR can specifically improve poetry learning. Conventional teaching methods often struggle to make abstract and intangible poetic concepts vivid and relatable, which can hinder students' motivation to engage with poetry. In contrast, VR can transform these abstract elements into immersive, interactive experiences, allowing students to "step into" the poem and visualize its elements and symbols in a way that promotes deeper engagement (Kuo et al., 2023). This is particularly relevant in poetry, where students frequently face challenges in visualizing or comprehending the content.

The immersive nature of VR allows students not only to read but to actively experience poetry, helping to overcome traditional barriers such as disengagement and difficulties in visualization. Additionally, VR offers great promise for enhancing poetry education by fostering a strong sense of presence and active participation—key factors that can contribute to improved learning outcomes (Hartikainen et al., 2019). The utilization of graphic representations of the poem in a virtual environment may prove an effective aid to the memorization of the poem. Specifically, when these images are associated with words. The association of words and pictures has indeed been demonstrated to facilitate the development of two distinct cognitive representations (i.e., verbal and visual) and the establishment of connections between them, thereby promoting learning (Mayer and Moreno, 1998; Mayer, 2005). Furthermore, as poetry is often perceived as a tedious subject by young students, and as VR has been demonstrated to enhance motivation in other educational areas (Liu et al., 2022), it can be posited that learning poetry through VR may prove an engaging experience for students. Finally, as previously stated, teachers lack innovative pedagogical strategies to facilitate the learning of poetry. Moreover, HMDs are currently affordable in price and no longer require a computer connection as they have the potential to operate independently, reducing practical organizational issues. In addition, as recently outlined by Araiza-Alba et al. (2022), further empirical studies conducted in a real classroom setting are required to gain a deeper understanding of the advantages of immersive learning tools than traditional learning methods. In conclusion, the aforementioned points prompt an investigation into the feasibility and effectiveness of learning poetry through VR in the classroom.

In line with the preceding paragraphs, the objective of this study was to explore the potential of VR tools (i.e., HMDs) in facilitating poetry learning in a real classroom setting. To this end:

- A virtual environment related specifically to the poem will be created to enhance learning.
- The primary learning indicator will be the degree of poem memorization. Additionally, motivation levels, presence, and cybersickness symptoms (for the VR group) will be measured.
- Participants will be divided into an experimental group (VR group) using HMDs and a control group following traditional learning methods.

- The experimental design will include a pretest, segmented learning sessions, a posttest, and a retention test.
- Finally, the "field" nature of the experiment is expected to provide insights into how students and teachers engage with this new learning medium in a real-world classroom setting.

Accordingly, the research questions and the related hypotheses are as follows:

- Research question 1 (RQ1): Do VR tools increase motivation and sense of presence, even for less engaging subjects in learning, such as poetry?
- Hypothesis 1 (H1): Levels of motivation and presence will be higher in the VR group.
- Research question 2 (RQ2): Does the act of immersing oneself in a virtual environment that illustrates the abstract concepts of a poem facilitate the memorization and subsequent learning of the poem?
- Hypothesis 2 (H2): The VR group will demonstrate better memorization than the control group.

2 Materials and methods

2.1 Poem and virtual environment

3D artists designed the virtual environment. Its content was aligned with the poem's content to facilitate memorization (i.e., "Après trois ans" by Verlaine (1866)). This poem recounts the poet's return to the garden of his infancy. It includes descriptions of notable elements such as an old tree, a statue, and an arbor. The objective was to create an environment conducive to memorization of the poem. The artists were thus instructed to include as many clues and graphical elements from the poem as possible. In addition, the artists incorporated a colored directional light and a skybox to simulate the morning light as described in the poem. Figure 1 shows screenshots of the resulting virtual environment.

The development of the application was done with Unity 2022.3 3D game engine. Moreover, the 3D assets were done using Blender, ZBrush, and Substance Designer, respectively, for modeling, sculpting, and texturing the assets.

In addition to the visual content, audio was also displayed. These included ambient sounds (e.g., birds and fountain) sourced from freesound.org, and male and female audio recordings of the poem generated using the Textmagic text-to-speech tool. The provision of male and female voices enabled learners to select the gender of the voice they would listen to. This approach aligns with the gender-matching effect, which posits that students learn best when the characteristics of virtual agents match their own gender (Makransky et al., 2019). A user interface (UI) for launching the recordings (see Figures 1, 2) was positioned near the ground to avoid occupying too much space in the user's field of view. Audacity was used to ensure all verses were delivered simultaneously, allowing the verses to be displayed like subtitles during the initial exposure.

2.2 Data collection

2.2.1 Motivation questionnaire

To assess the intrinsic motivation of learners regarding the learning means (e.g., HMD or conventional way), we submitted a questionnaire based on the one developed by Isen and Reeve (2005). In order to facilitate comprehension among the younger participants, the vocabulary has been adapted to a more simplified and accessible style. Two versions were created, with each adapted to the target group. The questionnaire employed a 7-point Likert scale with response options ranging from 1 (i.e., strongly disagree) to 7 (i.e., strongly agree) on six items as follows:

- Learning a poem with VR is interesting (e.g., for the control group: Learning a poem is interesting.)
- Learning poetry with VR is fun.
- Learning with VR makes me want to learn other subjects.
- Learning poetry with VR makes me curious.
- Learning poetry with VR is pleasant.
- I want to learn other things in the same way.

The total score was computed by summing the scores for each item.

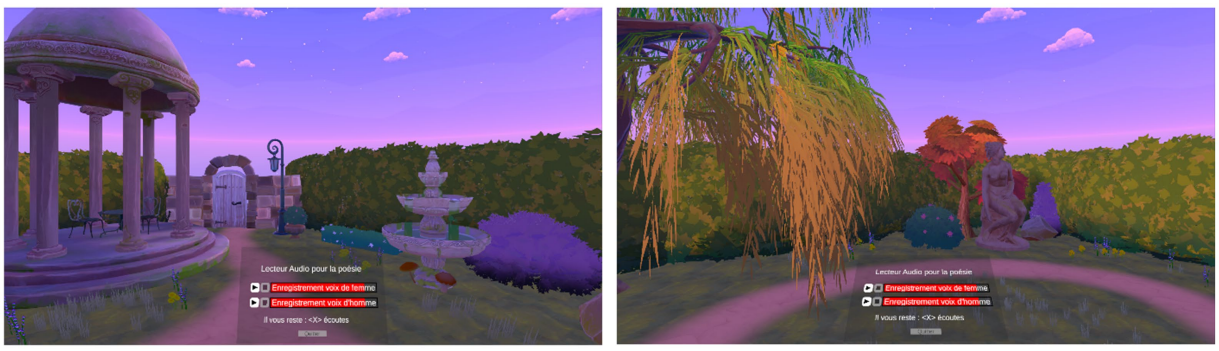

FIGURE 1
Screenshots of the virtual environment displaying the remarkable elements: **(A)** door, arbor, chairs, fountain (water jet); **(B)** old tree, statue (Veleda). The user interface (UI) to launch the poem reading is also displayed.

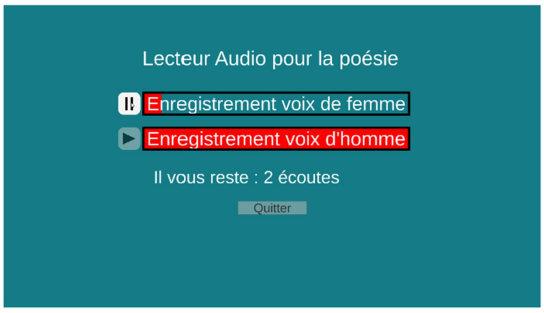

FIGURE 2
Zoom of the UI displayed; Translation: Audio player for poetry // Female voice recording //Male voice recording // You have 2 listens left // Quit.

2.2.2 Presence questionnaire

Among the various reliable methods to evaluate the "sense of presence" (Grassini and Laumann, 2020), we choose the Slater-Usoh-Steed (SUS) questionnaire (Slater and Steed, 2000). This choice was made in consideration of the necessity to minimize the burden on participants and to manage time efficiently (Usoh et al., 2000). Following the approach of prior research (Usoh et al., 2000; Alem et al., 2006), we tailored the questions to reflect the specific virtual environment of our study. The vocabulary was modified to enhance comprehension among the younger participants. The questionnaire employed a 7-point Likert scale with response options ranging from 1 (i.e., strongly disagree) to 7 (i.e., strongly agree) on six items as follows:

- I felt like I was in the poem.
- I have actually seen the objects the poem refers to.
- It is like the poem is alive.
- I felt like I was no longer in the classroom.
- I felt like I was on a journey.
- I felt like I was touching objects, trees, and so on.

The total score was computed by summing the scores for each item.

2.2.3 Memorization variable

Three experts conducted a blinded evaluation of the students' recollections regarding the group and evaluation session. They employed a pre-established scoring grid based on the following three criteria:

- Accurate word recall: a total of 58 cited words were identified in the poem; 2 points were awarded if the recalled word by the student was indeed cited in the poem and 1 point if a synonym was provided. In all other cases, no points were awarded.
- Rhyme memorization: the poem consisted of a total of seven rhymes, each of which consisted of two words; 2 points were awarded to students who correctly recalled the words for the rhyme while only 1 point was awarded if the words were recalled inaccurately but the sound of the rhyme was correct (e.g., "Balancelle" (swing) instead of "Tonnelle" (arbor)).
- Adherence to poetic structure: the objective of this evaluation criterion was to assess the students' ability to identify the poetic structure. This approach also allowed for the inclusion of a subjective criterion. Verlaine's poem was a sonnet composed of four stanzas (i.e., two quatrains and two tercets). Raters could award up to five points if a similar structure was observed.

Moreover, it is notable that, insofar as the experts were able to read and identify the words, the orthography and handwriting quality were not taken into account. In the event that this was not the case, no points were awarded. The scores assigned by each expert to each student based on the aforementioned criteria were then added together. Subsequently, the scores provided by the experts were averaged to obtain a single, composite score.

The memorization evaluations were collected on three different occasions: at the pretest (i.e., T1), posttest (i.e., T2), and retention test (i.e., T3). T1 served as the baseline, T2 was used to evaluate the immediate gain following the learning sessions, and T3 was used to evaluate the degree of retention over the long term.

2.2.4 Cybersickness questionnaire

To assess cybersickness, we used a questionnaire adapted from the SSQ (Kennedy et al., 1993; Stone III, 2017). Although this test is widely used (Anwar et al., 2023, 2024; Hasan et al., 2024), we deemed it too lengthy and complex for eighth-grade students. Instead, students were asked to indicate whether they experienced symptoms such as nausea, headaches, stomach pain, dizziness, and eye strain using a simple yes/no scale. Additionally, if symptoms were reported, students rated their intensity on a scale from 1 to 10, with 1 indicating "very low" and 10 indicating "very high."

2.3 Context and participants

The experiment was conducted at a middle school in the Valenciennes region of northern France. The school was classified as a prioritized education network, due to its location in an area with socioeconomic disadvantages.

To ensure the safety of all participants, a parental consent form was distributed to students in three classes of the eighth grade prior to the initiation of the experiment. This precautionary measure permitted the determination of which individuals were eligible to participate and which were not with regard to health matters, including diseases and mental disorders. Following this selection process, a sample of 49 students was deemed eligible to participate. Regarding the previous experience with a VR headset, 20 students reported that they had never used one, 14 students indicated that they had tried it one time, 9 students reported that they had tried it less than 5 times, and 4 students reported that they had tried it between 5 and 10 times. Furthermore, it was ensured that none of the students had previously used the model of HMD utilized in the study. Among the latter sample, the students' level of literary proficiency was also evaluated to reduce discrepancies in the upcoming groups regarding their abilities. Consequently, teachers were requested to categorize all students into three groups (i.e., low, medium, and high) based on previous academic ratings and their own insights into the students' abilities.

2.4 Apparatus

The experiment was conducted in two adjacent rooms, provided by the school director. This was a prerequisite as the students were requested to transition from one room to another, without being distracted by other students. The first room was a spacious one, equipped with a video projector and speakers (see Figure 3A). This room served for both the introduction phase and the resting periods. The second room, which was utilized for the learning and evaluation sessions, was a computer room where the desktop computers could be controlled by the experimenters through a single central device (see Figure 3B). This device permitted the experimenters to regulate each computer, thereby precluding any potential for deception. As this room served for the learning sessions, the equipment, including VR HMDs (i.e., PICO® 4 Enterprise) and headphones (i.e., Jabra® Evolve2 55) with active noise cancelation, was placed in it. To prevent disruptions during the sessions, the learning tools (HMDs and headphones) were distributed in a manner that ensured at least one seat between students.

2.5 Experimental process

Although 49 students volunteered, on the day of the experiment six students were absent and therefore unable to participate. Additionally, five students were excluded from the study as they indicated that they were no longer interested in participating. Finally, one student was excluded due to an auditory disability. Descriptive data of the remaining 37 students were collected (19 females, 18 males; mean age = 13.2, *SD* = 0.4). Students were then randomly assigned to either the experimental group (VR headset) or the control group (no VR headset). It is important to note that the group allocation process considered the previous level categorization of the students. This resulted in the following repartition: VR group with 18 students (8 females; 10 males) and the control group with 19 students (11 females, 8 males).

The process for both groups consisted of the following steps: (A) introduction to the poem, (B) pretest (i.e., T1), (C) learning sessions, (D) posttest (i.e., T2), and (E) retention test (i.e., T3). The VR group underwent an additional phase of explanation regarding the use of the VR HMD prior to the start of the study (see Figure 4).

(A) The introduction phase, which lasted 15 min, consisted of the following elements: (1) reading the poem, (2) listening to the female audio recording of the poem with subtitles, (3) scripting concise explanations of the poem and advanced vocabulary that the teacher provided, (4) reading the poem a second time, (5) listening to the male audio recording of the poem with subtitles.

(B) The pretest involved a baseline memorization evaluation conducted via paper and pencil. In both groups, students were allotted 10 min to compose their recollections.

(C) During the learning sessions, both groups were afforded an equal amount of time (i.e., 10 min) to memorize the poem. Two audio recordings, which lacked subtitles, were made available to the students. One of the recordings was of a female voice, whereas the other was of a male voice. The instructions were to listen to a recording of their choice a total of three times within the allotted time for learning. Instructors were present to help and to serve as a reminder to students, ensuring that they completed the listening exercises. The learning process for the VR group involved exploring the virtual environment while listening to the recordings. In contrast, the control group was provided with headphones and an audio player (see Figure 2)

a **b**

FIGURE 3
Pictures of the rooms in the middle school: **(A)** room with students listening to the audio recording during the introduction; **(B)** evaluation and learning room equipped with HMDs and headphones.

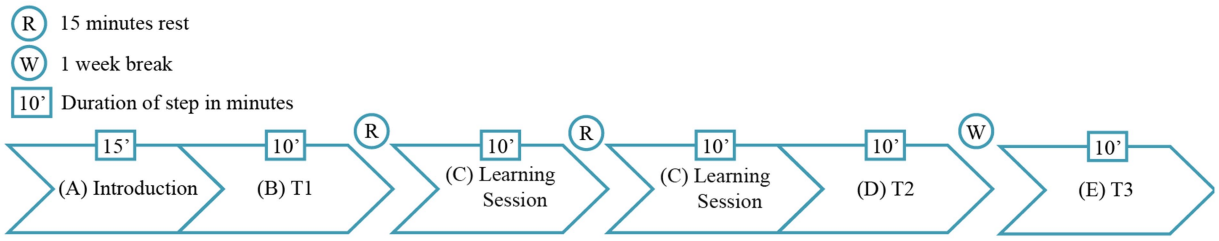

FIGURE 4
Timeline of the experiment with the steps as described in the experimental process section.

for the listening task. Additionally, given that the students in this group were required to learn in a conventional manner, paper and pencil were made available to them should they wish to draw what the poem inspired. Furthermore, students of this group were permitted to rehearse the poem mentally, although they were prohibited from writing any words.

Finally, to ensure the wellbeing of the students, it is important to note that between the learning sessions, the students were given 15 min to rest. Moreover, the division of learning material into smaller units has been shown to facilitate the learning process (Çeken and Taşkın, 2022). During the resting time, students were provided with food and refreshments by the instructors. Nevertheless, students were prohibited from communicating with one another during this period.

(D) For both groups, the posttest session, which lasted 10 min, entailed a second evaluation of the memorization levels and assessments of their motivation and presence levels. Furthermore, the VR group was required to complete the cybersickness questionnaire.

(E) The retention test, which lasted 10 min, was conducted 7 days after the conclusion of the experimentation. In order to ensure that no students deliberately influenced the outcome by reading or learning the poem during this 7-day period, they were not made aware of this test.

2.6 Data analysis

We used JASP software (JASP Team, 2024) to analyze our data. We followed the guide provided by Goss-Sampson (2019). For all our tests, we assumed a 95% significance level.

2.6.1 Motivation and presence

At first, to compare the levels of motivation and presence between the VR and control groups, we employed the *t*-test for independent samples. This test is suitable for comparing the means of two independent groups to determine whether there is a statistically significant difference between them. The Shapiro–Wilk test confirmed that our data did not deviate from normality, with *p*-values ranging from 0.2 to 0.9, justifying the use of the *t*-test for independent samples.

2.6.2 Memorization

Then, to assess changes in memorization scores over time and ensure that students effectively learned, we conducted *t*-tests for paired samples or Wilcoxon tests, depending on the normality of the data as determined by the Shapiro–Wilk test. These tests were run over all students, independently of their group assignment:

- T1/T2 and T1/T3: normality was confirmed ($p = 0.915$ and $p = 0.576$), so *t*-tests for paired samples were used.
- T2/T3: normality was not confirmed ($p = 0.022$), so the Wilcoxon test was used as a non-parametric alternative.

These tests ensured that the analysis was robust and accounted for potential deviations from normality.

To investigate the impact of the learning condition (VR or control) on learning efficiency over time, we employed repeated-measures (RM) ANOVA. This test is appropriate for comparing means across multiple time points within the same subjects, accounting for the correlation between repeated measures. RM ANOVA allowed us to analyze the interaction between the learning condition and the time points (T1, T2, and T3), providing insights into whether the VR intervention significantly affected learning efficiency compared to the control group.

2.6.3 Cybersickness symptoms

Finally, for the cybersickness questionnaire, we only reported descriptive statistics, as it was only applicable to the VR group.

3 Results

3.1 Motivation

Analysis showed that motivation for the VR group was significantly higher (t (35) = 4.499, $p < 0.001$) with a mean difference of 12.626 (VR group: $M = 33.889$, $SD = 6.106$; control group: $M = 21.263$, $SD = 10.311$). The effect size, measured by Cohen's d, was $d = 1.48$, indicating a large effect.

3.2 Presence

Analysis showed that the sense of presence for the VR group was significantly higher (t (35) = 2.150, $p = 0.039 < 0.05$) with a mean difference of 6.111 (VR: $M = 30.667$, $SD = 6.686$; control: $M = 24.556$, $SD = 10.037$). The effect size, measured by Cohen's d, was $d = 0.72$, indicating a medium-to-large effect size.

3.3 Memorization

The normality test showed that the pairs T1/T2 ($p = 0.915$) and T1/T3 ($p = 0.576$) did not deviate from normality. However, for the pair T2/T3, normality was not verified ($p = 0.022 < 0.05$).

Results showed a significant difference in score between T1 and T2 (t (36) = −2.314, $p = 0.026 < 0.05$). The effect size, measured by Cohen's d, was $d = -0.380$, indicating a small to medium effect. On average, students increased their score by 4.180 points, regardless of the learning group (see Table 1).

No significant difference was found in the score between T1 and T3 (t (36) = 0.954, $p = 0.346$). The effect size, measured by Cohen's d, was $d = 0.157$, indicating a small effect.

Results showed a significant difference in scores between T2 and T3 ($z = 2.825$, $p = 0.005$). The effect size, as measured by the matched rank biserial correlation, was 0.548, suggesting a medium-to-large effect size. In addition, we found that after 7 days, on average, the benefits of learning decreased by 6.559 points (see Table 1).

Finally, the RMANOVA confirmed the previous results by demonstrating a significant main effect of time on memorization scores, (F (2, 70) = 4.588, $p = 0.013$, $\omega^2 = 0.013$). However, no significant interaction between time and group was found (F (2, 70) = 0.233, $p = 0.793$, $\omega^2 = 0.000$).

Between-subjects analysis indicated a significant difference between the VR and control groups, F (1, 35) = 5.461, $p = 0.025$, $\omega^2 = 0.058$, with the control group consistently scoring higher than the VR group. Specifically, the control group had a mean score of 30.579 ($SD = 21.996$) at T1, which increased to 36.211 ($SD = 25.869$) at T2, before dropping to 28.912 ($SD = 29.197$) at T3. Meanwhile, the VR group showed a lower starting mean score of 17.056 ($SD = 13.234$) at T1, increasing slightly to 19.704 ($SD = 13.920$) at T2, and then dropping to 13.926 ($SD = 14.984$) at T3.

3.4 Cybersickness

Among the 18 students in the VR group, 11 reported experiencing symptoms of cybersickness as follows:

- Seven students exhibited mild-to-moderate symptoms (ranging from 1 to 5 on the used scale). Within this group, two students exhibited a single symptom (headache or dizziness), three students exhibited two symptoms (headache and dizziness or eye strain), one student exhibited three symptoms (headache, dizziness, and eye strain), and one student exhibited four symptoms (headache, dizziness, eye strain, and stomach pain).
- Regarding the remaining four students, although they did not withdraw from the experience, they exhibited between three and four symptoms out of the five assessed (i.e., nausea, headaches, stomach pain, dizziness, or eye strain). Moreover, the intensity of these symptoms can be classified as severe, with scores potentially reaching up to 8 on the 10-point scale.

Finally, it is noteworthy that the most prevalent symptoms were dizziness and headaches, reported by nine students. Additionally, six students reported eye strain, while three students reported nausea and stomach pain.

4 Discussion

This study aimed to assess the efficacy of immersive learning tools (i.e., HMDs) in facilitating the memorization of poetry among eighth-grade students. Hypotheses were that the VR group in our study would report higher levels of motivation and presence (H1) and that learning with HMDs would outweigh the traditional learning group (H2).

Regarding H1, the results indicate that students who utilized HMDs exhibited greater motivation for learning poetry than those in the control group. These findings align with existing literature indicating that individuals exhibited heightened motivation when using HMDs as opposed to conventional learning methodologies (Liu et al., 2022; Cabero-Almenara et al., 2023). The subject of poetry is of particular interest given that previous research has indicated that conventional learning methods may not be sufficiently innovative (Hennessy and McNamara, 2011) or inspiring for learners (Gönen, 2018; Kangasharju et al., 2022), which has contributed to a decline in the practice of poetry. Consequently, the motivation scores combined with the field impressions in this study regarding the attitudes of the learners suggest that immersive learning has the potential to rekindle students' interest in poetry. Furthermore, VR group students reported feeling more 'present' in the poem compared to the control group. This result is also consistent with existing literature indicating that full immersion provided by HMDs enhances the sense of presence (Dengel and Mägdefrau, 2019; Jicol et al., 2023). In other words, the high-realistic virtual environment certainly facilitated the students' ability to immerse themselves more readily in the poem.

The subsequent hypothesis (H2) was to ascertain whether the use of an HMD displaying a virtual environment that illustrates the abstract concepts inherent to a poem facilitates the memorization of the said poem in contrast to traditional learning methods. The results show that both the control group and the VR group exhibited a significant increase in their scores between the pretest and posttest. Both groups also exhibited a significant decrease in their scores between the posttest and the retention test. However, when examining the group effect, the results indicate that students using the HMDs did not outperform the control group on the posttest nor on the retention test. The lack of a significant difference

TABLE 1 Data on changes in memorization scores over the course of the study for the entire sample as well as separately for the VR and control groups.

Group	*N*	T1	T2	T3
Entire sample	37	24.000 (*SD* = 19.276)	28.180 (*SD* = 22.273)	21.622 (*SD* = 24.289)
VR	18	17.056 (*SD* = 13.234)	19.704 (*SD* = 13.920)	13.926 (*SD* = 14.984)
Control	19	30.579 (*SD* = 21.996)	36.211 (*SD* = 25.869)	28.912 (*SD* = 29.197)

The variables T1, T2, and T3 correspond to the pretest, posttest, and retention test, respectively.

between an immersive learning condition and a conventional one is not a novel finding, as outlined by Hamilton et al. (2021). However, more surprising is that students evaluated the HMDs as more motivating and more immersive; however, this did not enable them to perform better than the control condition. This outcome has been previously observed in a study conducted by Ochs and Sonderegger (2022), in which a desktop group demonstrated superior performance to a VR group, although participants evaluated HMDs as a more effective learning tool. As in the aforementioned study, the "novelty effect" may provide a potential explanation for the results observed in our study. The "novelty effect" can be defined as "an initial fascination with new technology" and has several consequences, including an expansion of excitement and distraction (Miguel-Alonso et al., 2024). Excessive excitement can lead novice users to attempt a wide range of interactions enabled by the tool and virtual environment (Hopp and Gangadharbatla, 2016), rather than focusing on the content to be learned. Similarly, distraction may lead to an overestimation of the potential of the tool, without consideration of whether the learning has been enhanced by it (Huang et al., 2021). Given the youthful age of the students in our study and their lack of prior experience with virtual reality, it is probable that excessive excitement and distraction may have influenced the results of the VR group. Indeed, it is possible that during the learning sessions students of the VR group may have focused on the graphical representation of the word rather than the word itself, subsequently expressing it with their own words. The following example of the posttest evaluations illustrates this point. In the VR group, in five instances, the term "fountain" was employed in place of "water jet" (see Figure 5). This is due to the fact that in the virtual environment, the water jet was represented by a fountain (see Figure 1B). In contrast, the control group did not cite the term "fountain," as it does not appear in the poem's text. On the contrary, the term "water jet" was referenced by the control group on five occasions, whereas the VR group only cited it three times. This evidence suggests that while the virtual environment may have assisted students in recalling contextual elements of the poem, it did not facilitate the precise recall of the cited words in the poem.

Finally, this study addressed a significant gap in the literature by examining in real classroom conditions the prevalence and intensity of cybersickness symptoms in young students. Prior research on children and virtual reality overlooked this aspect (Stapleton et al., 2023; Bexson et al., 2024). While the symptoms did not impede the students' ability to complete the learning process, this study confirms that children may be susceptible to cybersickness (Petri et al., 2020; Porcino et al., 2020). The ethical implications of investigating the relationship between cybersickness and children are significant (Kaimara et al., 2022). Nevertheless, given the growing affordability of HMDs and the pervasive digital exposure of children, a more comprehensive investigation into the long-term use of HMDs by children is imperative before their implementation in actual classrooms.

In summary, this study demonstrated that using HMDs to enhance poetry learning can be beneficial, as they boost motivation and offer students a unique immersive experience. This is particularly intriguing in the context of educational matters that may be perceived as tedious by students, despite their intrinsic educational value. However, our study did not show greater learning outcomes regarding conventional learning means. As previously stated, this can be attributed to the novelty effect. Consequently, a limitation of this study is that the learning sessions occurred in a single day, which did probably not allow for the overcoming of this effect. This invites researchers to conduct further field investigations of the novelty effect in immersive learning over multiple sessions distributed over a longer period. Another limitation of this study was the learning content. Although it was engineered by developers and literature experts, it appears that the content may have inadvertently influenced the perception and therefore the memorization among some students. This underscores the challenge of accurately representing abstract content in graphical form, given that the interpretation of such representations is inherently subjective. Regarding our poem, a question arises as to whether it would have been more efficient to represent only a "water jet" without a fountain. Indeed, as explained by the cognitive-affective model of immersive learning, adding graphical representation (i.e.,

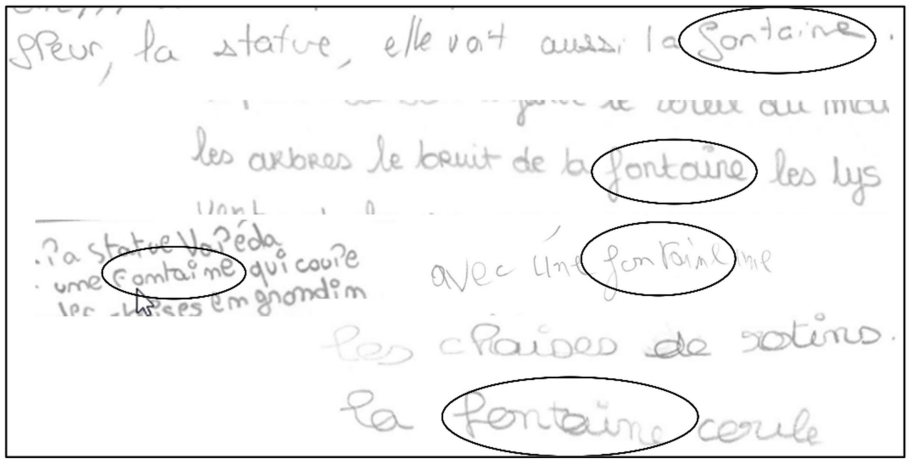

FIGURE 5
A compilation of students' posttests showing the word fountain ("fontaine") instead of the water jet.

extraneous load), may constitute unnecessary information leading to an increase in the allocated cognitive load as learners have to find relevant content (i.e., extraneous load), (Makransky and Petersen, 2021). Further studies need thus to find out how it would be possible to stimulate learning without inducing a perception bias. In the same way, studies should also investigate whether using a VR environment stimulates or contains imagination. Indeed, as learning poetry in a conventional manner depends on the capacity for mental imagery (Liu, 2023), it would be interesting to investigate whether a virtual environment impedes this mental ability by constraining imagination or, conversely, enhances the capacity to create mental images of abstract content. Finally, a last limitation is the absence of a cognitive load test, such as the NASA TLX (Hart and Staveland, 1988). However, considering the study design (i.e., field study and the age of the students), we opted to exclude this test, believing it might prove too complex for the students to comprehend. Furthermore, it is possible that the students would have found the purpose of the test to be overwhelming, which would have resulted in a reduction in their level of involvement.

5 Conclusion

In conclusion, the originality of this study lies in the creation of a virtual environment based on a poem, and its subsequent implementation in a field study to investigate its learning effect. Moreover, the fact that this was investigated with students at a prioritized school is even more interesting. Indeed, as in France the label of "prioritized network" means that students may face challenges in learning, trying to introduce new learning means increases the rationale behind this experimental approach. In our opinion, investigating new learning means is even more valuable, when people encounter extra challenges with the traditional methods. The "field" particularity enabled also to harvest impressions and feelings, whether it was by observing the students or by exchanging with teachers about their perception of immersive learning tools. Studies on how teachers perceive immersive learning tools and their implementation in real classrooms are still under-investigated (Buragohain et al., 2024). Hence, to contribute to a comprehensive understanding of immersive learning applications, it is essential to consider the following limitations and research implications:

- Limitations:
  - The study was limited to a single-day learning session, which may have reinforced the novelty effect and influenced learning outcomes.
  - The design of instructional content, particularly in the context of visualizing abstract concepts, may have had an unintended impact on students' perception and memorization.
  - The absence of a cognitive load assessment, like the NASA TLX, left certain aspects of cognitive engagement unexplored, although it was considered too complex for the students involved.
- Research implications:
  - Future research should examine the novelty effect over multiple sessions to evaluate its sustained impact on learning.
  - It is imperative to investigate methods to minimize perception biases in content design, particularly in the context of abstract content, in order to enhance the effectiveness of educational interventions. This latter implication also gives rise to the question of how the virtual graphical representation of abstract content affects the learner's mental abilities. In particular, it is pertinent to determine whether such a representation contains or stimulates the mental imagery ability, which is involved in creating images of abstract learning content (e.g., poetry).
  - Ultimately, for immersive learning to be considered effective, it must be demonstrated to be harmless to the users. Despite the implementation of safety measures, some minor cybersickness symptoms did occur. A more comprehensive investigation into the long-term use of HMDs by children is essential before their implementation in actual classrooms.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving human samples in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

VR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Writing – original draft. JP: Resources, Writing – review & editing. CD: Funding acquisition, Project administration, Writing – review & editing. DK: Software, Supervision, Writing – review & editing. BA: Conceptualization, Methodology, Writing – review & editing. BW: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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