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Immersion, interaction, and experience-oriented learning: Bringing virtual reality into FL learning

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Introduction

Virtual reality (VR) is not only attracting the attention of the information and computer technology (ICT) industry (Shirer & Torchia, 2017), especially in the production of consumer VR hardware, but also that of educators. Three years in a row, the Horizon Reports of 2016, 2017, and 2018 have mentioned that VR, or mixed reality, is one of the most important technologies that will be generally adopted in education in the very near future (Adams Becker, Freeman, Giesinger Hall, Cummins, & Yuhnke, 2016; Freeman, Adams Becker, Cummins, Davis, & Hall Giesinger, 2017; Adams Becker et al., 2018). Furthermore, mixing VR with physical environments allows the learners' spaces to be redesigned and expanded (Adams Becker et al., 2018). The online Cambridge Dictionary defines VR as "a set of images and sounds, produced by a computer, that seem to represent a place or a situation that a person can take part in." Such an environment can be either authentic or imaginative.

One of the important features of VR is immersion, which enhances the situated experience of users. The sensation of being there no longer necessitates a physical presence (Flower, 2015). This aspect allows second language (L2) and foreign language (FL) learners to combine learning an additional language with an intercultural experience beyond geographical limitations with no need to step out of the classroom or leave their home countries (Wang, Petrina, & Feng, 2017). Another important feature supported by VR applications is interaction, which provides users with a special channel of interpersonal communication (Ip et al., 2016). Given the importance of situated and contextual learning to FL learning, the specific features of VR of immersion and interaction are also of great interest to language educators.

While most of the VR literature related to language learning refers to virtual worlds (VWs) and virtual environments (VEs) (Lin & Lan, 2015), the popularity of low-cost VR hardware (e.g., Google Cardboard) has led to VR entering the traditional classroom (Heathman, 2016). Advances in VR hardware undoubtedly not only provide users with new experiences of immersion and the sense of appearance (Schott & Marshall, 2018), but are also inspiring more pilot trial on the use of VR hardware in FL education (e.g., Y. L. Chen, 2016; Cheng, Yang, Andersen, 2017; Keighrey, Flynn, Murray, & Murray, 2017).

This article reviews previous studies of the application of VR for FL learning, introduces the present-day advanced developments in VR technology that have considerable potential for FL learning, and describes the research trends of VR in this area.

VR For Language Learning: Matching the Features of VR with Second Language Acquisition (SLA)

VR can be classified based on the different perspectives adopted, with a very common classification being immersive versus non-immersive (Robertson, Card, and Mackinlay, 1993). Immersive VR emphasizes spatial immersion (Howard-Jones, Ott, van Leeuwen, & De Smedt, 2014), with a restricted meaning of being there in the task environment from the first-person view. This can be implemented by wearing a VR headset, which is a device like a thick pair of goggles that go over your eyes. Being immersed in such an environment makes the experience more realistic while lessening the awareness of time and being detached

from the real world (Jennett et al., 2008). In contrast to immersive VR, non-immersive or desktop VR involves users in a 3D environment that can be directly controlled by using a mouse, a keyboard, and a monitor. Since such an environment does not involve wearing a VR headset, the users usually explore the worlds from a third-person view via their avatars, although some non-immersive VR platform can allow the user to change the view to a first-person view by a mouse operation.

Papagiannidis, Bourlakis, and Li (2008) investigated VR worlds based on the function of being either game-based or socially based. VR-based games such as World of Warcraft (WoW) and Half-Life 2 have entertainment as their main purpose, and usually set a theme and goals and encourage multiple or single players to play in a free style. The players control the game in the VR world. In contrast, socially based VR such as Second Life and vTime provides the users with a world that allows social connections (Lan, Kan, Sung, & Chang, 2016). By logging into socially based VR worlds with their avatars, users are able to build social connections with others without the usual physical restrictions of the real world.

A perspective of VR that has been utilized for second-language acquisition (SLA) serves as the foundation of interpretation in this article. As mentioned in the Introduction, the existing VR-related literature about FL learning comprises a combination of research, most involving non-immersive, avatar-based VWs or VEs, and with the emerging use of immersive VR headsets. Therefore, in this article VR does not necessarily refer to the research of VR involving the use of a headset and motion-capture technology for FL learning. Instead of strictly differentiating immersive from non-immersive or game-based from socially based VR, the three essential components for FL learning (Lan, 2014)—immersion and active learner participation, social interaction, and authenticity—are adopted as indices to analyze the features of VR and how they are relevant to language learning. Figure 1 shows how the essential components of successful language learning could be satisfied by mediating the three specific characteristics of VR through learner-centered language activities.

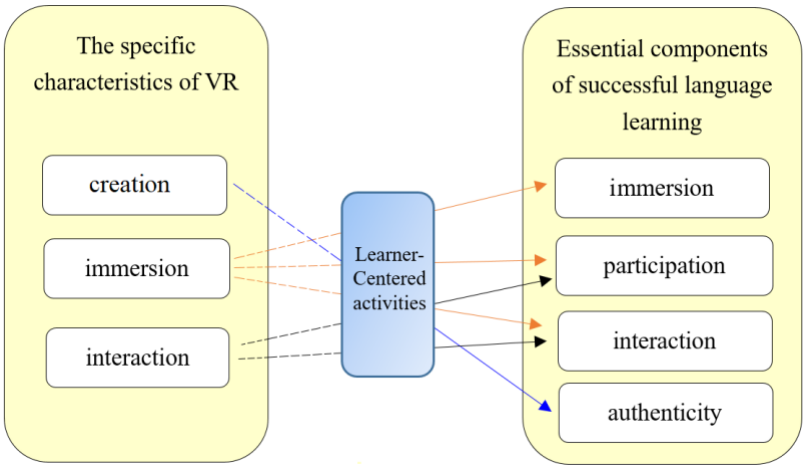

Figure 1. Matching the essential components of successful language learning to the specific characteristics of VR.

VR provides a world in which imagination can be realized. Contexts can be created that either exist or do not exist in the real world. 3D modeling software can be used to create 3D objects and scenes, either real (e.g., the Great Wall, ancient Egypt, or an airplane) or fictional (e.g., a monster, a fairy, or Atlantis). Additionally, a 360° video can be easily created nowadays by using a commercially available 360° 3D camera and shared in VR. This means that VR technology can also satisfy authenticity requirements. The provision of an authentic context will allow FL learners to immerse themselves in the created contexts by using their avatars or by simply wearing 3D glasses, and then explore the contexts. They can also interact with the objects and other learners in the contexts. As described in Lan, Kan, Hsiao, Yang, & Chang (2013), three kinds of interaction can be implemented in VR: avatar–object, avatar–avatar (both text and voice based), and avatar–object–avatar. However, the expected learning effects cannot be guaranteed by simply

supplying FL learners with a VR world. The arrows on the dotted and solid lines in Figure 1 show the left and right hand sides of the learner-centered activities, respectively. This means that although the three characteristics of VR have the potential to facilitate the essential components of successful language learning, the expected learning outcomes cannot be guaranteed if no appropriate learning activities are provided as mediators (Lan, 2016).

A learner-centered activity is rooted in constructivist learning theory and aims to deepen learning by engaging learners in a powerful learning environment that helps them to connect what they learn in the classroom with the real world (Baeten, Kyndt, Struyven, & Dochy, 2010). Different approaches are viewed as learner-centered activities, such as collaborative or cooperative learning, problem-based learning, discovery learning, project-based learning, and task-based learning. Teachers act not as knowledge providers but as learning facilitators in learner-centered activities (Bhattacharjee, 2015) by organizing activities that assist learners in developing new insights and to connect them with their previous learning. Involving learners in the process of asking their own questions, carrying out their own experiments, refining their hypotheses based on meaningful feedback provided by teachers or the learning environments, and finally reaching their own conclusions will motivate the learners and enable them to cultivate new skills that they can then apply in real life. If VR does not involve the above-mentioned activities, it simply becomes just another new fancy technology that can easily lose support from teachers and the interest of students as its novelty fades.

While VR is a new trend of advanced technology for many educators and schools (Chun, Kern, & Smith, 2016), the absence of sufficient infrastructure support and training in classroom management and activity design will result in tremendous challenges when implementing VR in school learning (Castaneda, Cechony, Bautista, & Pacampara, 2017). Moreover, negative effects may happen and the learning benefit might not be realized (Castaneda et al., 2017; Castaneda & Pacampara, 2016; Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014).

VR for Language Education

VR has been attracting the attention of FL educators and researchers for nearly 20 years, especially following the increasing popularity of socially based VR. With support from the perspective of sociocultural SLA, numerous researchers have investigated involving FL learners in immersive and social VR environments with the aim of promoting their linguistic skills and cross-cultural awareness (Lin & Lan, 2015). The increasing popularity of affordable VR equipment, such as Google Cardboard, that utilizes user cell phones has made integrating VR into daily educational settings more achievable compared to several years ago when the Oculus Rift VR headset was first commercially released (BBC News, 2012). Meanwhile, learning by experiencing, doing, or creating is now one of the most important trends in education, and has been associated with dramatic increases in the numbers of teachers and researchers trying to enhance student learning by including VR in their teaching (Heathman, 2016; Reisoğlu, Topu, Yılmaz, Yilmaz, & Göktaş, 2017). The various VR applications for language education can be roughly classified into five categories based on different pedagogical purposes: visual experiences, entertainment, social networking, operation, and creation. These five VR categories are described below.

VR for Visual Experiences

A VR system allows users to visit places that they cannot visit physically in the real world, such as outer space, the deep sea, the inside of a volcano, or the first Olympic game. Using VR for field trips is a very common application (Blyth, 2018). For example, teachers can integrate Discovery VR or Google Expeditions into classroom learning. Discovery VR provides teachers with 360° real-world video to involve students in a new style of learning, allowing them to virtually visit amazing places such as the Arctic and Antarctic poles or witness the day that an asteroid struck. They can also observe elephants swimming and whale sharks up close. Students can not only visit natural places, but also historical locations such as the Anne Frank house. Students can also experience ancient life, such as in Roman times. TheBlu is another deeply immersive VR series that simulates being underwater and allows users to experience and come face

to face with some of the most awe-inspiring sea creatures.

In such a VR-integrated classroom, students can be involved in activities that go beyond print-based reading and writing and help them develop language skills—such as reading, writing, and communicating—mediated by technology. For example, Lan, Lyu, and Chin (2019) created several virtual contexts in Second Life, including a zoo and two restaurants (western and Chinese), to help students of Chinese as a second language (CSL) in Singapore to improve their Chinese essay writing. Grant (2010) owned a Chinese Island in Second Life, and his students of Chinese as a foreign language (CFL) were able to experience Chinese culture in VWs, including a Chinese tea ceremony, Tomb Sweeping Day, and making Chinese dumplings. Hutchison (2018) used VR in an integrated science and literacy lesson to engage students in discovering, answering, and writing questions they developed during their exploration in a VE. Legault, Fang, Lan, and Li (2019) investigated how L2 learning in context changes the function and structure of the learner's brain.

The increasing popularity of VR is also increasing the availability of free VR applications. Some large-scale pilot VR applications have been used in education to determine the effects of integrating VR into daily school learning on student learning. For example, Google intended to bring VR to one million UK school children (Heathman, 2016), while Foundry 10 was a large-scale VR project involving more than 1,500 middle-school and high-school students conducted in the USA and Canada during 2016 and 2017 (Castaneda et al., 2017). These large-scale pilot applications have revealed that not all VR applications or contexts can be easily integrated in current teaching curricula. Although VR allows students in the classroom to virtually observe events, places, and stories from a new perspective that they did not have previously, without appropriate learning tasks, the expected learning outcomes cannot be guaranteed. The survey of Foundry 10 by Castaneda et al. (2017) revealed that appropriate VR contents are still the main concern of teachers. Learning tasks therefore need to be well designed in order to enhance the effects of VR immersion on learning improvements among students.

VR for Entertainment

VR games—regardless of whether or not they use a headset or motion-capture technology—are the mainstream application of the VR industry. Immersive games, especially massively multiplayer online role-playing games (MMORPGs), are the most widely discussed application of VR for entertainment (Hung, Yang, Hwang, Chu, & Wang 2018), such as WoW, the most popular MMORPG by player count (Godwin-Jones, 2014). Usually a storyline is embedded in this kind of VR application, and players can choose their avatars and play with other players in the games. During the gaming process, players may lose their lives or points by making mistakes or wrong decisions, or strengthen their position by conquering challenges, defeating enemies, and reaching the game goals, such as by fighting aliens (e.g., Rick and Morty VR) and participating in rescue missions (e.g., Edge of Nowhere). For example, Star Trek Online is based on the popular Star Trek series, and it can be freely downloaded and installed on a PC. Players can choose their characters from among three canonical races with different inherent blends of racial traits: Federation, Klingon, and Romulan. Players not only have the opportunity to customize their own unique species, but also obtain skills to assist them with their missions.

Digital game-based language learning (DGBLL) refers to the use of digital games as a medium for language learning aiming at either enhancing learning outcomes or improving learning motivation. MMORPGs such as WoW that place learners in a real-time, in-game, and co-problem solving context, can potentially provide them with extramural communities of practice in their target languages (Hung et al., 2018; Zheng, Newgarden, & Young, 2012). Teamwork is usually encouraged, and social interaction occurs when players immerse themselves in the game contexts and pursue their goals with other team members. Zheng, et al. (2012) argued that providing such a communication-rich environment enables FL learners to participate in an intercultural, technology-mediated FL network.

While many DGBLL studies related to FL have found positive learning outcomes, the investigated games have usually been custom-made (Hung et al., 2018). For example, Lan, Hsiao, and Shih (2018) designed language games for use in Second Life to assist four special-education children to learn their first language

(L1), Mandarin. Those authors found that immersing special-education children in such authentic and gamified learning contexts produced unexpectedly large improvements after only 16 hours of learning (2 hours per week). In contrast, such large effects on language learning are not guaranteed when applying commercial, off-the-shelf digital games such as WoW, with the outcomes depending more on the group dynamics and shared interests in terms of the willingness to use the target language during the gaming process (Vosburg, 2017). This is due to entertainment rather than FL learning being the main design purpose of this kind of VR application (Lan, 2016). Moreover, the players' toxic behaviors and conversation, especially insults and taunts were found (de Mesquita Neto & Becker, 2018). These discordant opinions on the use of VR games for FL learning indicate the need for further research to obtain more insight into applying entertainment-based VR to language education.

VR for Social Networking

Real-life-like interaction is one of the main features of VR that is attracting the attention of language researchers and educators. According to the perspective of sociocultural SLA, social interactions among FL learners enhance their learning outcomes. Immersing learners in social VR allows them to not only explore the environment, but also make friends in different areas around the world. Additionally, the use of avatars frees the learners from the physical constraints of the real world. In addition to text or oral interaction as a general method of computer-mediated communication (CMC), the contexts included in social VR make the interactions more authentic. Moreover, in addition to enabling conversations in a virtual location such as a coffee shop (e.g., vTime), social VR also allows users to do more things with others via their avatars, such as participating in sport (e.g., Rec Room), playing games (e.g., capture the flag in VRChat), and exploring unknown environments (e.g., Second Life).

Social VR has been revolutionizing online interactions (Metz, 2017), and numerous CMC-related studies have adopted social VR as the facilitating platform. Similar to the studies of CMC implemented in a general online platform, several psychological constructs, such as autonomy (Yeh & Lan, 2018) and anxiety (Melchor-Couto, 2016), and linguistic skills, such as oral interaction, have been investigated in social VR. For example, Tang, Sung, and Chang (2016) explored how a CFL community was formed and the transformation in the role of the participants from being peripheral to central practitioners along the interaction process. Similarly, Liang (2012) investigated how students of English as a foreign language (EFL) interacted with international speakers of English. Moustafa and Steed (2018) investigated social interactions in a small group of 17 adults with a mean age of 30.4 years over a 4-week period. It was found that various emotional states encountered in real-world, face-to-face interactions, such as love, shame, and fear, can also be experienced in VR. Furthermore, the participants expressed that they could have more social interactions in VR than on Skype.

In addition to the free-style interpersonal interactions mentioned above, teacher-guided, student-centered language tasks are another commonly used learning approach in social VR. For example, Lan et al. (2016) compared the effects of carrying out different tasks in Second Life on the oral performance of CSL students, while J. C. Chen (2016) examined the patterns of communication strategies of nine EFL adults during task-based interactions in Second Life.

Although watching 360° VR videos allows for a rather passive interaction with human beings, if compared with the opportunities for active interaction that using avatars in virtual reality can provide, it is still likely to inspire inter-personal interaction with task-based activities to enhance FL or cross-cultural learning. For example, although students are not involved in real interpersonal interactions while learning the story of Amisa, a child affected by malaria in the Nyarugusu Refugee Camp in Tanzania, by watching the VR video entitled *Under the Net*, or while watching the story of *Henry*, a cute hedgehog who is determined to make a friend, their emotional responses were still elicited (Scanlon & Castaneda, 2018). In addition, Castaneda, et al. (2017) mentioned in a report on Foundry 10 that teachers can use VR in the classroom to engage students with real people. One activity involved students contacting actual refugees in addition to viewing a refugee in VR. Those authors found this to be a good approach to helping students better understand a

variety of different people.

FL researchers and educators also need to consider that most of the literature relevant to the use of social VR for language learning relates to non-immersive VR, especially Second Life. The study of Liaw (2018) is one of the few that used immersive VR as the platform for FL learning. VirtualSpeech and vTime were used for improving EFL oral language skills and intercultural learning of Taiwanese college students. Compared with using the Web 2.0 tool Voice Thread, using VR tools was found to be more interactive and facilitated engagement in practicing language tasks. The increasing popularity of immersive VR means that better evidence is needed from research into immersive social VR for language learning in order to improve the understanding of the effects of immersion in social VR on FL learning.

VR for Operation

This kind of VRs emphasizes the hands-on experiences that users can have when interacting with VR objects. It includes two kinds of operation: manipulation and simulation.

Manipulation

In manipulation VR, learners can manipulate a VR object that they might not be able to in the real world, such as practicing flying a helicopter or manipulating and observing a priceless treasure, such as the Jadeite Cabbage. Learning FL vocabulary and sentence patterns are the most common applications of manipulation-based VR. For example, Taiwanese students have logged into Second Life to learn English words by clicking the objects and hearing their English names as well as to learn English sentences by interacting with nonplayer characters (Lan, 2015; Lan, Hsiao, Fang, & Chen, 2018). Students at Penn State University have learned Mandarin words by interacting with the objects in different contexts in Second Life (Lan, Fang, Legault, & Li, 2015).

Madini and Alshaikhi (2017) confirmed the effects of interacting with virtual objects while watching 360° videos on the acquisition of English-for-specific-purposes vocabulary of postgraduate students. Vázquez, Xia, Aikawa, and Maes (2018) further compared vocabulary learning in three modes: Virtual kinesthetic, virtual non-kinesthetic, and text-based. They found that the vocabulary retention rates after a week of exposure were better in virtual kinesthetic learners than in those who learned via other modes, although the superior results were not confirmed in an immediate post-test. Mohsen (2016) compared the effects of EFL vocabulary learning by 43 Arab adult learners in two modes: Dragging various virtual-surgery devices during a knee surgery simulation and watching a YouTube video of the surgery. The results showed that learning in the former way was better than the latter.

Simulation

In simulation VR, the learners become involved in an imitation of how a real-world process or system works, such as learning about a stock market, being in a courtroom, or rehearsing for an oral presentation or job interview. One decade ago it was found that more than 150 educational institutions were present in Second Life (Jennings & Collins, 2008). For example, Harvard Law School offered a course called CyberOne in Second Life that allowed students to receive real college credits (Lamb, 2006). The participating students were not limited to those enrolled at Harvard University; instead anyone from around the world with an Internet connection and interested in the course could also join for free. They could access the course and also participate in a mock trial courtroom in Second Life.

Given that anxiety has always been an affective filter (negative emotion) of FL learning (Maclntyre & Vincze, 2017), involving students in a safe affective context can lower their anxiety and consequently improve their performance. By immersing themselves and taking actions in simulation VR, learners are able to obtain target skills, such as those required for a job interview, while being subject to a lower affective pressure associated with making mistakes (Hu-Au & Lee, 2017; Smith et al., 2014). This has resulted in simulation VR being used to enhance various competencies, such as vocabulary, speech, cross-cultural understanding, and language teaching. Franciosi, Yagi, Tomoshige, and Ye (2016) used simulation VR for vocabulary learning to investigate how learning using a simulation game called 3D Word Farmer helped

213 EFL learners at a Japanese university learn English words. Their findings confirmed that involving learners in a farming simulation game allowed them to memorize the words for much longer compared to those who did not have that experience.

Cultural learning is another important issue in FL instruction. Cheng et al. (2017) used a VR game to teach learners of Japanese culture how to bow during a Japanese greeting. Sheridan et al. (2018) developed a virtual game for training a military audience, in which cross-cultural competency was obtained by involvement in a simulation of a collaboration between the US Army and the Chinese People's Liberation Army.

In addition to FL learning in personal contexts, giving a public talk or presentation in a FL or attending an interview are activities that make FL learners very anxious (Azevedo et al., 2017). Stupar-Rutenfrans, Ketelaars, and van Gisbergen (2017) found that practicing public speaking in 360° live recorded VR environments with audiences significantly decreased the speaking anxiety of students. Tandy, Vernon, and Lynch (2017) used Second Life to produce a chatbot called Jenny, which is a prototype standardized client avatar that is programmed to run automatically. Those authors found that the students enjoyed the experience of talking with Jenny, and it helped them to learn about the factors that could result in a successful or unsuccessful interview.

In addition to considering FL learners as the target audience, the training of language teachers is also an important issue that is worthy of research attention. For example, Lan et al. (2013) investigated the teaching behaviors of two CFL teachers in Second Life, and identified different types of interaction in the VW. Similarly, Tseng, Tsai, and Chao (2013) examined the perceptions of student teachers about using Second Life as a CFL teaching platform.

VR for Creation

VR creation tools, such as Omni-Immersion Vision (OIV), Minecraft Realms, Tilt brush, Google Blocks, and Tinkercad, exist to help users create their own VR objects or contexts. After these items have been created, they can be shared with others by uploading them to the cloud (e.g., Google Blocks) or printing them in 3D (e.g., Tinkercad). Some VR software even allows creators to participate in role-playing and interpersonal social interactions in the contexts that they have created (e.g., OIV and Minecraft Realms).

While numerous VR applications are used in education nowadays, user-created virtual content is still necessary to satisfy the wide variety of learning needs and situations (Castaneda et al., 2017). Moreover, students involved in a collaborative VR creation process will engage in critical thinking, collaboration, problem-solving, and self-directed learning (Grover, Pea, & Cooper, 2015), which will consequently enhance their learning autonomy and ownership (Yeh & Lan, 2018). As mentioned in the Horizon Report of 2017 (Castaneda et al., 2017), this approach can deepen learning by students and help them to make clear connections between what they learn and the real world. Given the ample opportunities for interpersonal interactions during the creation process, FL learning outcomes can also be enhanced.

Yeh and Lan (2018) integrated a 3D authoring tool called Build & Show (the previous version of OIV) into EFL learning in an elementary school in a rural area of northern Taiwan, and found that the collaborative creation of authentic contexts for their daily English class significantly enhanced the learning autonomy of the students. Yeh, Lan, and Lin (2018) similarly found that elementary-school students enjoyed using Build & Show to create their own virtual airport and write stories based at that location. They then acted out the stories by role-playing and making videos to share with others. Yeh et al. were also surprised by the creativity of the students in integrating their daily living experiences, current events happening in society, and imagination into their stories. A particularly interesting finding of that study was of gender differences in the outcomes.

Minecraft is a 3D authoring tool that also allows users to create their own virtual contexts and share them with others. Interpersonal interaction is supported in Minecraft (Minecraft Realms), but this is only text based, although a text-to-speech engine is used to automatically read out chat messages. The ease of using

Minecraft has resulted in its widespread application in education (e.g., Gallagher, 2015). Kervin (2016) observed the literacy development of 16 children (ages three to 10 years) from six families when they played using five digital applications, including Minecraft. Reciprocal learning was identified during the playing process. It was found that the children shared their understanding of the scenarios they set for each other by using actions, and the vocabulary and phrases associated with the construction tools they used.

Despite the positive effects of using VR creation in FL learning found in many studies, the current lack of usage rules should be taken into account when involving students. Well-designed language learning tasks should therefore be developed to guide the learning process (Scholz, 2015). For example, Craft (2016) successfully integrated Minecraft into his Latin classes by using cooperative tasks to help students improve their understanding of Roman architecture. Similarly, Roman and Racek (2018) used Google Blocks in a cross-disciplinary course on design for social impact, with the aim of addressing learner needs and the cultural aims of an authentic client-based project. In that study, a university initiative aiming to improve and enrich the health, prosperity, and vitality of nearby communities was the goal of designing and constructing 3D models. Although the participating students constructed the 3D models individually, they shared their works in front of the client and peers.

In short, there are many different ways in which VR can be utilized in FL education. Additionally, some VR applications can be used for different purposes. For example, social connection and simulation can be implemented in Second Life, while OIV facilitates creation and social connection, and Minecraft provides creation ability and entertainment simultaneously. It is obvious that an innovative instruction design is one of the main factors required for successful VR applications in FL education.

New Research Trends into VR for Language Learning

VR is one of the advanced reality technologies that will make it possible to redesign the learning spaces available for education applications over the next few years (Adams Becker et al., 2018). The immersion provided by VR will release learning from the physical classroom barriers to reach new possibilities without limitations of space, location, time, and physical disabilities. As mentioned above, many experiences that have been difficult or impossible for learners to have, such as visiting Mars or practicing a public speech in front of a group of people many times without embarrassment, can now be simulated in a VR world.

The huge potential benefits to FL learners from learning that is facilitated using VR mean that more studies of the possibilities and challenges of VR for FL education need to be conducted. Some suggestions for future research into virtual language learning and teaching are provided below.

Large-Scale and Empirical Research

Based on results in the literature including the reports in review papers (Lin & Lan, 2015; Reisoğlu et al., 2017), investigations of the use of VR for language learning have been insufficient. The review of Reisoğlu et al. (2017) reported that only 27 out of 167 studies on VR were relevant to language learning. Furthermore, the sample sizes have usually been small (<100), and the effect sizes were not reported for most of the reported studies (Wang, Lan, Tseng, Lin, & Kao, 2019). This means that only descriptive results are available for reviewing, and the extent to which VR could be empirically beneficial to FL learning remains unclear. In order to more clearly understand how VR can contribute to FL learning, large-scale studies of language learning that provide systematic empirical data and analyze learning outcomes and processes are essential.

Diverse categories of FL learners

Reisoğlu et al. (2017) also reported that most of the participants of VR studies have been university students. Since VR users in recent years have included students spanning K–12 to college level (e.g., Castaneda et al., 2017; Freeman et al., 2017), participants of different age levels need to be included in future studies. In addition to expanding the age ranges of included FL learners, differences in individual characteristics should also be taken into account, such in learning styles (e.g., field dependent versus independent), ability

levels (high versus low achievement), and motivation levels.

The use of VR for language learning and development by special-education students is also a very important research topic that deserves more attention. VR has already been used to enhance the learning of special-education children, including their social and language skills (Ke et al., 2015; O'Sullivan, Robb, Howell, Marshall, & Goodman, 2017; Parsons, 2016). Using VR with special-education students requires extra attention to the design of learning contexts, especially the human–computer interface (Lan et al., 2018). Experts from special education and VR programming should work closely to develop VR applications that are well suited to special-education students with different disabilities.

Student-Centered Learning Focusing on Creation, Cooperation and Collaboration, and Social Interaction

VR and different learning approaches can be integrated into different stages of instruction to enhance FL learning. For example, VR exploration can be used at the preview stage of a flipped learning approach, while VR creation can be used in cooperative-task projects to deepen the learning by students (Roman & Racek, 2018; Yeh & Lan, 2018). Moreover, further investigations are required into how to implement well-known learning approaches, such as scaffolding, self-regulation, and peer reciprocity, as well as how common issues of concern to FL researchers and educators (see the investigation structure of FL research in Lan, 2009) can be embedded in VR language learning to produce the most satisfactory outcomes. In short, the effects of the above-mentioned approaches on FL learning need to be carefully evaluated to provide FL educators and researchers with informed and reliable suggestions.

Teacher Training and New Methods for Evaluating Learning Outcomes

Classroom management is always an important factor for the successful integration of ICT in daily teaching. The adoption of VR in learning not only involves in the facets of technology and curricula, but also health and psychology (Castaneda et al., 2017). Regarding the technology and curricula, teachers have to be familiar with the available VR resources, including the application software and the devices on which it is implement; while many challenges have to be dealt with to address health and psychology, such as students being anxious about using new technology, too excited to focus on learning, or feeling dizzy when watching 3D videos or being immersed in VWs.

A major problem often encountered is an insufficient number of physical devices for use with VR, which means that teachers need wisdom and experience when organizing the learning activities. In short, they need to address the 5W-H questions (who, what, when, where, why, and how) when planning to introduce VR into their teaching. Teachers also need to consider whether their role in VR language learning will be as a learning agent, facilitator, or supervisor. This question is followed by another one: How to evaluate learning outcomes when VR is introduced in education, since traditional pencil-and-paper tests are definitely inadequate. How to embed assessments in the VR environment (Lan et al., 2018) and provide FL learners with appropriate feedback (including text-based and verbal) are also major challenges. New assessment technology and methods have to be considered, such as data visualization (e.g., Hsiao, Lan, Kao, & Li, 2017) and learning-process analysis (e.g., Jong & Shang, 2015).

Conclusion

New technology is always emerging, but the rate of advancement of technology has increased markedly in the digital age. VR is becoming a new favorite of both researchers and educators due to its ability to provide hands-on and being there experiences. It is highly worthwhile to investigate how to effectively and efficiently use VR as a learning environment for enhancing the SLA of FL learners. According to Lan (2016), whenever VR is adopted for pedagogical purposes in the field of language learning, the following elements should be considered: Learners, linguistic knowledge and competence, and the process of acquiring the language. FL researchers and educators must focus on providing each individual with precise suggestions and scaffolding during the VR exploration process.

In summary, research directions into the use of VR for FL learning and teaching are still emerging. There is a considerable amount of potential in VR language learning, but more empirical evidence (both positive and negative) is needed to guide its direction in order to fully realize the huge possibilities.

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