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An online collaborative virtual reality environment for promoting listening comprehension

Miguel Angel García Ruiz
Arthur Edwards
Raúl Aquino Santos
College of Telematics
Universidad de Colima

Abstract
Although Virtual Reality (VR) was extensively researched in the 1980s, it was not used in educational settings until the early 1990s. The research and application of VR in language instruction, however, is even more recent, dating back to approximately a decade. Consequently, there is a relative lack of solid research in the area of VR and its possible applications in the area of second language learning.

This chapter provides background research and information in the areas of Computer Assisted Language Learner (CALL), VR, collaborative learning, and second language methodology. It then presents a technical and qualitative description of Realtown, a Collaborative Virtual Reality Environment (CVRE) designed to promote listening comprehension, developed by researchers of the College of Telematics of the Universidad de Colima, Mexico. This chapter also includes a usability study that was applied to improve ease of use of Realtown that was conducted as a preamble to subsequent studies employing collaborative applications of Realtown for listening comprehension. Future work points to longitudinal studies on learning issues and first-person actions and experiences in CVRE.

1. Introduction

Virtual Reality can be defined as a high-end user-computer interface that involves real-time simulation and interactions through multiple senses, including visual, auditory, tactile, smell, and taste (Burdea and Coiffet, 2003). Although VR was first introduced in the 1960s, its initial use was in the area of battlefield simulations and trainers. In the 1980's, although still primarily used by the military, VR technology was adapted by private industry, particularly in the pharmaceutical and oil industries, as well as specific commercial and industrial niches that required simulators.

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Virtual Reality became more widely used in educational settings in the 1990s, with most of the research and development in the in the areas of chemistry and medicine (Youngblut, 1998). The primary focus of much of the research in the early and mid 1990s is related to teaching complex spatial relationships.

The application of VR to second language instruction has been a much more recent development. One of the most important investigations is the Zengo Sayu Project, which is an immersive educational environment for learning Japanese. The Zengo Sayu project researched whether students could learn spoken Japanese using the Zengo Sayu VR system, how the System compared to other teaching methods in terms of learning gain, and whether the Zengo Sayu approach had a positive effect on student motivation and attitude towards learning Japanese. Conclusions from the study, however, were inconclusive (Rose and Billinghurst, 1996). This is possibly because the research pretended to “compare it (Zengo Sayu) to other methods and a comparison of effectiveness in terms of entire teaching methods is perhaps too wide in scope to provide more concrete results.

Today, there is insufficient research in the area of VR and its application in CALL to firmly establish its potential and limitations. Realtown is an online CVRE that provides the context for studying how students interact with and learn from virtual online CVREs. Consequently, the present focus of this work is to present results from a pilot study that was realized in 2005 with regards usability of the CVRE, as usability studies are necessary before actually applying the CVRE to listening comprehension. Realtown was evaluated according to general usability parameters of user satisfaction, ease of use, efficacy and efficiency of the system (Le Peuple and Scane, 2003; Preece et al., 1994).

The rest of the paper is organized as follows: underlying background theory and research in the areas of CALL, virtual reality, collaborative learning and foreign language methodology is discussed in Section 2; Section 3 provides a technical description and the results of a usability study to evaluate Realtown; Section 4 offers a discussion of the present challenges facing VR and some difficulties

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related to the development of Realtown, and finally, section 5 provides conclusions and suggestions for future work.

2. Theory and research

Computer Assisted Language Learning

Computer assisted language learning (CALL) reflects advances in applied linguistics, language learning theory and methodology as it explores the limits and discovers the possibilities computer and communications technologies can play in providing increasingly relevant and effective language learning or acquisition activities or experiences. CALL bridges technology and language learning as it employs programming and hardware, in conjunction with a digital stream of data and information to provide learning experiences in a pedagogically sound and technologically harmonious manner. Consequently, the evolution of CALL directly depends on advancements in the area of computer science as is continually rejuvenated by employing, modifying, or adapting technology.

A simple and direct definition of Computer-Assisted Language Learning (CALL) is “the search for and study of applications of the computer in language teaching and learning.” (Levy, 1997) During the last 4 decades, CALL materials have evolved from very basic text processing, gap-filling tasks and simple programming to interactive multimedia presentations, including sound, animation and full-motion video. (Papert, 1984 in Beatty, 2003). CALL, therefore, to a great degree reflects technological development and is limited by developments in the areas of hardware and software development as it evolves to incorporate new technologies. What is certain, however, is that computer-assisted language learning will continue to develop in the areas of speech production and recognition, as well as intelligent systems and virtual reality (VR). (Chapelle, 2001)

The development of CALL can be divided into three time periods, the 1960s and 1970s, the 1980s, and the 1990s. The 1960s and the 1970s were dominated by applications that were behaviorist and were influenced by the work of Skinner, who published his views on learning in Verbal Behavior (Skinner, 1954). Teaching

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in the 1960s and 1970s was largely based on the Audio-Lingual Method and used technology in language laboratories. Repetition, habit formation and the elimination of errors was the basis of the Audio-Lingual Approach, and computerized teaching materials reflected this perspective, relying often on fill-in-the-blank, matching, multiple choice, and true-false type exercises.

Another important concept of the time was programmed instruction, which significantly contributed to the thinking of that period with respect to learning, in general, and specifically, to language instruction. According to B.F.Skinner, language learning was to be promoted by teaching machines that would individualize instruction and respond to the pace at which a student could more comfortably learn (Larsen-Freeman, 2000). What Skinner was proposing at the time are now known as expert systems, which today, can evaluate user knowledge and provide the corresponding information or activity.

The 1970s saw a revolution with regards to language teaching methodologies, based on the principles of Communicative Language Teaching (CLT). Some of these methods include Community Language Learning (Curran, 1976), Total Physical Response (Asher, 1977), Caleb Gattegno's Silent Way, (Larsen-Freeman 2000), and Krashen and Terrel's Natural Approach (Krashen and Terrel, 1983). These humanistic methods view language learning as a human endeavor that tried to engage the entire person, including emotions and feelings. (Moskowitz, 1978) These methods also propose that language is a collaborative endeavor that, by definition, requires at least two people (transmitter and receptor) who must interact and negotiate meaning, placing more importance on the communicative act than on its form or structure.

During this stage, CALL provided a greater variety of exercises. Whereas in the 1960s and 1970s, exercises tended to be stimulus response with limitless repetition, the 1980s saw the advent of authoring programs that dealt with text manipulation and text construction. This permitted students to use contextual knowledge and form hypotheses in order to solve lexical, grammatical, semantic, or logical problems presented within the activity. This proved to be a great

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advantage as the programs became simpler to use and permitted the common teacher to participate in the edition process (Chapelle, 2001).

Increased computational processing power and speed, as well as algorithms to compact and stream the transfer of information, audio and visual elements characterize the 1990s. Also, new, more versatile and powerful programming tools permitted developers to create new CALL software, affording language learners the opportunity to use VR, Artificial Intelligence (AI), expert systems, voice recognition, and multimedia applications in DVD format to provide students with a greater variety of activities and presentation of content (Levy, 1997).

The most significant development in last decade of the 20th century is the introduction of the Internet, which has provided an almost limitless source of information and learning activities for students. Today, the Internet offers many tools such a chat, e-mail, discussion forums, instant messaging, etc., that can be exploited by educators. These tools, although not created to teach languages *per se*, have proven to be very effective in assisting students learn languages because of the communicative and collaborative value of the interactions they provide (Soloway et al., 2000; Hudson and Bruckman, 2001).

The widespread introduction of the Internet in both educational and domestic settings via the “network of networks” has produced a fusion of computer and communications technology, resulting in an evolution of how educational services can be delivered. (Levy, 1997). This change is characterized, in part, by where the actual information or programming related to the where the learning activity was actually located. The last decade has witnessed a migration of many activities that were on CD-ROMs to more dynamic and collaborative activities located on servers.

Virtual reality

Virtual reality involves relatively new technologies that may have significant applications in the area of CALL. Although different aspects of online collaborative language learning have been studied, its possible application in conjunction with VR represents a relatively new area of investigation.

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Virtual Reality may prove to have a significant role in language instruction in the future.

> "Presently, many researchers and educational practitioners believe that VR offers strong benefits that can support education. For some, VR's ability to facilitate constructivist learning activities is the key issue. Others focus on the potential to provide alternative forms of learning that can support different types of learners, such as visually oriented learners. Still others see the ability for learners, and educators, to collaborate in a virtual class the transcends geographical boundaries as the major benefit." (Youngblut, 1998).

There is also some evidence that VR can contribute to raise interest and motivation in students and effectively support knowledge transfer. This is true, according to Dede et al. (1996) because learning can be settled within an experiential framework. However, more research is needed to explore the practical potential of this tool, and there is little published work on the application of VR in CALL literature.

The first attempt to employ something conceptually similar to VR was in 1962, when Morton Heilig invented the Sensorama Simulator, which, in fact, was the first virtual reality video arcade. The Sensorama Simulator had "three-dimensional (3D) video feedback, which was obtained using a pair of side-by-side 35mm cameras, motion, color, stereo sound, aromas, wind effects (using small fans placed near the user's head), and a seat that vibrated," much like today's luxury recliners (Grigore and Coiffet, 2003).

As a concept, however, VR was not entirely defined until 1965 when Ivan E. Sutherland described the main characteristics of VR (without actually mentioning the term), when he describes the need for a "display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world." (Sutherland, 1965). Although the actual ideas and principles of VR were defined during the subsequent 20 years, the actual term " Virtual Reality" was not coined until 1989 by Jaron Lanier (Burdea and Coiffet, 2003).

From 1965 to the mid 1980s, research and development of what is now known as VR was primarily military-oriented. The Defense Advanced Research Projects Agency (DARPA) realized much of the investigation related of VR applications during this period, because only the United Stated Department of

Defense (USDD), in conjunction with a select number of universities, had the mainframe computers required to do research in this area. Although computational speed and power have permitted a greater number of institutions to study VR, the USDD still undertakes educational research and makes recommendations (Youngblut, 1998).

Today, VR technology comprises a computer-generated graphical 3D space (also called a virtual environment, or virtual world), where users can interact with it using specialized input/output devices. The virtual environment senses the position and orientation of the participants, and they are reflected in the 3D viewpoint or its personification in the environment, called an “avatar”, as shown in Figure 1.

Figure 1. A virtual personification (avatar) of a participant.

Generally speaking, a virtual environment is a graphical representation of the real world in a particular context. The use of those devices for interacting with the virtual environment produces a physiological effect called “immersion,” produced with the participants’ senses. The psychological effect of being immersed in a virtual environment (the perception of actually “being there,” within the virtual environment) is called “presence” (Burdea & Coiffet, 2003; Kalawsky, 2000). Another characteristic of virtual environments is that they can convey tactile (haptic), auditory, or visual information to their respective human sensory channels simultaneously, that is, a multimodal virtual environment (García Ruiz, 2003). According to Dede et al. (1996), both immersion and multimodality in VR are important because students receive different sensory stimuli within a virtual environment, which promotes learning according to stimuli theory and constructionist theory. VR can be classified as semi immersive or fully immersive. The former consists of a desktop computer where the virtual environment is shown

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on the monitor, where the display is generally seen in stereo, and the participant can navigate using a special device or the conventional mouse. Generally, the desktop computer can sense the position and orientation of the participant, which is reflected in the virtual environment (Figure 2). In a fully immersive virtual environment, the participant can interact with the virtual environment with almost all his/her senses using special input-output devices, such as datagloves, a head-mounted display (HMD), headphones, possibly voice recognition, etc. (Figure 3). The degree of immersion and presence varies in both types of systems, although the desktop virtual reality system is enough to produce acceptable immersion for many applications (Robertson et al., 1997), including education.

Figure 2. A semi-immersive (desktop) virtual reality system. Photograph of the authors.

Figure 3. A fully-immersive virtual reality system. Photograph of the authors.

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Virtual reality has been applied in education mainly for training technical skills and to teach abstract or complex concepts, where students use their sensory channels to interact with the virtual learning environment, with the object to support the learning process and to foster competences and abilities (Youngblut, 1998; Su and Loftin, 2001; Dede et al, 1997; Zajtchuk and Satava, 1997).

In addition, VR technology can recreate situations or concepts that can be difficult to present in a real environment (Dede et al., 1997; Sherman and Craig, 2003). For example, in chemistry, students can explore a virtual atomic structure with virtual protons and electrons moving around its core (Byrne,1996). As Winn (1993) explains, scientific information can be presented in a different scale, facilitating comprehension of micro and macroscopic concepts. In relation to this, literature has identified five putative benefits of virtual reality in education:

- Reification. A virtual environment can make concepts more explicit and concrete (Winn, 1993).
- Transduction. A virtual environment can contain information that is not present in one sensory channel (Winn, 1993).
- Scale Manipulation. As (Winn, 1993) discusses, scientific information can be presented in a different scale, facilitating comprehension of micro and macroscopic concepts.
- Intrinsic and Extrinsic Views. A user can observe the virtual environment from many perspectives and angles, thus providing him/her with additional details to better inspect specific problems presented within different contexts (Dede et al., 1997).
- A medium to facilitate student collaboration. A virtual environment can be accessed by multiple students (either from a single or remote locations) via the Internet, where they can employ different communication tools (for instance, text chat and audio conference) to overcome distance barriers. More importantly, students can interact with information-rich virtual environments where they can explore, discuss, and analyze them in collaboration with one another. This is based on the Computer-Supported

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Collaborative Learning (CSCL) paradigm proposed by Silverman (1995), which supports the concept of collaborative virtual reality environments (CVRE), which is further explained in this chapter.

Youngblut (1998) wrote an extensive and important report about the history and the state-of-the-art (at the time the report was written) of the applications of VR technology for teaching and learning of a number of areas of knowledge. In that report, she emphasizes the benefits of learning with VR, together with some drawbacks. However, Youngblut points out that there are no conclusive results on the many projects and applications of VR in education reviewed in her report.

As far as language learning is concerned, VR offers the opportunity for students to immerse themselves in language learning contexts. VR can been defined as a type of technology that comprises a computer-generated graphical space (also called a virtual environment), where users can interact with it using specialized input/output devices. Generally, a virtual environment serves to represents of the real world in a particular context. One of the main features of VR is that it produces a psycho-physiological effect called “immersion”, where its user feels “being there”, inside the virtual environment (Burdea and Coiffet, 2003; Sherman and Craig, 2003). Another characteristic of virtual environments is that they can convey tactile (haptic), auditory, or visual information to their respective human sensory channels at the same time, that is, a multimodal virtual environment (García-Ruiz, 2003). According to Dede et al. (1996), both immersion and multimodality in VR are important for the ability of students to employ different stimuli within a virtual environment, which promotes learning according to stimuli theory and constructionist theory.

Rose and Billinghurst (1996) carried out one of the first applications of virtual reality to second language learning. Zengo Sayu is a virtual environment created for teaching spoken Japanese language (basic nouns, sentence structure, colors and prepositions of place) to children. Although the comparison of this teaching method with conventional ways of Japanese teaching was not statistically significant, the students were able to learn with Zengo Sayu. In addition, they were

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in control of their learning at their own pace, and explored the environment by themselves as active participants. This exploratory application paved the way for future VR applications to foreign language learning.

Milton and Garbi (2000) developed and applied Internet-based virtual environments with virtual representations of a zoo, towns, and a shopping center, for foreign language teaching of primary school students. In the virtual environments, learners collaborated in activities using avatars (graphical personifications of the students) and chat rooms to communicate. The researchers reported that students who participated in activities within the virtual environments were doing it in a "relatively naturalistic way", as in ordering food in a virtual restaurant. It was also noted that the students' communications were unforced.

Collaborative Learning

Communication is a very social and collaborative activity as it involves interaction among two or more participants (with the exception of monologues) who must turn take, negotiate meaning and allow for communication break downs by employing different strategies, including redundancy, discourse markers, etc., Because of its nature, communication shares many aspects with collaborative learning. In fact, collaborative learning depends directly on the communicative process and visa versa as they feed off each other mutually in a complementary relationship.

Some assumptions about collaborative learning include:

- Learning is active and constructive in nature.
- Learning is facilitated by rich contexts.
- Collaborative learning recognizes individual learners.
- Learning is social in nature.

(Smith and MacGregor, 1992).

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According to constructivist psychology, the focus of learning should be on how individuals interact with, and learn from the world that surrounds them. Constructionists view learning as a product of an individual's interaction with the environment in dynamic interaction with their proximal zone. Consequently, learning is a process of constructing knowledge and instructional practices should provide what the learner needs to construct knowledge. It therefore follows that the richer the context in which learning takes place, the more effective it will be (Laurillard, 2002).

Consequently, some recommendations for collaborative learning, focused on collaborative problem solving, which are applicable to online collaborative virtual reality environments include:

- creating leaning environments which are situated, learner-centered, integrated and collaborative;
- honoring the importance of authenticity, ownership and relevance of the learning experience for students in relation to the content to be learned;
- allowing students to be active participants in their learning process;
- fostering critical thinking and problem-solving skills;
- encouraging the exploration and analysis of content from multimple perspectives;
- acknowledging the importance of rich social contexts for learning

(Nelson in Reigeluth, 1999)

A collaborative virtual reality environment (CVRE) is a virtual world where multiple participants interact within it and among themselves. Each participant is represented as an avatar, which is a graphical object or human-like figure. General ways of communicating in a CVRE are: a chat window in real time, voice over IP (VoIP), and gestures made with the avatars (Sherman and Craig, 2003; Churchill, Snowdon and Munro, 2002). CVREs have been applied in educational settings to permit students to be cognitively present in a same virtual environment in order to communicate, share learning experiences, and work collaboratively to solve problems, as well as to better learn and comprehend a particular subject. Jackson,

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Taylor and Winn (1999) reported high levels of motivation and enjoyment of students who collaborated in a CVRE to learn a science phenomenon. In addition, it has been found that CVRE are effective for learning regardless of technical knowledge on communication and operation of VR equipment (Jackson and Fagan, 2000). It also has been reported that using natural voice for communicating in a shared virtual environment greatly enhances peer collaboration and self confidence in students (Jackson, Taylor and Winn, 1999; Jackson and Fagan, 2000). These research projects share the conclusion that further research on the optimization of virtual reality hardware and software and learning strategies in CVREs is necessary.

Insofar as language learning and teaching is concerned, CVREs imply that work should be structured so that there is a positive interdependence among the different participants. In other words, the participants need to work together towards a mutual goal and for mutual benefit and collaborative activities should be structured dynamically so that each individual of the collaborative effort work to their capacity and still require an equal effort from every member of the group. (Kohonen in Nunan, 1992).

Language teaching methodology

The Communicative Approach (CA) outlines most of the principles that guide second language instruction and materials development. Introducing VR into second language instruction or as a collaborative online activity is consistent with several premises of the CA, including:

- Language acquisition is promoted by “authentic language” introduced within a real-world context, and students should be given opportunities to develop strategies for interpreting language as it is actually used by native speakers.
- Communicative interaction (communication with purpose) encourages collaboration among students. It also provides students with the opportunity to work on communicative strategies, including negotiating meaning and

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pragmatics. Language use is based on linguistic functions and each linguistic function can have many different forms.

- Games share certain features in common with real communicative events in that they provide a reason for exchange. They also provide immediate feedback from the listener on whether or not he has successfully comprehended (Larsen-Freeman, 2000)

Although a virtual environment (VE) cannot approximate the real world insofar as language learning is concerned, Realtown can provide users listening experiences that employ "authentic language," such as the following transcript of actual instructions:

"Certainly, go straight down Bush Street until you reach the corner of Bush and Clinton. You'll pass a pharmacy and a hardware store. Then take a left on Clinton Street in front of the hospital. After that go straight on Clinton Street until you see the elementary school on the left, right in front of the park."

Figure XX. Avatar following the preceding instructions

Because Realtown is intended to provide a low-anxiety space for practicing listening comprehension skills, the fact that it is not "real-life" interaction, in fact, is an advantage as its users are not exposed to social or performance variables that can lead to anxiety. (Harris et al., 2002) As far as second language learning is concerned, "it has been shown that anxiety negatively affects performance in the

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second language. In some cases, anxiety provides some of the highest simple correlations of attitudes with achievement." ((MacIntyre and Gardner, 1991 in Ellis, 1994).

Because language is purposeful and collaborative in nature, Realtown not only provides traditional tools such as instant messaging, chat and voice over IP, but provides for gestural communication in the sense that an avatar can be manipulated while another student can observe and comment in real time about it, allowing students to negotiate meaning and employ pragmatics in their interaction, as they attempt to achieve the goal of reaching a specific location.

More specifically, Realtown parallels the pedagogical many of principles of James Asher's Total Physical Response, including:

- Meaning in the target language is often conveyed through actions and carrying out physical activities help activate memory.
- The imperative is an important linguistic device to direct behavior.
- Students can learn through observing actions as well as by performing them.
- Feelings of success and low anxiety facilitate learning
- Students should not be made to memorize fixed routines
- Students must develop flexibility in understanding new language that is presented in chunks, rather than individual words or exact sentences. (Larsen-Freeman, 2000).

Within the Realtown CVRE, students must demonstrate their comprehension by manipulating an avatar in something that is parallel to actually walking through the environment itself. The imperative case is among the first things learned in the case of instructions, permissions and prohibitions. Consequently, Realtown provides a very rich environment for students to act upon what they are instructed to do. Because students can view the avatar's behavior, which they manipulate via the direction arrows on a standard computer keyboard, they become not only actors, but observers. VR activities are perceived by students as being games, and consequently fun. Games serve to lower affective barriers, which decreases anxiety and helps facilitate language learning. (Krashen, 2004; Ariza, 2002).

Because the Realtown VR environment offers close to 30 locations, plus and equal or greater number of objects, and because the students listen to instructions that are provided randomly, students can participate in the activity for hours without listening to a repeated set of instructions, which is important because it provides flexibility by providing many novel language and situational combinations. Finally, because language is presented naturally, or in chunks, students must comprehend language that is contextualized within more extensive discourse and is just slightly above their actual comprehension, providing what Krashen (2004) calls comprehensible input (i + 1). According to Krashen (2004) "a strong affective filter (e.g. high anxiety) will prevent comprehensible input from reaching those parts of the brain that do language acquisition."

Realtown, therefore, has been designed to present language and provide a language learning environment consistent with many of the most fundamental second language methodological principles of the Communicative Approach, which is presently the principal methodological second language teaching approach, as well as many basic principles of Curran's Community Language Learning, Caleb Gattegno's Silent Way, (Larsen-Freeman 2000), and Krashen and Terrel's Natural Approach (Krashen and Terrel, 1983), although the most applicable in the case of Realtown, is Total Physical Response (Asher, 1977; Larsen-Freeman 2000).

3. The Realtown research project

Based on the theories and research reviewed in this paper, a CVRE is being developed under software engineering techniques, following the prototyping software development method (McConnell, 1996), which is designed to minimize errors and promote good software design of the virtual environment. In addition, usability methods are being applied to enhance the ease of use and "look and feel" of the virtual environment interface, such as the Think Aloud Protocol, which is carried out with by end users, in this case students, and the Heuristic Evaluation,

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done by usability and software engineering experts (Le peuple and Scane, 2003; Nielsen and Mack, 1994; Preece et al., 1994).

The virtual environment is developed using Distributed Interactive Virtual Environments (DIVE) program (Carlsson & Hagsand, 1993; Frecon and Stenius, 1998). It is a virtual environments browser that can run on various versions of Unix, Linux, Windows, and Solaris operating systems. A DIVE virtual environment can be distributed (can run on an intranet or the Internet) using peer-to-peer multicast architecture, but a DIVE proxy and a server must be installed prior to its use. Participants in a distributed environment are represented as avatars, and they can communicate with each other by using a microphone through Voice over Internet Protocol (VoIP), using an instant-messenger window, or by gestures using the avatar. For optimum performance, it is possible to configure and fine-tune the DIVE system according to the network and computing capacities. DIVE can run on most recent personal computers, where a decent graphics card with more than 64 Mb of memory is highly recommended. Transatlantic tests have been done with a distributed DIVE virtual environment between Mexico and Spain, where two people successfully communicated using VoiP and the text messaging provided by DIVE, using computer laptops and local fiber optic networks on both sides. Moreover, the participants' avatar navigation (movements and gestures) was seamless (García Ruiz and Alvarez Cardenas, 2005).

DIVE handles two programming languages: DIVE and Tcl/Tk (Tool command language/ Tool kit), and can integrate VRML (Virtual Reality Modeling Language) code into them. The binaries and source code of DIVE are freely available for non-commercial use at: http://www.sics.se/dive/. The School of Telematics of the University of Colima, Mexico, has been using DIVE collaborative features for a number of educational projects, such as a collaborative virtual learning environment for teaching bone injuries to medicine students (Cervantes Medina, 2004), and another one for teaching car mechanics (Esqueda Machiche, 2005).

Realtown contains buildings that can be found in a typical United States town. The variety of public and private buildings including a city hall, police and fire

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stations, schools, etc., as well as a supermarket, bank, pharmacy, hardware store, etc. Figure 4 shows a typical public building of the Realtown CVRE.

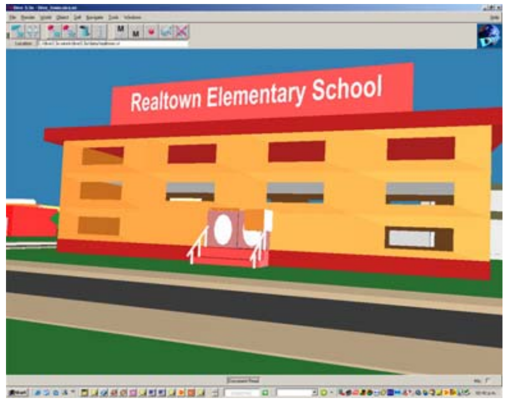

Figure 4. A view of a typical building.

Background sounds are being incorporated into the virtual town, and are played through hi-fi speakers to help increase realism. Some of these sounds include background traffic noise as well as competing foreground noises such as dogs barking or children playing. Students, therefore, receive three different kinds of stimuli to help them incorporate their knowledge: visual, auditory and kinesthetic. DIVE has the capacity to play monophonic and 3D sounds both locally and in a distributed virtual environment. This contributes to a more realistic representation of the real world. Thus, participants can hear the same sound effects according to its sound source placed in the virtual environment.

The virtual environment has been projected on a large screen (about 2 x 2 meters) to enhance the students' immersion experience, due to its size (Figure X). Students are represented as avatars in the virtual environment. The virtual environment runs on a high-end personal computer with Windows 2000 and a powerful graphics card. In the created virtual environment, students can be randomly placed at different points within the virtual town and must move (navigate) from that point to a randomly selected place, i.e. the park, the bank, the bakery, etc. Each of students has to navigate through the virtual town using the arrows of a wireless keyboard.

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3.1 Pilot study description

As a preamble for further collaborative virtual reality in CALL studies, a pilot usability study was conducted with Telematics Engineering students using one of the first prototypes of Realtown, running as stand alone. It was part of a Telematics Engineering thesis (Gonzalez Ruiz, 2005), carried out at the University of Colima. The usability study was based on the Think Aloud Protocol (Preece et al., 1994) and a usability questionnaire with some of the questions taken from the Questionnaire for User Interface Satisfaction (QUIS), developed by Shneiderman (1998), and other questions with 9-point Likert scales regarding quality of sounds, textures and graphics. It was applied as posttest. Each participant did the pilot study separately. The main task was to navigate from point A to B in Realtown following pre-recorded instructions of a native English teacher. Preliminary results show that participant reactions were very favorable. They never mentioned or showed frustration or boredom, and most of them felt immersed in Realtown. None of the participants reported feeling dizzy when navigating the avatar through the virtual streets of Realtown. This indicates that the virtual environment was displayed adequately and had low latency (the delay in the 3D graphics rendering and response to interactions). Most of participants declared that the sound effects helped them navigate and find their way in the virtual environment. Seventy percent of participants could correctly follow the pre-recorded instructions after hearing them just once or twice.

Although Realtown was initially tested as a stand-alone virtual environment, it can run as a distributed environment as is. Participants could access Realtown from a local network or through the Internet. To function properly, a DIVE server, which is a small software application, needs to be installed on a computer dedicated to run this application.

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4. Discussion

There are, however, some challenges in virtual reality. Brooks (1999) points out that latency (the delay of processing and rendering a virtual environment), the lack of high quality graphics and displays and coarse haptic simulations are still serious issues in most virtual reality applications. The lower the latency, the better the sense of immersion the virtual reality system provides (Fraser et al., 2000). Also, the lower the graphics quality and haptic simulations, the lower the sense of immersion. Fortunately, faster low-cost computers with better graphics cards and displays are being developed and being available on the market every few months.

In order to run Realtown with a minimum of latency on a network, it is necessary to do a significant graphics optimization and to reconstruct some of the virtual buildings that are taking many bytes of space, as well as to enhance and optimize the textures used in Realtown, especially all the street signs and similar objects. Optimization techniques and programs such as described by Lipman and Reed (2000) can be used. It is also necessary to configure in DIVE the way sounds are played in the distributed virtual environment, since they take significant amount of time to broadcast them between participants that are connected to the same virtual environment. It has been suggested to try the different audio compression codecs that DIVE provides to find the most effective one to minimize sound lag. Since DIVE must be installed on a server for collaborative applications, it is also suggested that the computer working as server should be dedicated only for that purpose.

DIVE is not the only application that can run CVREs. There are other free programs and programming libraries, for example VR Juggler (http://www.vrjuggler.org/). There are commercial applications as well, such as Worldtoolkit and World2World (http://sense8.sierraweb.net/). DIVE was chosen for this project because it is relatively easy to program, it is free, runs on multiple platforms, and allows the integration of VRML code. However, DIVE documentation is limited. Presently, there are only manuals available from the DIVE Web site, and some research projects that employ DIVE have posted important and relevant information about its use on their Web pages. On the

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positive side, DIVE architecture and functionality have been explained in detail in a number of research articles, book chapters and paper conferences (see http://www.sics.se/~emmanuel/?Publications for more details on DIVE).

5. Conclusions

It has been proposed that virtual reality can function to teach languages in that it permits the student to use visual, auditory and kinesthetic stimuli to place the learner nearer to "real-life" contexts, and since language is best learned when used in real-world contexts, it would appear that VR and CVREs may contribute significantly to second language instruction in the future. Realtown, therefore, was developed to test a series of premises related to visual and spatial orientation when provided oral instruction. The realization of usability studies has permitted consequent stages of research to initiate as usability issues should be addressed and factors related to usability variables must be eliminated in order to do subsequent research and report reliable results

Although high-end virtual reality equipment is very effective for doing realistic and multisensorial immersion in participants, its cost is very high and sometimes it is difficult to maintain. For those reasons, it has been opted for using an open source program (DIVE) and a desktop personal computer for doing research and development as CVRE for learning, according to current infrastructure situation of a developing country like Mexico. This research shows that relatively modest computer infrastructure is enough for usable and functional CVRE.

Future work points to longitudinal studies on comparisons of graphical representations of aerial views of a city for listening comprehension, learning issues and first-person actions and experiences in CVRE. Traditional listening comprehension exercises in most common textbook series present a two-dimensional aerial perspective of a city based on a regular grid system. Many commercial CD-ROMs only transfer the same listening comprehension exercises to a digital format. Because the traditional view of the city does not approximate what a person would perceive at street level, and because most city schematics

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are based on a regular grid pattern, it is difficult to determine how much the student has actually comprehended. The question of how much of the actual listening “comprehension” is attributable to the user’s knowledge and application of grid coordinates in resolving the comprehension exercise thus arises. Future study will compare student listening comprehension of an exercise based on a traditional two-dimensional aerial view of a regularly patterned city with an exercise involving an irregularly patterned three-dimensional street-level perspective. This is work in progress done at the College of Telematics, in conjunction with the University English Language Program of the University of Colima, Mexico.

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Biodata

Miguel A. Garcia-Ruiz graduated in Computer Systems engineering and obtained his MSc in Computer Science from the University of Colima, Mexico. He received his PhD in Computer Science and Artificial Intelligence from Sussex University, England. He has been teaching Computer Science courses, and is a researcher at the University of Colima.
Contact: mgarcia@ucol.mx

Arthur Edwards is senior professor at the College of Telematics of the University of Colima, where he researches Computer Assisted Language Learning. His current research involves online concordancing platforms and their integration into online database and learning systems, as well the application of virtual reality in collaborative language learning environments.
Contact: arted@ucol.mx

Raul Aquino Santos holds a PhD from the Department of Electrical and Electronic Engineering of the University of Sheffield, England. His current research interests include wireless and sensor networks and the implementation of Quality of Service for online educational applications.
Contact: aquinor@ucol.mx