VIRTUAL REALITY IN ENGLISH VOCABULARY TEACHING: AN EXPLORATORY STUDY ON AFFECT IN THE USE OF TECHNOLOGY

REALIDADE VIRTUAL NO ENSINO DE VOCABULÁRIO DE INGLÊS: UM ESTUDO EXPLORATÓRIO SOBRE AFETO NO USO DA TECNOLOGIA

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ABSTRACT
The evaluative studies of hypermedia effects on second language acquisition have been mostly applied to interfaces whose user's input is limited to clicks, typed texts, and voice. Nonetheless, virtual reality (VR) technology expanded user's interactions with a data processing machine since it explores a sense of presence through body language, 360-degrees images, and tactile techniques. It is in this context that this paper approaches VR to explore its potential for foreign language vocabulary teaching and learning, considering mainly the appraisal mechanisms *novelty* and *pleasantness* proposed by Schumann (1999). This exploratory research presents the preparation and the results of a study applied to sixteen undergraduate English students at the Federal University of Juiz de Fora, Brazil, as well as to nine students from the author's one private course. The technology used in this study were three Google products: Cardboard™, as the VR headset; Expeditions, for the narrative; and Polly, for the building of the VR scenes. The following methodological actions were addressed to the participants of the study: an English placement test; vocabulary tests; exposure to the virtual environment, a guided visit to Museo Frida Kahlo, in Mexico; and a questionnaire on the evaluation of the experience. At the theoretical level, the present study is based on the assumptions of the Cognitive Theory of Multimedia Learning (MAYER, 2001) and in the role of affect in language learning (SCHUMANN, 1997; 1999). The results of vocabulary tests, the questionnaire, and limitations of the technology are discussed, giving a basis for the conclusion that VR can significantly contribute to foreign language vocabulary teaching and learning since the technology has the potential to motivate students and immerse them into real-life-like scenarios.
Keywords: virtual reality; english teaching and learning; affect.

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RESUMO
Os estudos avaliativos dos efeitos da hipermídia na aquisição de segunda língua foram aplicados principalmente a interfaces cuja entrada do usuário é limitada a cliques, textos digitados e voz. No entanto, a tecnologia de realidade virtual (RV) expandiu as interações do usuário com uma máquina de processamento de dados, uma vez que explora o senso de presença por meio da linguagem corporal, imagens em 360 graus e técnicas táteis. É nesse contexto que o presente trabalho busca explorar o potencial da RV para o ensino e aprendizagem de vocabulário em língua estrangeira, considerando principalmente os mecanismos de avaliação *novidade* e *agradabilidade* propostos por Schumann (1999). Esta pesquisa exploratória apresenta a preparação e os resultados de um estudo aplicado a 16 alunos da graduação em Letras da Universidade Federal de Juiz de Fora, e a nove alunos de um curso particular da primeira autora. A tecnologia usada neste estudo foram três produtos Google: o visor de RV, Cardboard™; Expeditions, para a narrativa; e Polly, para a construção das cenas em 360 graus. As seguintes ações metodológicas foram direcionadas aos participantes do estudo: teste de nivelamento em inglês; testes de vocabulário; exposição ao ambiente virtual, uma visita guiada ao Museu Frida Kahlo, no México; e um questionário sobre a avaliação da experiência. No nível teórico, o presente estudo se baseia nos pressupostos da Teoria Cognitiva da Aprendizagem Multimídia (MAYER, 2001), e no papel do afeto na aprendizagem de línguas (SCHUMANN, 1997; 1999). Em seguida, são discutidos os resultados de testes de vocabulário, o questionário e as limitações da tecnologia, dando base à conclusão de que a RV pode, significantemente, contribuir para o ensino e a aprendizagem de vocabulário de língua estrangeira, uma vez que esse meio tem o potencial de motivar estudantes e imergi-los em cenários mais realistas.
Palavras-chave: realidade virtual; ensino e aprendizagem de língua inglesa; afetividade.

INTRODUCTION

In this study, a rationale behind choosing to investigate VR as a tool is the potential that affective qualities of the medium, i.e., the eliciting of emotions in its user, have for enhancing learners' sense of presence in vocabulary learning activities. This could be due to, hypothetically, the aided and extended imprint in learners' memory by a full-body experience. As Matlin (2004, p. 79, our translation) puts it: "You will find the material easier to remember if you imagine how you could answer to the stimuli or the situation". In the case of VR, learners no longer need to imagine themselves in the situation but feeling as if they were in it. Therefore, in the background of this research is the idea of extended cognition, a form of understanding information processing not as an isolated process of the mind, but as a result of the whole human body system in interaction with the environment. Thus, according to this view:

> Cognition is embodied and contextualized, i.e., it depends on the concrete experience of the individual and uses sensorial and social abilities; [...] the cognitive process operates in a distributed way, a kind of socio-technical network, involving the brain/body and its interactions

> with humans and non-humans (social interactions and technical objects). (REGIS; MESSIAS, 2012, p. 42, our translation).

Such a perspective was brought here since VR technology agencies the body as a means of content manipulation. The type of content considered here is that designed for learners of English as a foreign language. There have been some recent studies, using state of the art VR technology, that targeted vocabulary teaching and learning of a foreign language (CHO, 2018; VAZQUEZ et al., 2018; GUPTA, 2016). These studies are inconclusive to validate VR as a tool to improve the recall of target-words immediately after the activity, in comparison to other hypermedia resources, such as desktop applications. However, the studies by Vazquez et al. (2018) and Gupta (2016) have in common the fact that their participants who were in the VR experimental group scored better in long-term-memory vocabulary tests[1].

Concerning peer interaction strategies, VR has been used as a context in which students talk about a topic before and after being immersed in it. As Parmaxi, Stylianou and Zaphiris (2017) suggest with their study using Google Cardboard™ in an English classroom, students were more motivated and at ease with the oral task imposed on them. Bonner and Reinders (2018) recommend VR to teachers who wish to provide their students with contextual vocabulary learning, i.e., learning within a real life-like scenario, using low-cost VR headsets (Google Cardboard™ or similar) and 360-degree YouTube videos[2].

In sum, the literature review shows that research in VR in the field of Applied Linguistics is somehow new and still lacking a theoretical framework, especially considering the characteristics of the medium that could approach affect. Schumann (1997, 1999) has his own approach to a definition of affect, and how it is directly involved on the success of second language learning. His work is based on neurobiology and the assumptions of the *appraisals theory*, a framework for studies in the field of psychology and communication. According to Schumann's approach to this theory, motivation and affect are interchangeable terms, and it involves appraisal mechanisms through which second language learners use to evaluate stimuli. In this context, we sought to explore the potential of VR for foreign language vocabulary teaching and learning, considering mainly the *novelty* and *pleasantness* appraisal mechanisms defined by Schumann (1999).

1. In all research mentioned above on VR and foreign vocabulary learning, the long-term memory tests consist of the same test applied immediately after the experiment, i.e., a vocabulary test on the words seen in the virtual environment.
2. YouTube.com and its application support the upload and streaming of spherical videos and photos, meaning images that are captured by cameras with 360 degrees lenses, allowing the viewer to access all angles of a given image.

The following three sections explore two axes from which the study develops its methodology, information processing and affect, beginning by presenting how a cognitive model (MAYER, 2001) has been used to explain the way vocabulary learning takes place in multi/hypermedia environments. Then, we introduce Schumann's model (1997) as an attempt to explain how motivation in foreign language learning is fostered at the very beginning of stimuli perception. In this sense, it is possible that, at least indirectly, Schumann (1997) had provided a way to start thinking of answers for the question suggested by Huckin and Haynes (1993, p. 295), as a topic for future investigations: "is successful learning a function of type of attention, rather than sheer volume of repetition?". Next, the Methodology section presents how the study was designed, its tools, and the profile of its participants, followed by the analysis of the vocabulary tests and evaluation questionnaire. Finally, we conclude this study's description pointing out the major findings of the use of VR technology in vocabulary teaching and learning.

1. COGNITIVE MODELS APPLIED TO MULTI/HYPERMEDIA FOREIGN VOCABULARY LEARNING

Amongst a few models and theories of information processing, Mayer's (2001) Cognitive Theory of Multimedia Learning is, perhaps, the most often cited in hypermedia studies for second/foreign vocabulary learning.

Although Mayer's theory is an outcome of methods to facilitate the understanding of scientific explanations, it was outlined widely enough so it can be applied to any field of knowledge, in terms of presentation of didactic material. The core of the theory states that "people learn more deeply from words and pictures than from words alone" (p. 47), and it is based on the following assumptions: a) humans process information via two separate channels, auditory and visual; b) there is limited capacity in each channel, and the process of incoming information actively creates mental representations; and c) learning is an active process of filtering, selecting, organizing, and integrating information. The more this information is related to prior knowledge, the higher the chances are for learning to occur successfully.

Thus, based on how the human mind works, Mayer's theory (2001) also presents guidelines for the design of instructional media since simply adding pictures to words does not guarantee a more effective way of learning. Although there are twelve design principles in his work, we opted for highlighting the following since these were applied to our study, as it can be seen in the Methodology section.

According to these principles, learning takes place more effectively when 1) a multimedia lesson is presented in user-paced segments rather than as a continuous unit; 2) learners know what to expect to be learned from the lesson, and/or when knowledge is pre-activated; 3) words are presented in conversational (informal) style rather than in formal style; 4) narration is spoken in a friendly human voice rather than a computer-generated voice.

Moreno and Mayer (2002) also experimented with VR in the creation of a learning environment, although the state of the art of VR technology used in their study was quite different from the current one addressed here. Nonetheless, the so-called VR apparatus used in their comparative study provided a higher degree of immersion than the desktop application presented to the control group, i.e., participants in the experimental group wore an HDM (head-mounted display). As for the findings of this study, although the motivation to learn was rated higher in the experimental group, the lesson displayed in VR did not affect the quantitative results for learning. According to the authors of the study, this confirms the idea that

> the same factors that improve student understanding in one medium (such as modality effects in a desktop environment) improve student understanding in another medium (such as immersive VREs). Despite the temptation to take a technology-centered approach to learning, it is necessary to search for empirically-based principles for the design of VREs. As long as instructional methods promote appropriate cognitive processing, then media does not seem to matter. (MORENO; MAYER, 2002, p. 3).

In other words, VR would be just another form of presenting multimedia educational content, and as long as the principles for multimedia design are applied to its features, learning is likely to happen, regardless of the effects of immersion and motivation. Despite being one of the few models used to understand vocabulary learning in a multimedia environment, presenting significant advances in the area, Mayer's model is quite simple and limited for having excluded learners' individual characteristics, such as attention, motivation, learning styles, among others, which directly influence information processing. Exploring these characteristics in the VR medium can be facilitated by its features, as section 4 intends to show.

2. INVESTIGATIONS ON THE ROLE OF LEARNER'S MOTIVATION: THE NEURAL MECHANISM OF AFFECT

In the history of Applied Linguistics' theories on how and why learning in hypermedia environment alters motivation (see, for example, SAITO, 2015), this

section was thought to introduce the concept of affect and its relation to second language learners' motivation, a variable not directly contemplated by Mayer (2001). Schumann's work (1997) also gives us hints on how to harvest the affordances of VR to design learning experiences that are impacting and relevant.

According to this research, it is possible[3] that a tri-partite system is involved in a neural mechanism responsible for stimulus appraisal, i.e., classification of stimuli based on the emotional memory of previous experiences. These three structures are the amygdala, the orbitofrontal cortex, and the body proper.

In this way, Schumann argues that stimuli in the way of events, agents, and objects generate mental images in the early sensory cortices, such as sight and sound. In these cortices, they become thoughts by the action of dispositional representations (DRs), which are dormant patterns of neuronal firing activity[4]. Mostly, as the author continues, "they are latent memories of all our innate and acquired knowledge" (SCHUMANN, 1997, p. 53). Also, DRs in the orbitofrontal cortex store knowledge of emotional responses paired with certain situations/ experiences. Besides, these DRs sign to the peripherical nervous system bodily states that constitute emotional reactions to the perceived stimulus. Then, the brain interprets that as a feeling which becomes associated with the stimulus, i.e., an image or a sound, for example. In the chemical level,

> When the stimulus appraisal has been made, neurotransmitter systems in the brainstem and the basal forebrain release chemical messengers such as dopamine, norepinephrine, and acetylcholine into various parts of the cortex that regulate perception, attention, memory, and cognitive and motor investigatory-exploratory action toward the stimulus. [In this way], characteristics of the stimuli may be learned. Negatively appraised stimuli are recognized so that they can be dealt with to the extent necessary, recognized in the future and avoided if possible. (SCHUMANN, 1997, p. 53-54).

Using the neurobiology and psychology of these mechanisms for stimuli appraisals, Schumann intended to explain different levels of proficiency in second language acquisition. The language learning situation, either in the target language environment or in the classroom, is the context where appraisals take place,

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3. Schumann's work (1997) in presenting a model for stimulus appraisal is based mainly in the case studies of Damasio and LeDoux, and should not, according to himself, be taken further than speculation. Such a claim is due to the lack of direct experimental evidence since the only way to suggest which structures are involved in each information process possibly is through brain-damaged humans and animals. For example, orbitofrontal patients demonstrate difficulties in making appropriate appraisals along with three of the five dimensions: goal/need relevance, copying ability, and self and social image.
4. Neuronal firing refers to the communication between neurons, which takes place in form of electrical impulses and neurotransmitters.

always encoding its corresponding emotional response. The types of appraisals deliberated by the brain are shown in table 1. In this study, we focused on the first two mechanisms, novelty and pleasantness, for they could be directly related to the characteristics of the technology used. Schumann (1997) also examined diary studies and autobiographies of second language learners and suggested that positive appraisals enhance language learning, while negative appraisals inhibit second language learning. Here, it is important to mention that not everything unpleasant, during second language acquisition, receives a negative appraisal's typical response. As Schumann explains using a study case, as an immigrant, language flaws perceived by others can either inhibit the learner towards speaking the language or give them the cues to improve their knowledge continuously, especially if what is at stake is a long-term goal whose importance surpasses the negative feelings after social disapproval.

Novelty appraisal	Assesses whether internal or external stimulation contains unexpected or familiar patterns.
Pleasantness	Determines whether an agent, an action or an object is appealing and thus fosters approach or whether it is unappealing and promotes avoidance.
Goal/need evaluation	Assesses the degree to which the stimulus event is conducive to satisfying the individual's ability to cope with the event.
Norm/self-compatibility check	Accesses a) the compatibility of the event with social or cultural norms, or with the expectations of significant others, and b) the compatibility of the event with the individual's self-concept or ideal self.

Table 1. Qualities accessed by the appraisal's mechanisms (SCHUMANN, 1999).

According to Schumann (1997), although motivation questionnaires and diary studies usually highlight the dimensions mentioned above, the novelty appraisal did not appear in them. The topic was also generally absent in the autobiographies of second language learners. The importance of this type of appraisal relies on novelty being a scale with two extremes. At one end, there is the totally unexpected, which can be frightening. At the other end, there are the learning experiences that sound and seem very familiar or tried several times, which could lead to demotivation. In this sense, technology plays an important role, yet not fully understood, in delivering content that can manage to find a mid-way between innovation and the maintenance of learner's confidence in their capacity to cope with tasks.

As seen in Moreno and Mayer (2001), new technology does not necessarily address learning differently. Besides, there is always the risk of taking affect to a level illustrated ironically by Stevick (1999, p. 43), by those seeking to find a single variable responsible for learning success:

> Before us nothing was. And after us nothing else need ever be. Of late, a possible candidate for philosopher's stone is exactly [...] 'affect' – the teacher's sensitive awareness of learner affect. If we can only – if we will only manage our teaching so as to take leaner affect into account, then dead materials will come to life, and the lead-headed students will produce golden achievements.

Nonetheless, the importance of affect given by Vygotsky is well-known: "If we want students to remember or exercise their thinking better, we must make these activities emotionally stimulated. Experience and research have shown that a fact steeped in emotion is remembered more solidly, firmly and prolongedly than an indifferent fact". (VYGOTSKY, [1926]2003, p. 121, our translation).

3. METHODOLOGY

This section describes the study that is intended to explore the potential of VR for foreign language vocabulary teaching and learning, considering mainly the appraisal mechanisms novelty and pleasantness proposed by Schumann (1999). Section 4.1 presents the participants of the study, while from 4.2 to 4.5, it is addressed the procedures and tools adopted in the research. Section 4.6 analyses the results of the vocabulary tests and section 4.7, the preliminary results of the qualitative questionnaire. Lastly, in section 4.8, some observations about participants' comments and reactions regarding the exposure to the virtual environment are shared.

3.1 Participants of the study

According to the studies by Hulstijn, Hollander and Greidanus (1996), Chun (2001), Souza and Braga (2007), and Yun (2011), students of higher language proficiency levels do not make much use of hypermedia resources since they are typically able to make intratextual inferences to the unknown vocabulary. Therefore, the sample chosen for this study was 16 students of English II and III, from elementary to pre-intermediate proficiency levels, from Faculdade de Letras at the Federal University of Juiz de Fora (UFJF), and nine students, from elementary to intermediate levels of a private English course taught by author one.

The three categories (elementary, pre-intermediate and intermediate), with which the 25 students were identified, are based on the results of the proficiency test *Solutions Placement Test* (EDWARDS, 2007). Table 2 shows the proficiency levels distributed among the sample of this study. Most students were from an intermediate level. The median of the participants' ages was equal to 23.

Number of participants	25
Elementary	28%
Pre-Intermediate	32%
Intermediate	40%

Table 2. Number and level of proficiency of the participants of the study.

After the proficiency test, 24 participants (one participant was absent in this phase) answered a questionnaire containing eight questions designed to evaluate their studying practices, especially with regards to their total time as English learners, the use of hypermedia resources and learning preferences.

As to the total time learning English, 64% of the participants had been studying the language for more than three years. Most participants (62,5%) of the study declared to dedicate some time to the studying of English vocabulary usually. Among these, 79% of the participants said to use a computer, cell phones, and tablets for vocabulary learning. In addition, an informal interview revealed that none of the students had access to VR as a medium to language learning.

3.2 Methodological tools and procedures

Table 3 presents the methodological tools and procedures of the study, as well as what was expected from them.

1) Visits to the classrooms of the targeted English learners for the study.	Invited the English learners to the study, explained its phases and goals, distributed the term of free and clarified consent (Termo de Consentimento Livre e Esclarecido).
2) Proficiency test	Evaluated the participants' levels of English proficiency.
3) Questionnaire about study practices	Knew the participants' use of Hypermedia resources.

4) Vocabulary pre-test	Identified participants' familiarity with the lexical items displayed as glosses in the virtual reality learning environment.
5) The virtual reality learning environment	Displayed the target-words among the extracts of text provided in the environment, together with their pronunciations and corresponding images.
6) Vocabulary post-test	Quantitatively measured the learning of targeted words immediately after participants' exposure to the learning environment and guided tour.
7) Questionnaire about the experience	Qualitatively measured participants' enjoyment, management of the devices, and navigation in the virtual environment, as well as their opinions about the experience.
8) Field diary	Registered my observations about students' comments and reactions during the study.

Table 3. Methodological tools and procedures (phases of the study).

3.3 Pre-vocabulary test

Following the questionnaire, participants took a vocabulary test, based on adaptations of the *Vocabulary Knowledge Scale* (PARIBAKHT; WESCHE, 1997). In this adapted scale, which evaluates the knowledge of specific lexical items in three categories (columns), answers can vary from total novelty of the item to a confident definition of it, as in: "I have never seen this word before", "I have seen this word before and I think it means[5]…", and "I know this word. I know its meaning. The meaning is…". The participants could give definitions to the words using: translations, English synonyms, and representations in the form of a drawing.

The pre-vocabulary test had 17 English words, presented as a random word list. Those were: *self-portrait*, *bedridden*, *cast*, *courtyard*, *disease*, *hardships*, *struggle*, *strength*, *velvet*, *affairs*, *easel*, *foetuses*, *miscarriage*, *nips*, *sketch*, *ups and downs*, and *whole*. These appeared as glosses in the texts of the VR environment, and orally during the teacher's (author 1) guidance of the tour's scenes. In this way, each word had an average of 5 repetitions. This amount was chosen based on Nation's (2001) minimum number of repetitive exposures needed for a new word to be learned, in the context of second language acquisition.

5. In the actual test used for the study, participants had access to the categories' translations into Portuguese.

The main criteria for choosing such vocabulary were that they should be: a) keywords referring to the topic; b) potentially unknown vocabulary, considering the participants' proficiency levels[6]; and c) words that were possible to be represented by the images used in the VR environment.

The pre-test was applied to the participants to provide a true measure of their learning since some of the words could have already been part of their vocabulary knowledge. The results of this test were analysed in comparison to the ones from the post-vocabulary test, discussed in more detail in section 4.6.

3.4 On devices and techniques

The gadgets that make up the VR experience come in a variety of arrangements, technologies, and prices on the market, from the Google Cardboard™ headset (figure 1), developed in 2014 for use in conjunction with a smartphone, to the sophisticated headsets that display computer-generated three-dimensional images, such as the Oculus Rift™ and HTC Vive™.

In classroom scenarios, the reality has been the use of technological devices that are close to the simplest that VR can get, meaning the view of 360° photos and videos on the screen of a smartphone attached to a headset. This headset holds the device in front of its user's eyes, typically blocking the entire exterior view (see figure 1). This sort of arrangement seems to be the case because 3D images, created by computer programs in such a way to enable immersion in its full potential, require expertise that is usually beyond the applied linguists/teacher set of skills. In their VR technology review, Peltekova and Stefanova (2016) highlighted the advantages of the Google Cardboard™ in comparison to other devices which, up to date, vary from 399 to 799 US dollars[7]. Thus, in addition to research on the possible positive effects of VR in the field of education, one has to think about how realistically accessible technology will be in the educational context, especially in classrooms.

6. In addition, none of them were found on the TOEIC Service list (BROWNE, C; CULLIGAN, B. 2016), which lists the 1254 highest-frequency English words.
7. As last consulted in July 2019.

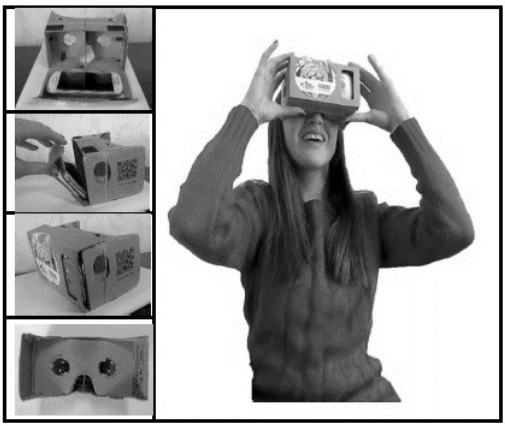

Figure 1. Example of how Google Cardboard™ is used with a smartphone, currently the cheapest option among VR devices (PELTEKOVA; STEFANOVA, 2016).

The simplest VR devices do not deliver a completely immersive experience since they lack tracking of the user's position in 6 degrees of freedom (meaning the possibility of moving right and left, up and down, forward and backward, combined with rotation on three perpendicular axes). However, a sense of presence is instead a psychological feature, less caused by technology than by the individual's willingness to suspend disbelief, as it was possible to state by observing the reactions of the subjects from the study. Besides, although stereoscopic photography creates a more predictable narrative, such an environment allows the student to explore it at their own pace, following the principle of segmentation proposed by Mayer (2001), according to which people learn best when multimedia lessons are presented in user-driven segments.

In the educational field, the Google Cardboard™ headset has been used to view, among others, the Google Expeditions application, whose purpose is to simulate field trips for groups of students guided by their teacher. This application, developed in 2015, has over 500 experiences (tours) available for free download, along with text-based scripts for the guide of the virtual experience. The following description of how the virtual environment was created is a step forward from the research on the state of the art of VR, by Peltekova and Stefanova (2016), since ready-made content has now an option to be customized to a point.

3.5 The virtual reality learning environment: a trip to Frida Kahlo museum

The choice of the environment was made according to the tours available on Google Expeditions at the time and it took into account the following criteria: the tour should a) be in English, b) make use of visual and auditory resources, following Mayer's (2001) multimedia principle, c) have informative text, and d) the theme of the tour should be potentially appealing and emotional to foster learners' engagement in the activity (SCHUMANN, 1999) and learning (VYGOTSKY, 2001; HEDE, 2002).

Among the themes available in the application at the time, a biography was likely to fulfil such requirements, especially considering its potential to generate empathy. The only possible VR tour among the options available on Google Expeditions at the time, considering the above criteria, was called Life and Art of Frida Kahlo. The tour contained scenes from the premises at Frida Kahlo's museum in Mexico City, as well as extracts of text. In total, the original tour had 18 scenes, which would be unpractical to use due to the time spent in the activity and the number of potentially unknown words in the text. Thus, it was used some of the same texts (edited to be shorter) and four scenes from this tour on another free application, Google Poly, designed to create 3D objects and scenes for VR and AR devices. For the scenes used in the tour from Google Expeditions, the same locations were found, recorded in 360°, using the address of the museum on Google Earth, street view mode, which also included images of the museum's interior.

The tour created with the adapted text from Expeditions had 17 words (see section 4.3) that were highlighted in the form of capital letters, and none of them had translations or definitions of any sort in the environment, although they appeared in the context of what was being seen on the screen. Occasionally, some of the participants asked for translations during the tour, but the first mentions to the words, by the teacher, were followed by their synonyms in English and/or questions directed to the participants to check their comprehension. Besides, some of the questions elicited answers based on their previous experience and world knowledge since knowing a lexical item does not occur only at the linguistic level, but it also happens extralinguistically (PROCÓPIO; SOUZA, 2016).

The teaching approach used in the tour made use of implicit and explicit strategies. The first takes place in context and contributes to lifelong learning, providing more learner's autonomy through lexical inference (LAUFER; HILL, 2000). The second, explicit teaching, facilitates learning by the control of exposure and vocabulary repetition (SCARAMUCCI, 1995).

The tour begins in the patio of the museum, (the courtyard of Frida Kahlo's house), and goes to a room where her dresses and pictures were displayed, followed by a garden scene, and Frida's and Rodrigo Rivera's painting studio. The tour has been published, and it is available to public view on Google Poly since the study[8] took place.

To access the tour, there were eleven Google Cardboard™ headsets, smartphones[9], and earphones[10] for individual use. The configuration of the tour and the safety instructions were presented to the participants at the beginning of section one of the tour, in the form of a slide show. Figure 2 shows how to navigate the scenes[11].

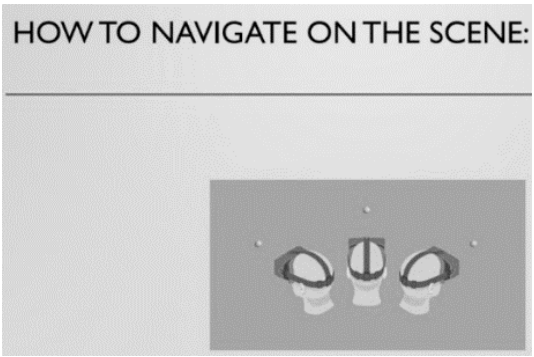

Figure 2. Because the image is recorded in 360°, the viewer's gaze finds an image in any direction their head turns.

The possibilities given to the students, in terms of navigation, were 360° gazing of the environment and access to links to text plus image and audio files (the narration of the same text, recorded with a human voice). Besides, there was a link to the main menu where the links to all the scenes were. To click on links, participants needed to press a button on top of the headset, without taking off the device from their faces. Figures 3 to 5 illustrate these configurations and figure 15 shows how the environment appears on the screen of the smartphone, as well as an example of how the target-words appeared in the text, together with a related image.

8. Available on: <https://poly.google.com/view/95G8h359dQ0>. Last accessed on 6 Jan. 2020.
9. A Motorola G4 Plus. At the time of the study, this model had the minimum requirements for VR content to be displayed: gyrospcope and accelerometer sensors.
10. From various models. The participant could also use his/her own.
11. The white dots in front of the headsets represents the gaze of the viewer.

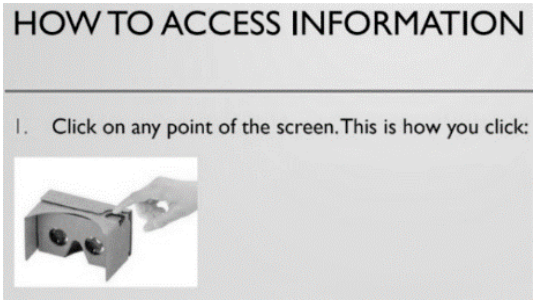

Figure 3. Button on top of the Google Cardboard™ headset used to click on links.

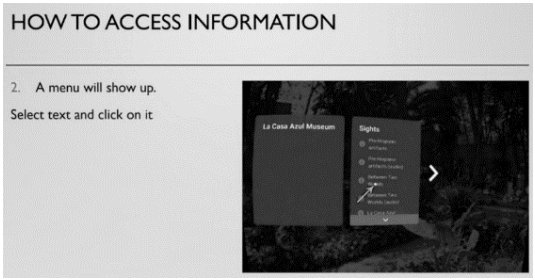

Figure 4. On clicking anywhere on the scene, a menu appears, and it is possible to navigate through the scenes.

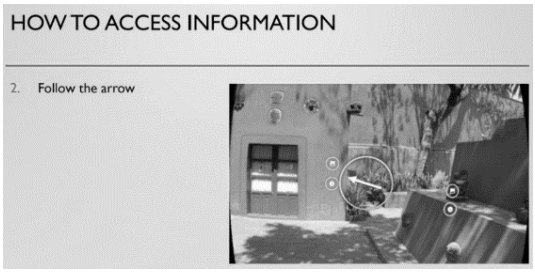

FIGURE 5. After clicking on the links, an arrow conducts the viewer's gaze to the corresponding text/audio icon, which needs to be clicked again for the text to appear or the audio to play.

Figure 6. One frame of the scene about Frida's dresses. After clicking on a text icon, the viewer sees one targeted word displayed in context. An image follows the text (here, Frida's first self-portrait). The lenses inside the Google Cardboard™ converge the two images into one, giving it the illusion of three-dimensional space.

3.6 Vocabulary post-test

After the virtual tour, a post-vocabulary test (identical to the pre-vocabulary test) was applied to the participants, who were not allowed to make consultations of any kind. Because of some peculiarities of each group, the results of pre and post vocabulary tests will be presented separately below. As in the pre-test, the participants could give definitions to the words using: translations, English synonyms, and representations in the form of a drawing. In this way, it was sought to explore multimodality not only in the virtual environment but also in the vocabulary tests, creating a test coherent to the learning environment.

The analysis of the tests considered unknown words (measured in the pre-vocabulary test) and learned words (in the post-test), which means all the correct answers (drawings, translations, or English synonyms) that were found in columns B and C of the test ("I have seen this word before and I think it means…", and "I know this word. I know its meaning. The meaning is…", respectively).

Groups 1 and 2 completed the tour in two sections, on different days of the same week, while group 3 completed the tour in just one day, with a break of about 20 minutes between the two sections. For each group, a table is presented below, containing the results obtained from the vocabulary tests in this group, displayed in percentages. These results were organized by the participants' three levels of proficiency. The learning gain by each level was calculated by subtracting from the correct answers in the post-test the percentage of correct answers from the pre-test.

Group 1 names seven participants from English III at Faculdade de Letras, UFJF. Among them, there were two students at the elementary level, two at the pre-intermediate, and three at the intermediate. Table 4 depicts the results. After the exposure to the virtual environment, participants at the elementary level had a learning gain of 64%; at the pre-intermediate, 50%, and the intermediate, 43%.

Elementary:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	100%	"I have never seen this word before" and wrong guesses	36%
"I know this word. I know what it means. The meaning is…" and correct guesses	0%	"I know this word. I know what it means. The meaning is…" and correct guesses	64%
Pre-intermediate:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	57%	"I have never seen this word before" and wrong guesses	7%
"I know this word. I know what it means. The meaning is…" and correct guesses	43%	"I know this word. I know what it means. The meaning is…" and correct guesses	93%
Intermediate:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	62%	"I have never seen this word before" and wrong guesses	19%
"I know this word. I know what it means. The meaning is…" and correct guesses	38%	"I know this word. I know what it means. The meaning is…" and correct guesses	81%

Table 4. Results of the vocabulary tests from Group 1 of the study.

Group two refers to nine students from English II at Faculdade de Letras, UFJF. Among them, there were four students at the elementary level, three at the pre-intermediate, and two at the intermediate. Table 5 shows this group's performance in the vocabulary tests. After the exposure to the virtual environment, participants at the elementary level had a learning gain of 33%; at the pre-intermediate, 36%, and at the intermediate, 46.5%.

Elementary:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	92%	"I have never seen this word before" and wrong guesses	59%
"I know this word. I know what it means. The meaning is…" and correct guesses	8%	"I know this word. I know what it means. The meaning is…" and correct guesses	41%
Pre-intermediate:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	94%	"I have never seen this word before" and wrong guesses	58%
"I know this word. I know what it means. The meaning is…" and correct guesses	6%	"I know this word. I know what it means. The meaning is…" and correct guesses	42%
Intermediate:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	81%	"I have never seen this word before" and wrong guesses	34.5%
"I know this word. I know what it means. The meaning is…" and correct guesses	19%	"I know this word. I know what it means. The meaning is…" and correct guesses	65.5%

Table 5. Results of the vocabulary tests from Group 2 of the study.

Group 3 is composed of nine students from author's one private course. Here, the proficiency levels are represented by elementary, two students; pre-intermediate, two students; and intermediate, five students. Table 6 depicts the results of their vocabulary tests. After the exposure to the virtual environment, participants at the elementary level had a learning gain of 58.5%; at the pre-intermediate, 32%, and at the intermediate, 27%.

Elementary:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	100%	"I have never seen this word before" and wrong guesses	42.5%
"I know this word. I know what it means. The meaning is…" and correct guesses	0%	"I know this word. I know what it means. The meaning is…" and correct guesses	58.5%
Pre-intermediate:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	91%	"I have never seen this word before" and wrong guesses	59%
"I know this word. I know what it means. The meaning is…" and correct guesses	9%	"I know this word. I know what it means. The meaning is…" and correct guesses	41%
Intermediate:			
Pre-test		Post-test	
"I have never seen this word before" and wrong guesses	67%	"I have never seen this word before" and wrong guesses	40%
"I know this word. I know what it means. The meaning is…" and correct guesses	33%	"I know this word. I know what it means. The meaning is…" and correct guesses	60%

Table 6. Results of the vocabulary tests from Group 3 of the study.

The average gain in learning, from all the groups and proficiency levels, adds up to 43%. Table 7 shows the breakdown of this gain by proficiency levels.

Elementary	52%
Pre-intermediate	40%
Intermediate	39%

Table 7. The average gain in learning among the different proficiency levels.

Considering the participants' options for representational knowledge used in the post-test (writing a synonym, a definition or a translation, as well as drawing), there was nearly no use of the drawing option (only two students made use of this resource).

3.7 Qualitative analysis: evaluation questionnaire of the experience

Six questions evaluating affect were addressed in terms of what the 24 participants (one participant did not answer the questionnaire) thought of the

environment; if they felt immersed in it, what features of the environment, among pre-selected options, they liked the most, and if they felt any discomfort during the experience.

For the first question, "what did you think of the experience?", table 8 shows the adjectives they used in their answers to give qualities to the experience, indicating that, overall, the experience seemed to be a pleasant one, which can be a relevant factor to associate with motivation and learning.

What did you think of the experience?	Number of times mentioned
Interesting	11
Different	4
Effective	3
Innovative	3
Good	2
New	2
Rich	2
Surprising	1
Enriching	1
Creative	1
Dynamic	1
Challenging	1
Didactic	1
Modern	1
Valuable	1
Valid	1
Cool	1

Table 8. Adjectives used by the participants to answer the first question of the qualitative questionnaire, "what did you think of the experience"?

The second question addressing affect was "Did you feel immersed in the environment? Justify your answer". Out of the total number of answers (16)[12], table 9 presents the ones that were translated here for offering insights into the qualities of both the medium and the lesson that influenced immersion:

12. Group 3, with 9 participants, did not have access to this question, because of the slightly different questionnaire that was applied to them.

Did you feel immersed in the environment?	Numbers of Participants	Some Comments
Yes	12	– "The images and the texts are much more visible than on a projector, for example. Besides, the audio in the earphones is better [than the one from a speaker?]". – "Yes, because virtual reality has this capability, and everything was conducted in such a way to offer the best possible experience". – "The images were very realistic and the movement in 360° allows more immersion". – "I felt totally immersed in the environment because the virtual environment brought me the knowledge [which is] very close to reality". – "Yes, since the headset offered a very directed and dynamic image of the environment." – "Yes, the environment was pleasant and had much relevant information". – "The images are very real and make me feel as if I am really in the museum".
Not entirely	2	– "A little, not entirely, because of the part [of the device] where the nose stays bothered me a little because of the cardboard smell. The cell phone does not stay still, then sometimes the vision blurs, and the audio did not work".
No	2	– "The images could not stay focused".

Table 9. Free translation of students' answers to the question "Did you feel immersed in the environment"?

The third question related to affect asked the participants to rank the options from 1 to 5 concerning what they liked the most in the VR environment (1 for what they liked the most and 5 to what they liked the least). Table 10 shows the number of times each option received the number 1 from the 24 participants who answered this question. The most number-one ranked option was the virtual environment, while no one selected the theme of the tour.

What do you like the most?	
The narration of the teacher/guide	42%
The recorded narration referred to the texts	4%
The virtual environment	54%
The theme	0

Table 10. The number of times each characteristic of the VR tour received the highest appreciation.

Lastly, the question: "Did you experience any physical or psychological discomfort during the experience?" was answered by all participants (25) of the study. More than half of them (16), answered yes to the question. Table 11 lists the sources of the discomfort mentioned by these participants, being dizziness (also known as motion sickness, when it comes to VR experiences) the main issue.[13]

Physical or psychological discomfort mentioned by the participants during the experience	Number of times mentioned
Dizziness	10
Headache	4
Itching/pain in the eyes	4
Nausea	3
The unpleasant smell of the cardboard	1
Psychological[13]	1

Table 11: Sources of discomfort and the number of times they were mentioned.

The question of whether and how the experience favoured the participants' learning style gives a hint of what features of the VR environment contributed the most to vocabulary learning, Table 12 highlights the most relevant answers out of 16[14].

13. The participant who answered this explained that her discomfort was caused by the sad passages about Frida's life.
14. Group 3 did not have this question on their questionnaire.

Did the virtual environment favour your learning style? Justify your answer.	Numbers of Participants	Some Comments
Yes	14	– "It favoured because it was very good to associate the word with images since sometimes I cannot understand the context, with images it helps a lot to identify the meaning": – "The environment favoured my learning style very much: realistic images, and short, explanatory/expositive, dynamic texts. – "This method stimulates vision and Kinaesthetic aspects, the ones with which I learn the most". – "The environment favoured learning because it worked with art-related content and words, which are difficult in the cultural context, in a ludic way. – "The theme was interesting, then learning was a consequence of immersion into the environment". – "My learning styles were contemplated (visual and auditory). – "The environment was very favouring to learning. The different, out of everyday learning, introducing new words in a new way to me, it enriched learning.
Not entirely	2	– "Not too much, I got a little confused". – "Yes and no. Yes, because of the images, together with the narration, contributed to the understanding of the lesson. And no, because of the physical discomfort that affected concentration".

Table 12. Translation of students' answers to the question "Did the virtual environment favoured your learning style? Justify your answer".

Regarding the features of the VR tour that favoured learning, it was asked from the participants to arrange the numbers from 1 to 5 according to the ascendant order (1 for what they thought it was the most helpful for learning and 5 to what they thought it was the least helpful). Table 13 shows the number of times each option received number 1. The virtual environment, which included the scenes, the information display and the 360-degree images, was the element that received most of the students' appreciation (53%), followed by the narration of the teacher (30%), and the recorded narration referred to the texts displayed in the scenes (17%). No mention was given to the theme as the first option when

it comes to a positive appraisal. It is worth mentioning, although this data was gathered by observation only, that participants at elementary level valued teacher's narration more than the other aspects of the activity. In contrast participants at pre-intermediate and intermediate levels considered recorded audio as helpful and most enjoyable. Additionally, the participants at the intermediate level benefited the most from the narration of the tour (they did not report being lost or confused).

Total of participants who answered the question: 23	
The narration of the teacher/guide	30%
The recorded narration referred to the texts	17%
The virtual environment	53%
The theme	0

Table 13. The number of times each characteristic of the VR tour received the highest appreciation regarding favouring learning.

3.8 Analysis of the results

Based on Mayer's theory (2001), it is possible to conjecture that the diversified input, in the way of texts, audio files, images, and narration contributed to the correct inference of the target-words meanings. Besides, the informational redundancy highlighted these words and made the establishment of many connections and relations possible between the different types of information, promoting their retention in memory. Mayer (2001), in the same direction, had pointed out that learning is more likely to happen when there is a well-implemented combination of different modalities of the same information. Another aspect that might have aided participants in their correct inferences is, according to Schumann (1997), the motivation to learn and remain immersed in the environment, which, in the case of this study, could have been fostered by the attractive (novel) learning environment and the intrinsic pleasantness that came from trying the medium for the first time.

In the qualitative questionnaire, novelty and pleasantness were directly and indirectly mentioned in most of the answers that evaluated the experience as a contributor to learning. The quantitative results reveal that all the participants learned new vocabulary. Some of them (12%) had 100% achievement in learning all the 17 target-words, being the elementary level the one that benefited most from the experience in terms of learning.

During the execution of the study, author one made notes in a class diary as she observed some relevant aspects of the experience that were not addressed

formally in the questionnaires but were rather a consequence of the interaction with the participants before and after the study, as well as from just looking at how they reacted to the virtual tour. The following summarises these observations: 1) Students from lower proficiency levels seemed to have benefited more from the explicit approach to vocabulary teaching, for example, when the teacher during narration highlights the fact that the word bedridden was made out of two words, and one of them they probably knew (bed/ridden). 2) Although most of the participants reported physical discomfort during the experience, none of them abandoned it, as it was recommended on the slideshow presented before the tour started. It may be the case that motivation played an influential role during the activity, which could also be inferred by the fact that all the participants remained focused on the tour, most of the time. 3) One participant said: "I forget that I am not in the real [world]", and such statement could be applied to others too, given their frequent gesture of reaching the hands in the air as if they could grab something that was appearing before them in the virtual environment (this affirmative is based on author's one observations during the experiment). 4) The fact that the teacher's narration occurred during the time the participants were wearing the headset led to the many occasions when the participants felt the need to take the headset off to pay attention to what was said. In this way, there were interruptions in the way attention was given to the virtual environment. 5) Some students suggested that virtual reality, applied to English learning, should be directed towards practical situations of daily life. 6) Because of the novelty of the medium, some participants spent much time trying to configure the device and the application properly so the smartphone would be centred in the headset. There were also occasional problems with the sound, due to misconfiguration of the audio settings within the application. Every time there was a technical issue, participants would get frustrated and lose track of what was being seen/heard during the tour. 7) Physical discomfort, such as nausea and headache/eye soreness, was reported only on day 1 of the experience. Some students said they had gotten "used to" the device and no longer felt the symptoms of the first contact with it. 8) Although it would not be possible to have the participants standing during the experience, due to the limited space of the classroom, the chairs and desks seemed to limit the participants' moves to explore the VR scenes fully.

FINAL CONSIDERATIONS

The use of virtual reality in the classroom has been contemplating mainly the field of hard sciences and History, with still only a few studies in Applied Linguistics. As this study shows, language learning, however, has a lot to gain if affect is exploited at the stimuli level, i.e., at the planning and delivery of didactic content.

The objective of this study was to explore the potential of VR for foreign language vocabulary teaching and learning considering mainly the appraisal mechanisms novelty and pleasantness proposed by Schumann (1999). Besides, the content of the vocabulary lesson was also implemented according to the applicable principles of multimedia learning (MAYER, 2001). The question whether VR contributes to the learning of foreign vocabulary learning has been answered, in this study, positively. All levels of proficiency showed a gain in learning (43%), although participants at the elementary level had a significantly better gain (52%) than the other two, pre-intermediate and intermediate. We assume this was due to the fact that students of lower language proficiency levels would engage more with extralinguistic cues and multimodal resources to infer meaning of unknown words.

Moreover, the pedagogical consequences of exploring VR as a vocabulary learning tool has also to do with learner's engagement in the activity, considering that the great majority of the participants reported feeling immersed in the environment. Another positive consequence of this type of lesson was to benefit the learning styles of most participants, which include the use of the visual and auditory senses, the dynamic rhythm of the tour guidance, and the enrichment of contextual information.

Regarding the limitations of the study, there are many issues to overcome, such as access to technology in the classrooms, stable and fast internet connection in schools, media literacy for teachers, and the development of theories and methods to support investigation and practices involving VR for foreign language learning. Nonetheless, low-cost devices such as the Google Cardboard™, together with applications such as Google Expeditions or even 360° YouTube videos, can provide ready-made narratives to be discussed among teachers and students for various purposes, for example, to promote oral discussions in the target language and vocabulary teaching in context.

Taking this study into consideration, the difficulties of the technical side relied on the functioning of the device during the entire time of the tour. Sometimes, due probably to the most basic configuration of the smartphones and/or the Wi-Fi connection provided by the university, the images of the tour were not displayed

properly, i.e., they would remain static or take very long to render. In addition, some participants reported no access to the audio files, although all earphones had been testing and were working properly before the sections. At times, two participants had to share one headset while one of their phones had to be reset. All these technical faults led to interruptions and frustration, although none of the participants manifested disinterest or abandoned the activity.

Despite the challenges faced during the execution of the study, we tend to believe that VR vocabulary lessons have great potential to engage students in the activity, enhancing their motivation, through the intrinsic pleasure from trying a new form of media, and learning, as a consequence of motivation and the way the lesson appealed to the learners styles and preferences. The results of the evaluation questionnaire and the classroom observations suggested the need for a refined design of the virtual tour and a different choice of a VR device so physical discomfort ceases to be an issue. Attention shifts between the virtual environment and the classroom can also be avoided if most of the guiding is inserted within the virtual tour, using a virtual agent (e.g. an animated character).

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