Article

An Experiential Learning-Based Virtual Reality Approach to Foster Students’ Vocabulary Acquisition and Learning Engagement in English for Geography

Yifan Li 1, Shufan Ying 1, Qu Chen 2 and Jueqi Guan 1,*

1 Key Laboratory of Intelligent Education Technology and Application of Zhejiang Province, Zhejiang Normal University, Jinhua 321004, China
2 College of Geography and Environmental Sciences, Zhejiang Normal University, Jinhua 321004, China
* Correspondence: jqguan@zjnu.edu.cn; Tel.: +86-13735742170

Abstract: EFL learners encounter a number of challenges in English for specific purposes, especially in understanding and remembering vocabulary. Therefore, exploring effective ways to improve their vocabulary and its applications is the key area of ESP. VR, as a newer type of audiovisual input on incidental vocabulary learning, is an important tool for innovation in language education. With its sense of presence and immersion, VR constructs an experiential learning process for students involving incidental vocabulary acquisition to promote their learning engagement and performance. Therefore, this study applied an experiential learning-based VR approach to an English for Geography course in a university. Thirty-six geography students participated in vocabulary acquisition on the theme of the hydrologic cycle. For the experiment, 18 students were assigned to the experimental group learning with the VR-based approach, while the other 18 were assigned to the control group learning with the video-based approach. The findings demonstrated that the experimental group outperformed the control group in terms of incidental vocabulary acquisition and cognitive, behavioral, and social engagement.

Keywords: virtual reality; experiential learning; vocabulary acquisition; English for Geography; learning engagement

1. Introduction

To prepare students for future careers in global society, teaching English for specific purposes (ESP) is one of the main objectives of language education [1]. Furthermore, vocabulary learning is a fundamental component of acquiring a second language [2]. The challenges faced by ESP mainly include two aspects: obscure vocabulary and the limitations in traditional teaching methods. This study is particularly interested in English vocabulary acquisition for non-English majors with a geography background, for whom the geography vocabulary contains many technical words, complex concepts, and theoretical knowledge that is abstract. Therefore, it is essential to explore the use of effective instructional tools and strategies to improve this group’s vocabulary and its applications.

Intentional learning and incidental learning are the two main methods for vocabulary learning. Aside from the common tasks of incidental vocabulary learning, such as fill-in-the-blank exercises, bilingual word lists, or consulting the dictionary, it mainly entails listening and reading activities, which facilitate students in building their vocabulary for effective and free use of a second language [3]. In recent years, vocabulary acquisition research has shifted from reading input to second-language audiovisual input [4]. Meanwhile, technology is also an essential tool for innovation in language education because of its benefits in the development of contexts and interactive environments. Empirical studies have shown that video games [5] and mobile applications [6] can create rich and realistic contexts for students, stimulate their interest and motivation, and induce incidental
vocabulary acquisition [7]. According to Webb, more research is needed to explore how latest innovative inputs affect incidental vocabulary learning [8].

Among the numerous new technologies, the emergence and development of virtual reality (VR) has opened up new ideas for language education reform and innovation [9]. The authenticity, social communication and active learner engagement needs that are essential to language learning can be satisfied by the “immersive, interactive, and imaginative” learning environments offered by VR [10]. Research has shown that VR not only encourages vocabulary but also influences learners’ engagement, motivation, and independent learning [11], and increases interaction [12] and self-efficacy [13]. Among them, there is a strong link between learning engagement and academic achievement [14,15]. Wilang and Soermphongsuwat reported that students’ learning engagement can be improved by using VR to learn English vocabulary, which encourages them to learn additional vocabulary that can be used in context [12]. However, to facilitate and support students’ learning engagement and vocabulary acquisition in English as a foreign language (EFL) learning, especially in ESP learning, remains a challenging issue [16].

VR can create multimodal scenarios to better activate memory and enhance learning experiences, realistic scenarios to visualize abstract geographical phenomena, and human–computer interaction environments to generate language and meaning in geographical vocabulary acquisition. While various studies have mentioned the use of VR in teaching college English [17]; urban planning in university geography [18]; and ESP in civil engineering technology, physics, and engineering [1,19,20], few have designed and investigated the effectiveness of the VR-based English vocabulary approach for geography students. Furthermore, it remains to be determined whether these enhancements in VR are more advantageous than video in incidental vocabulary learning considering the significance of authentic contextual experiences for language learners [3]. Consequently, the research designs an experiential learning-based VR approach for an English for Geography course based on experiential learning theory, incidental vocabulary theory, and literature related to VR-based English learning in the following sections. This study also conducts an experiment based on the above design and employs experimental analysis and discussion to provide answers to the following questions:

1. Does an experiential learning-based VR approach help geography students understand abstract concepts in geography? Does this approach help in acquiring vocabulary?
2. Does an experiential learning-based VR approach have a positive impact on students’ learning engagement?

2. Literature Review
2.1. Experiential Learning

Experiential learning is a process that involves learning through the experience of real-world activities or events and reflecting afterward on the ongoing process of goal-directed action. Kolb divides the experiential learning cycle into four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Among them, the concrete experience stage involves students actively participating in an activity such as fieldwork that they can personally relate to. This aspect has been recognized as a valuable learning opportunity in geography [21]. Therefore, the foundation of experiential learning in vocabulary acquisition is the creation of authentic circumstances in the classroom. VR offers new opportunities to promote experiential learning, which has been successfully employed to enhance learning outcomes in the design of learning activities over the past few years. For example, Moore explored the effects of experiential learning on developing the geographical skills and knowledge of college students by teaching geography through field trips. The research results indicated that experiential learning can foster college students’ knowledge and proficiency with a variety of geological materials and geographical experimental techniques, consequently boosting their research capacities [22]. Moorman et al. designed VR-supported interdisciplinary learning activities for Icelandic culture and geographical phenomena and allowed students to develop capacity
in geography and field methods [23]. In English learning, Somjai and Soontornwipast investigated the effects of combining different learning strategies with experiential learning on English vocabulary acquisition by high school students. They found that experiential learning not only facilitates vocabulary learning but also helps to create learning contexts, enhance self-confidence, and promote learning engagement [24].

However, researchers have also indicated that there might be a variety of challenges in teachers’ implementing experiential learning strategies in a course, e.g., a shortage of resources or facilities to support experiential learning approaches [25] or difficulty in re-designing traditional instruction that comprised good lectures. Therefore, the development of effective experiential learning activities in the classroom has emerged as a crucial and difficult topic.

2.2. Virtual Reality-Based English Learning

Immersive technology was integral to the development of language education. The significant advantage of VR in language instruction is that it can increase student retention and engagement while also broadening their exposure to practical knowledge to help them with real-world problems [25]. At present, VR has been applied to teaching various language knowledge and skills in EFL education, including vocabulary [1], pronunciation [26], grammar [27], listening [28], speaking [29], reading, and writing [30]. In vocabulary learning, VR has become an effective tool [31] to improve vocabulary acquisition due to the multimodal situation [32], interactive social environment [33], and learners’ autonomous learning space created by VR [34]. For instance, in the study by Madini and Alshaikh, twenty Saudi post-graduate students were exposed to VR movies to increase their special purpose vocabulary retention. The researchers found that learners’ motivation and engagement were enhanced in the virtual environment [35]. Alfadil’s research investigates the impact of “House of Languages”, a VR game, on junior high school learners’ English vocabulary acquisition. Students engaged in word guessing, puzzles, and other activities in a realistic gaming environment successfully learned and used vocabulary in immersive practice and were consequently more motivated to learn [36]. However, existing research still lacks theoretical support in the design of VR-based English vocabulary learning activities [10]. Therefore, the design of the VR-based vocabulary acquisition approach and the validation of its application effects deserve more research.

Furthermore, is learning in VR environments as a new form of input for incidental vocabulary acquisition more effective than standard audiovisual media? To explore the impact of VR and personal computer (PC) gaming on language learners’ vocabulary learning, Lai and Chen [37] created a visual novel game based on the theory of incidental vocabulary acquisition. They demonstrated that VR games encouraged higher levels of cognitive engagement and, consequently, assisted in vocabulary development more than PC games. Further research is required to better understand how VR differs from traditional visual media in terms of vocabulary input.

3. Methods

3.1. A VR-Based English Vocabulary Acquisition Approach for Geography Students

To promote geography students’ English vocabulary acquisition, this study designed an experiential learning-based VR approach based on experiential learning theory [38] and incidental vocabulary theory [8]. Laufer and Hulstijn reported that if students have different involvement loads in need, search, and evaluation in learning tasks, they will obtain vocabulary acquisition to varying degrees [39], whereas, high involvement load learning tasks (e.g., essay writing) are more conducive to understanding the spelling and meaning of vocabulary [40]. Two types of learning tasks were established—input and output. The input tasks were a VR experience, comprehension problems, group discussion, and a completed learning task list. The output task involved essay creation, that is, research abstract writing based on the VR experience and task list (Table 1).
Simultaneously, considering the characteristics of geography subjects, these learning tasks were organized in an experiential learning process to construct the VR-based approach (Figure 1). In the concrete experience stage, students built a holistic perception of specific geographical knowledge and formed concrete experiences by observing contextual content in VR. In the reflective observation stage, they consciously reflected on the experience and described the observed geographical phenomena based on the learning task list. This stimulated interest and motivation in vocabulary learning and visualized the students’ content perception and vocabulary expression. In the abstract conceptualization stage, the task list was the main component. Based on the VR experience, the group members discussed, communicated, summarized, and refined the specific experience obtained in the reflection and observation stage, abstracted the relevant geographical knowledge, and expressed it in English. In the active experimentation stage, based on group discussion, the knowledge gained from abstract conceptualization was applied to the output task, namely the writing of the research abstract. This writing task, with a high involvement load, required students to fully apply their understanding of professional knowledge developed in the above stages and vocabulary acquired incidentally, which is a process of knowledge application, verification, and development.

The theme of the learning context for this study was the hydrologic cycle. A manipulative activity area with VR devices and resources made up the learning environment in VR. The VR device (HTC Vive Pro2) was an immersive virtual reality device. Each set consisted of a head-mounted display, two single handheld controllers, and a positioning system that tracked both the display and the controllers in space. Students entered and interacted with the virtual environment through the head-mounted displays and handheld controllers. The “hydrologic cycle” VR resource was “Edmersiv” (https://www.viveport.com/ad388f58-43a3-432c-8efe-fe7edba57d77, accessed on 15 April 2022), which was adapted to HTC Vive Pro2. The VR-based approach enabled students to experience the causes, manifestations, and functions of the hydrologic cycle reproduced

---

**Table 1. Vocabulary incidental acquisition task based on involvement load hypothesis.**

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Contents</th>
<th>Status of Target Words</th>
<th>Need</th>
<th>Search</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR experience and comprehension questions</td>
<td>Completing the task list and discussing in groups</td>
<td>Not glossed but relevant to task</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Writing an essay</td>
<td>Writing a research abstract</td>
<td>Topics selected by L2 learner-writer</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

A plus (+) denotes the presence of the factor in its moderate version, and a double plus (++) marks the strong version of an involvement factor. Reprinted with permission from [39]. 2001, Laufer, B. & Hulstijn, J.

---

**Figure 1.** A VR-based English vocabulary acquisition approach framework for geography students.
in the hydrologic cycle module in a VR, which facilitated the transformation of abstract geographical concepts into concrete experiences and prompted students to make reflective observations, develop abstract conceptualizations, and engage in active experimentation (Figure 2). The opposite of the VR-based approach was the video-based approach, an important audiovisual medium for learners to acquire vocabulary [35]. The students learning with the video-based approach watched a video dubbed by English professionals with English subtitles. Its content was consistent with the VR context; the activity allowed them to repeatedly watch the video for a specific knowledge point and, thus, accomplish their learning goals.

Figure 2. The way learning resources are presented.

3.2. Experiment Design

This study conducted a hydrologic cycle teaching experiment in a college English for Geography course and conducted a comparative study of target word acquisition level and learning engagement to assess the effect of the experiential learning-based VR approach for vocabulary acquisition of geography students.

3.2.1. Participants

Thirty-six geography majors from a university in Zhejiang took part in this experiment. All participants signed the informed consent form before the start of the experiment and were voluntarily participating in the VR experience. They were split into two groups at random: a VR-based experimental group (N = 18) and a control group (N = 18) that watched videos in place of the VR experience. Participants in both groups were randomly matched to work in pairs. Every participant was being exposed to VR for the first time, had normal or corrected vision, and was a native Chinese speaker with English as a second language. The learning process was organized by the same teacher for each group, who has been teaching English for Geography for more than five years, and the experimental group was assisted by technicians to operate the VR system.

3.2.2. Procedure

All participants were asked to complete pretests to ascertain their target word level and English learning engagement before the main experiment start (Figure 3). Technicians then instructed the experimental group of students to operate the VR equipment. The teacher organized the educational activities in the same way throughout the experiment.
The experimental group conducted VR-based English vocabulary acquisition, while the control group conducted video-based English vocabulary acquisition. Both groups were required to work in pairs to complete a learning task list, which included observing the content of the situation, describing the hydrologic cycle, and negotiating the research topic and the basic framework of the research. Subsequently, both groups were given writing requirements and an essay paper, and each participant was asked to complete a research abstract in English.

![Flowchart](image)

**Figure 3.** Experimental process of the English vocabulary acquisition approach for geography students.

Figure 4 depicts students in experimental group learning with the VR-based approach.

![Images](image)

**Figure 4.** (a) Participants are having a VR experience; (b) Participants are completing the learning task list.

Finally, the two groups of participants completed a post-test on the target vocabulary and completed the English learning engagement questionnaire.
3.3. Measuring Tools
3.3.1. Questionnaire of Learning Engagement

The two groups using different approaches were measured for their learning engagement using the English for Geography learning engagement questionnaire. This questionnaire was modified from that of Wang et al. [41] and comprised four dimensions: emotional engagement, cognitive engagement, social engagement, and behavioral engagement, 33 items in total. A 5-point Likert rating scheme was employed in this questionnaire ranging from 1 point to 5 points, with corresponding attitudes ranging from strongly disagree to strongly agree. The scale is commonly used to examine the learning engagement in online learning [42], or in learning activities supported by intelligent technologies such as VR [43] for students at the K12 [44] or higher education levels [45]. We replaced science/math courses in the scale with English for Geography courses. The Cronbach’s alpha value was 8.99 as a result of the questionnaire, indicating high internal consistency and reliability.

3.3.2. Target Vocabulary Test

This study used a target vocabulary test and abstract writing test to assess the students’ vocabulary acquisition. The target vocabulary test referred to Alladil’s [31] idea, which was derived from the Wesche and Paribakht Vocabulary Knowledge Scale [46] for measuring students’ progressive vocabulary knowledge. Ten target words for learning English for Geography were extracted from relevant learning materials by the instructor and two geography students, and the participants were required to evaluate their understanding of the target words based on the criteria (Table 2). The researchers assessed the participants’ acquisition of the target words from 1 to 4. If Level 3 or Level 4 was selected but the word translation results were incorrect, participants were demoted to Level 1. To control the variables, the pre-test and post-test had identical content, but the ranking of the target words was reordered to form the post-test questions to avoid students’ mechanical memorization of words, which would affect the experimental results.

Table 2. Target word test scoring criteria.

<table>
<thead>
<tr>
<th>Self-Description Category</th>
<th>Score</th>
<th>Scoring Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Don’t know the word’s meanings)</td>
<td>1</td>
<td>Select the first level; Choose the third or fourth level but the translation is wrong</td>
</tr>
<tr>
<td>II (Seen but don’t know the word’s meanings)</td>
<td>2</td>
<td>Select the second level</td>
</tr>
<tr>
<td>III (Seen and know the word’s meaning)</td>
<td>3</td>
<td>Select the third level and the translation is correct</td>
</tr>
<tr>
<td>IV (Know the word’s meanings clearly)</td>
<td>4</td>
<td>Select the fourth level and the translation is correct</td>
</tr>
</tbody>
</table>

3.3.3. Abstract Writing Test

To further explore the effect of participants’ incidental acquisition of vocabulary, this study established a writing output task. The participants negotiated the research topic based on their understanding of the hydrologic cycle and discussed the research methodology and the value and significance of the research. The final research abstract, based on the hydrologic cycle theory, was completed independently by the participants without the provision of a target word prompt.

To evaluate the participants’ research abstract writing, the study referred to Allagui’s rubric for descriptive paragraph writing [47] and adapted it accordingly to the writing requirements of this experiment. The criteria were divided into four dimensions: use of target words (TW), illustration of research topics (RT), illustration of theoretical foundations
(TF), and Content and Constructions of the abstract (CC) (Table 3). Dimension 1 focused on the mastery of the target words; dimensions 2 and 3 characterized the participants’ understanding and application of knowledge of the hydrologic cycle; dimension 4 reflected the participants’ ability to compose. In each of these dimensions, the two coders first selected five short texts and pre-coded them in a back-to-back manner. Then, the two coders discussed the inconsistent content and revised the pre-coding results. Finally, the two coders coded the remaining short texts. The three dimensions were rated on a scale of 1–7, except for dimension 1, which recorded the frequency of target word use and the number of errors for each subject. Spearman’s rank correlation test revealed that the evaluations provided by the two researchers had an inter-rater reliability higher than 0.830 \( p < 0.01 \), indicating fair to acceptable reliability.

**Table 3.** Grading criteria for writing scores.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Interpretation</th>
<th>1 Point</th>
<th>3 Points</th>
<th>5 Points</th>
<th>7 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>TW</td>
<td>Refers to the frequency of use and accuracy of the target word</td>
<td>Instead of scoring, record the frequency and accuracy of the target word in the abstract written by each participant.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RT</td>
<td>Refers to the student’s understanding of professional knowledge</td>
<td>The research topic is not clearly stated.</td>
<td>The research topic lacks certain rationality.</td>
<td>The research topic has certain rationality.</td>
<td>A clear and reasonable research topic is presented in the abstract through a detailed explanation.</td>
</tr>
<tr>
<td>TF</td>
<td>Refers to the accurate description of the hydrologic cycle theory</td>
<td>The theory is not mentioned.</td>
<td>The theory is less precise and not easily understood.</td>
<td>The theory is described, although there are some minor errors.</td>
<td>The abstract contains an accurate statement of the hydrologic cycle theory.</td>
</tr>
<tr>
<td>CC</td>
<td>Refer to covering all the elements in the stem requirements; The abstract is organized logically and clearly</td>
<td>Most of the elements are not covered, and the abstract is very disorganized.</td>
<td>Only a few elements are covered, and the organization of the essay is difficult to follow in many places.</td>
<td>All elements are covered, and the abstract has a clear organization with a logical progression of ideas.</td>
<td></td>
</tr>
</tbody>
</table>

**4. Experimental Results**

The research data were mainly obtained from students’ vocabulary acquisition, learning engagement pre-test and post-test, and \( t \)-test as well as analysis of covariance (ANCOVA) assessment were used to test whether there were significant differences between the two groups.

In order to exclude the effect of students’ a priori knowledge level on the experimental results, the two groups’ English composite scores and target vocabulary pre-test scores were used to test the differences in students’ English vocabulary levels. \( t \)-test results showed no significant differences between the two groups \( t = 1.165, p > 0.05; t = 0.037, p > 0.05 \), indicating that the two groups’ English vocabulary levels were similar before VR experience.

**4.1. Analysis of Target Vocabulary Test Results**

To examine the effect of the VR-based approach on students’ vocabulary acquisition, this study conducted an ANCOVA with vocabulary pre-test scores as the covariate and post-test scores as the dependent variable. The between-subjects effect test indicated that the groups met the condition of equal slopes of the regression lines \( p > 0.05 \). The homogeneity variance test results for the two groups of target word posttest scores were \( p > 0.05 \), which satisfied the requirement of homogeneity of variance, indicating that ANCOVA could be conducted.

The corrected means were 30.72 for the experimental group and 27.56 for the control group (Table 4). The target vocabulary acquisition scores of the two groups were statistically significantly different \( F = 4.363, p < 0.05, \eta^2 = 0.12 \), which means that the experimental group with the VR-based learning approach outperformed the control group with video-based learning in terms of target vocabulary acquisition.
Table 4. Results of ANCOVA analysis of students’ target word test scores under two different vocabulary learning approaches.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Adjusted Mean</th>
<th>SE</th>
<th>F</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>EG</td>
<td>18</td>
<td>30.72</td>
<td>5.46</td>
<td>30.71</td>
<td>1.06</td>
<td>4.363*</td>
<td>0.12</td>
</tr>
<tr>
<td>CG</td>
<td>18</td>
<td>27.56</td>
<td>3.82</td>
<td>27.57</td>
<td>1.06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\* \( p < 0.05 \).

4.2. Analysis of the Level of Learning Engagement

Between-subject effects tests indicated that \( p \) values were much higher than 0.05: the groups met the condition of equal slopes of the regression lines for each dimension. The homogeneity of variance test was conducted on the post-test scores for learning engagement for the two groups of participants. The data of four dimension are \( p > 0.05 \) (cognitive engagement), \( p > 0.05 \) (behavioral engagement), \( p > 0.05 \) (social engagement) and \( p > 0.05 \) (social engagement), which satisfied the requirement of chi-square, indicating that ANCOVA could be conducted.

There were significant differences in cognitive engagement (\( F = 0.496, p < 0.05, \eta^2 = 0.12 \)), behavioral engagement (\( F = 5.794, p < 0.05, \eta^2 = 0.15 \)), and social engagement (\( F = 5.714, p < 0.05, \eta^2 = 0.15 \)) between the different learning approaches (Table 5). Nevertheless, the two groups did not differ significantly in their performance on the emotional engagement dimension (\( F = 0.452, p > 0.05 \)). The results showed that the VR-based group achieved better learning performance than the video-based group in terms of cognitive, behavioral, and social engagement.

Table 5. Results of ANCOVA analysis of students’ learning engagement levels.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Adjusted Mean</th>
<th>SE</th>
<th>F</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive engagement</td>
<td>EG</td>
<td>18</td>
<td>3.68</td>
<td>0.38</td>
<td>3.66</td>
<td>0.07</td>
<td>0.496*</td>
</tr>
<tr>
<td>CG</td>
<td>18</td>
<td>3.43</td>
<td>0.40</td>
<td>3.45</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral engagement</td>
<td>EG</td>
<td>18</td>
<td>3.98</td>
<td>0.40</td>
<td>3.99</td>
<td>0.07</td>
<td>5.794*</td>
</tr>
<tr>
<td>CG</td>
<td>18</td>
<td>3.75</td>
<td>0.41</td>
<td>3.74</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional engagement</td>
<td>EG</td>
<td>18</td>
<td>3.74</td>
<td>0.59</td>
<td>3.73</td>
<td>0.08</td>
<td>0.452</td>
</tr>
<tr>
<td>CG</td>
<td>18</td>
<td>3.64</td>
<td>0.41</td>
<td>3.65</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social engagement</td>
<td>EG</td>
<td>18</td>
<td>3.99</td>
<td>0.46</td>
<td>3.96</td>
<td>0.10</td>
<td>5.714*</td>
</tr>
<tr>
<td>CG</td>
<td>18</td>
<td>3.57</td>
<td>0.48</td>
<td>3.60</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\* \( p < 0.05 \).

4.3. Comparative Analysis of All Dimensions of Abstract Writing

The results of the descriptive analysis revealed that the per capita target word usage was 4.17 and 2.94 for the experimental and control groups, respectively; however, the rate of target word use errors in the two groups was 4% and 8.5%, inversely proportional to the number of target words used per capita. The typical errors in the use of target words were spelling errors and errors in the use of parts of speech. For example, “hydrologic” was misspelled as “hydrologis,” and “vaporate” was used incorrectly. That is, the experimental group had a higher frequency use and correct rate of target words during writing activities. The results of the \( t \)-test demonstrated that the experimental group performed better in the level of TF (\( t = 2.143, p < 0.05 \)) (Table 6). However, the research abstracts of the two groups of participants did not differ significantly in terms of illustration of RT and CC (\( t = -0.282, p > 0.05; t = 1.424, p > 0.05 \)) were evident. These findings indicated that the VR-based approach improved students’ understanding and representation of the hydrologic cycle theory but did not have a significant impact on the structure and organization of the short essays, based on the research topics proposed.
Table 6. Results of t-test for writing scores.

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
<td>EG</td>
<td>18</td>
<td>3.11</td>
<td>0.98</td>
<td>−0.282</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>18</td>
<td>3.22</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>TF</td>
<td>EG</td>
<td>18</td>
<td>3.58</td>
<td>1.27</td>
<td>2.143 *</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>18</td>
<td>2.78</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>EG</td>
<td>18</td>
<td>6.61</td>
<td>2.27</td>
<td>1.424</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>18</td>
<td>5.75</td>
<td>1.19</td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05.

5. Discussions

5.1. The Potential of the Experiential Learning-Based VR Approach for Incidental Vocabulary Acquisition

Using the experiential learning-based VR approach, students were able to experience the causes and manifestations of the hydrologic cycle in the English for Geography course. The concrete experiences gained and the reflection, abstract conceptualization, and experimentation based on them contributed to the students’ vocabulary incidental acquisition. This result supports earlier research suggesting VR facilitates EFL vocabulary acquisition and retention, indicating that VR provided more word input than PC video games [37]. The reason that the VR-based approach can promote students’ incidental vocabulary acquisition can be attributed to both the immersive multimodal context created by VR to enhance the learning experience and the task-guided integration of experiential learning to promote knowledge comprehension. On the one hand, according to the dual coding theory (DCT) [48], multimodal input eases cognitive load throughout processing, supplies extra destinations for meaning making, and enhances memory retention, so as to promotes learning. The modal reconstruction function of VR provides students with a contextualized and visualized presentation of professional vocabulary [13], which supports their access to visual, auditory, and tactile multichannel information. The experiment immersed students in a realistic hydrologic cycle thematic environment, enabling them to use their prior knowledge and experience to guess and make inferences about the meaning of words in relation to the contextual content. Consequently, they were able to understand the meaning of the speech and captions guiding the content. When using the VR, the students entered the virtual space on a physical and mental level from a first perspective, allowing specific memories in their long-term memory to interact directly with their sensory register and “bypass working memory”. This more strongly activated their long-term memory and facilitated a deeper learning experience [49]. As in the vocabulary learning studied by Tseng et al., the multimodal representation of vocabulary in VR environments facilitated learners’ vocabulary acquisition [34]. Tai et al. also found that VR provided rich contextual information and multimodal stimuli to facilitate learners’ learning outcomes in terms of vocabulary acquisition and retention [32].

On the other hand, the VR-based approach supported students learning in an iterative cycle of “experience-reflect-discuss” as they interacted with the target language in various tasks [50]. It has been shown that repetition of target words is the key to vocabulary growth in incidental vocabulary acquisition [51]. It is challenging to have a full firsthand experience of the “hydrologic cycle” in the physical world because it is an abstract term. However, the integration of this abstract content into the VR context provided a meaningful context for vocabulary acquisition, complemented by task lists that guided students’ interaction with the VR context to understand the subject knowledge. It facilitated students’ knowledge comprehension and English expression through reflection and conceptualization, enabling them to ultimately achieve incidental vocabulary acquisition through repeated exposure to and use of the target words. Additionally, users have the chance to create good connections through experiential learning when learning in the VR environment. Moreover, interactive
activities helped students identify linguistic constructions that required improvement. This enhanced the precision and complexity of language production [52].

5.2. The Potential of the Experiential Learning-Based VR Approach for Learning Engagements

Learning engagement stems from active, physical involvement [53]. The VR-based approach can effectively enhance students’ cognitive, behavioral, and social engagement. This finding is consistent with that of previous research on VR’s contribution to enhancing learning engagement among seventh graders [32,54], non-English majors [55], graduate students [56], and adults [57] in EFL vocabulary acquisition.

Learners are placed in the VR environment with a first perspective to carry out game-, task-, and problem-based learning. Realistic scenes can increase students’ engagement in their learning, improve their interactive learning experience, and build their relationship to the course material [55]. Previous research has reported that the 3D perspective helped promote cognitive reflection, so as to facilitate cognitive engagement [58]. The VR-based approach created a visual, self-directed learning space for students to gain concrete experiences and reflective observations, maintaining their focus and mental effort [59], until they truly understood the vocabulary related to the hydrologic cycle. Additionally, in this study, there were notable behavioral engagement variations between the two groups. Behavioral engagement is a continuous process that depends on the degree and quality of student engagement. The high input and output tasks in the VR-based learning task list motivated students to maintain a high level of interest and motivation, which in turn contributed to the retention of behavioral engagement. For example, Early and Marshall found that using multimodal devices to express ideas can promote English language learning outcomes through increased cognitive and behavioral engagement [60]. Moreover, from the perspective of social engagement, cooperation among peers is one of its important indicators [61]. The VR-based approach led students to engage in collaborative discussions and propose research themes related to the hydrologic cycle theory based on concrete experiences and reflections. In this process, students listened to each other, drew on each other’s expertise and perspectives, and shared feedback with each other, leading to better vocabulary acquisition. This result corresponds with Toth et al.’s findings that learners may learn language more effectively when they are socially engaged [62]. Yet, VR did not significantly promote emotional engagement. The reason may be that although VR can create immersive learning environments and promote students’ learning motivation, the VR-based English vocabulary acquisition for geography students is a complex emotional and mental activity. The process involves both individual thought processing, knowledge use, and verbal expression and is also related to their thoughts and emotions, life experiences, and psychological qualities [63]; it is difficult for a short VR experience to have a significant impact on students’ affective factors.

6. Conclusions

In this study, an experiential learning-based VR English vocabulary acquisition for geography students was proposed and implemented. It was found that the vocabulary input from the VR experience, and the reflection, abstract conceptualization, and experimentation based on it, helped improve students’ incidental vocabulary acquisition, foster their cognitive, behavioral, and social dimensions of learning engagement, and enhance vocabulary output (i.e., essay writing). Meanwhile, students also demonstrated improved learning experiences (i.e., more effective and enjoyable) after learning with the VR-based approach. The study supports the finding that VR is superior to video as a vocabulary input and provides more practical evidence for incorporating VR into English vocabulary acquisition in higher education. However, the study also has certain shortcomings: (1) Owing to the limitations of VR resources, the VR environment was not an immersive learning environment throughout the process of learning English vocabulary for specific purposes. It easily led to an impact on learning engagement when switching between the VR environment and the learning task lists. Greater investment is needed to create more
resources relevant to the teaching of the subject for VR educational applications. (2) As only questionnaire scales were used to measure student learning engagement in experiential vocabulary acquisition activities in the VR environment, the data results were somewhat subjective. Therefore, cognitive psychological techniques such as FNIR need to be applied in future studies to measure participants’ cortical neurological activity and hemodynamic responses to obtain more objective experimental data.

Author Contributions: Conceptualization, Y.L., Q.C. and J.G.; methodology, Y.L., S.Y. and J.G.; software, S.Y.; validation, Y.L. and S.Y.; formal analysis, Y.L., S.Y. and J.G.; investigation, Y.L., S.Y., Q.C. and J.G.; resources, Y.L. and S.Y.; data curation, Y.L. and S.Y.; writing—original draft preparation, Y.L. and S.Y.; writing—review and editing, Q.C. and J.G.; visualization, Y.L. and S.Y.; supervision, Q.C.; project administration, Y.L. and J.G.; funding acquisition, J.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received funding from The Ministry of Education of the People’s Republic of China (19YJC880028), and the Key Laboratory of Intelligent Education Technology and Application of Zhejiang Province (jykf22028).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References
12. Urun, M.F.; Aksoy, H.; Comez, R. Supporting foreign language vocabulary learning through Kinect-based gaming. *Int. J. Game-Based Learn.* 2017, 7, 20–35. [CrossRef]
17. Ding, Y. Effectiveness evaluation model of students’ English listening ability based on immersive computing. *Mob. Inf. Syst.* 2022, 2022, 9. [CrossRef]
24. Somjai, S.; Soontornwipas, K. The integration of implicit and explicit vocabulary instruction, project-based learning, multimedia, and experiential learning to improve Thai EFL senior high school students’ vocabulary ability. Arab World Engil. J. 2020, 6, 171–190. [CrossRef]
34. Tseng, W.T.; Liou, H.J.; Chu, H.C. Vocabulary learning in virtual environments: Learner autonomy and collaboration. System 2020, 88, 102190. [CrossRef]