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Game-like language learning in 3-D virtual environments

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ABSTRACT

This paper presents our recent experiences with the design of game-like applications in 3-D virtual environments as well as its impact on student motivation and learning. Therefore our paper starts with a brief analysis of the motivational aspects of videogames and virtual worlds (VWs). We then go on to explore the possible benefits of both in the area of foreign language learning. For our research study we have designed a VW-platform, called VirtUAM. This permits us to store and record data related to users’ behaviour within the VW. Furthermore the platform has been employed to build several islands (virtual spaces), which implement different game levels. The virtual spaces themselves are used to give students a basic training in different language skills related to the German language. In order to obtain data regarding the game’s impact on student learning and motivation, we designed several tests, which were completed both before and after the student participants played the game. Additionally we gave them a general questionnaire, which was only filled out after the game and which aimed at getting personal feedback from the learners. Quantitative and qualitative results shown in this work are part of a larger project which intends to study the impact of game-like applications within virtual environments and with regard to teaching and learning processes in general.

1. Introduction

In recent years many educational institutions have based their teaching on blended learning, which combines face-to-face teaching with an unusually high percentage of autonomous learning and online tutoring. Since then not only students, but also teachers have been facing new challenges. While students are increasingly expected to gravitate towards autonomous learning, teachers have to adopt the role of instructor and guide. This means firstly, that teachers need to explore new ways to ensure that the competences students are expected to have at the end of the term are acquired. And secondly, to make sure that learners receive the necessary guidance to succeed in their learning (Garrison & Kanuka, 2004). One of the main trends in recent years has been the exploration and integration of Information Communication Technologies (ICTs) in autonomous learning, considered to be complementary to face-to-face learning. While face-to-face teaching refers to the general learning process which takes place in the classroom, online learning refers here to autonomous learning through Virtual Learning Environments (VLEs), that usually are supported by Learning Management Systems (LMSs). An LMS is a software application that facilitates the administration and tracking of online events and e-learning programs. It allows to manage documentation, tracking, and reporting of training programs and contents.

The most commonly platforms used by teachers and instructors are Moodle,1 Sakai,2 Claroline3 or WebCT/BlackBoard.4 The reason for this is the huge number of options as well as facilities they usually offer in terms of the design and use of educational contents. However, following our own teaching experience, as well as the results of several research studies, the above mentioned LMS are not always the most interesting learning tools from the students’ point of view. Instead of this, those platforms are often considered as “an unimaginatory repository for teaching materials” (MacLaren, 2004), lacking real time feedback as well as opportunities for meaningful and versatile interaction (Moore & Kearsley, 1996; Sun, Tsai, Finger, Chen, & Yeh, 2008).

2 http://sakaiproject.org/.

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From the students' point of view, the most interesting platforms seem to be VWs (such as Second Life or Active World), videogames and Social Network Sites (SNSs) such as Facebook or Twitter (Boyd & Ellison, 2007). However, although SNSs are among the students' most popular platforms, various researchers underline that students consider SNSs a "social glue" (Madge, Meek, Wellens, & Hooley, 2009) rather than a formal teaching tool (Li, 2007; Selwyn & Grant, 2009). Despite the fact that the findings on the educational potentials of popular SNSs are still limited, many researchers express caution about invading a social networking space that students feel clearly is theirs in order to utilize this space for teaching purposes (Baran, 2010; Madge et al., 2009; Selwyn & Grant, 2009; Usuel & Mazman, 2009).

In recent years there have been several attempts to design specific SNSs to be used mainly in the area of education. Some examples are GoingOn5 or Edmodo6 which both have been created in 2008 to enhance learning communities and to foster collaborative learning processes. In these SNSs, students and faculties are connected to create aggregate content by collaborating with each other. Although the idea behind the aforementioned SNSs is very interesting, they do not provide as we will see further on neither the same immersive 3D environments nor the same possibilities for interaction as for instance VWs do.

Bearing in mind the aforementioned aspect, we started exploring the possibilities of integrating VWs and videogames in our blended teaching. The reason is that we believe that VWs, together with videogames, represent very stimulating learning environments, as they increase significantly student's motivation as well as learning (Amory, 2010; White, Torrente, Moreno-Ger, & Fernandez-Manjon, 2009; Chang & Chou, 2008; Dondlinger, 2007; Garris, Ahlers, & Driskell, 2002; Lepper & Cordova, 1992; Lepper & Cordova, 1992, 2008; Mitchell & Savill-Smith, 2004; Torrente, Moreno-Ger, Fernandez-Manjon, & Del Blanco, 2009).

Before we continue analysing the benefits of combining VWs with game-like applications, it is worth explaining briefly what we mean by VWs. VWs are 3-D environments where users' graphical representations, called avatars can interact with other avatars as well as objects within the environment. Additionally, users are allowed to create new objects. What particularly makes VWs highly attractive for many users is its similarity to the real world's appearance, coupled with its varied possibilities of interaction.

Interaction is here seen as a multidirectional process in which students cooperate with instructors as well as other learners in real time activities, getting furthermore the opportunity to perform tasks in a collaborative way. The fact that a huge number of real life activities can be reproduced or simulated makes VWs a highly immersive environment (Helmer, 2007; Melchor Couto, 2010; Molka-Danielsen, 2009).

While VWs have already been recognised by many educational institutions (universities, high schools, language academies, etc.) for having great potential for teaching and learning purposes (Consortium, 2007; Nardi, L., & Harris, 2007), the same does not apply to the videogame genre. Although many researchers have underlined the educational potential of videogames (Aldrich, 2009; Gee, 2007, 2008; Lepper & Cordova, 1992; Malone, 1981a, 1981b; Prensky, 2008, 2009; Rieber, 1996) there are still others who are quite sceptical and reluctant to consider them useful learning tools (Hays, 2005). Instead of this, they often consider them to be childish and disruptive activities to schooling (Meyers, 2009).

Nevertheless, the number of teenagers and adults who play videogames is increasing every day. From our perspective, this can be explained by the fact that videogames provide several features which make them attractive to a wide range of people (Garris et al., 2002; Gee, 2007; Prensky, 2009).

Among these, we can briefly outline the following:

- They are highly immersive because objects and environments are created in 3-D.
- They stimulate cooperation and competition by focusing on the achievement of goals.
- They provide players with real-time feedback on their failure or success.
- They encourage attitudes like exploration, experimentation and risk taking in problem solving.
- They are fun and highly entertaining because both are task-based oriented.
- They support different levels of difficulty depending on the player's experience.

However, the above mentioned features are not only the main components of VWs and videogames, but they also support some of the key-principles of foreign language teaching, established in recent years by many researchers (Deutschmann, Panichi, & danielsen, 2009; Dörnyei & Ushioda, 2010; Krashen, 2003; Moore & Kearsley, 1996). Such principles include the need to:

- Motivate learners through meaningful and learner-focused topics.
- Provide learners with comprehensible input through context-based learning.
- Provide learners with opportunities for real and meaningful interaction through task-based and goal-oriented activities as well as cooperative learning.
- Underline the role of failure in successful language acquisition.
- Encourage learners to experiment and take risks while communicating in the target language.

Smailesa and Gannon-Leary (2011) have studied what is the best virtual model to facilitate a peer mentoring scheme. They analysed three different models: VLE, SNSs and VWs. The authors finally conclude that even though SNSs are the most popular platforms among students, they are not necessarily the most appropriate ones for educational purposes. Furthermore they deduce from their analysis that even though VLEs are well established learning tools within many educational institutions, students are often not interested in them. With regard to the use of VWs, Smailesa and Gannon-Leary maintain that many students are unfamiliar with them and thus often do not have the knowledge to use them successfully.

Unlike Smailesa and Gannon-Leary, we consider that young people are very familiar with VWs. There are, for instance, popular games that provide the skills needed to use VWs. Among those games are for example The Sims as well as Second Life. Nevertheless we believe that sometimes it might be difficult to use VWs in the area of teaching as they often lack of a well defined goal (Berns, Gonzalez-Pardo, &

5 http://www.goingon.com/.  
6 http://www.edmodo.com/.
Camacho, 2011b). The consequence is that many users get lost in the virtual environment and lose finally their interest in it. For that reason, the following paper explores whether VWs combined with specific videogame-features, can be used as part of the online-learning process and whether they are useful to complement and consolidate the learning content seen before in face-to-face teaching. Therefore we have developed a 3-D Virtual platform, called VirtUAM. Additionally we have designed a game-like application called The supermarket-game which has been integrated in the mentioned platform. The game aims at the training of German vocabulary related to different supermarket products. The game has been tested and evaluated by 85 Spanish university students who had been enrolled in a German language course (Level A 1.1, CEFR) for over 8 months.

2. Game structure

The following section provides a description of both, the VW platform and the designed Supermarket-game. Firstly, we will outline the main software components and architecture, that compose the VirtUAM platform. Secondly, we will give a short description of The supermarket game as well as the different rooms (or levels) the game comprises.

2.1. VirtUAM platform

Virtual Worlds at Universidad Autónoma de Madrid (VirtUAM) has been implemented to allow the design of game-like systems. The platform contains four different modules: a grid of computers hosting the 3D environments; a Web portal to provide access to data; a background database; and, finally, a statistical module (see Fig. 1).

The relationship as well as the interconnections among these modules can be briefly described as follows:

1. A grid of computers which are charged with hosting the VW and the games designed within it. This grid of computers permits the execution and management of the VW. Several computers are needed in order to avoid performance problems, which might occur, should the number of students or objects within the VW increase.

2. A Web portal provides users (teachers, students and researchers) access to different documents about how to interact within the VW. These documents relate to beginners, advanced students, technical guides, construction and programming tutorials, etc. The web portal is as important as the VW-grid is, because it permits students, teachers and even researchers to get an inside view about the different actions they can do depending on their role. Additionally, teachers and application developers can use the web portal for administration tasks. For instance, teachers can include a new student into the system, access student profiles, or obtain statistics that describe the student behaviour and course performance. Furthermore, developers can manage teacher accounts, analyse the systems’ performance and get access to the logs stored in the database system.

3. A database system which stores information with regard to student behaviour and interaction within the VW i.e. interaction logs from avatars, tracking movements, documents and objects developed by users, etc. The database system also stores different logs related to

![Fig. 1. Software architecture of the VirtUAM platform.](image-url)
the VW platform. These logs can be used by both teachers and researchers to perform data analysis of student behaviour. At this point, the data analysis can be performed on two different levels:

- Real time analysis, where data is analysed while students and teachers are within the VW. The results obtained allow to change the game dynamically according to the needs. Currently, a simple recommendation system has been implemented: when a student stops paying attention (Gonzalez-Pardo, de Borja Rodriguez, Pulido, & Camacho, 2010), the system automatically sends a message to the teacher. Thus the teacher can take the appropriate action during the same session.

- Data can also be analysed by researchers once students have quit the game. In this type of analysis researchers try to identify those behavioural patterns which provide better student results in the final test, together with those which can be used by teachers in order to design more effective games.

In this database system the following information is stored to make the VW platform work successfully:

- Files that contain the different buildings, objects, documents, multimedia data, created in the VW. Those files are used to load the virtual environment where the sessions take place.
- Students’ and teachers’ profiles needed to identify the different users.
- User guides, manuals, and other documents (i.e. web sites, technical guides) to understand how the VW and the web portal work.
- Logs concerning student behaviour. These logs are used to identify several aspects, for example, behavioural patterns.
- Statistics that will be used to analyse both student and course performance.

4. A statistical analysis module that receives the data stored from interactions in the VW. Once these data are adequately mapped, they are processed by using data mining techniques. Several well-known data mining tools, such as Weka (Witten, Frank, & Hall, 2011) or R (Teetor, 2011), are employed to automatically retrieve patterns from data.

Our platform is built on top of the Open Simulator (OpenSim) platform which has been developed by IBM. Despite of the most known VW platforms such as OpenCobalt, Multiverse, Active Worlds or Second Life (SL), OpenSim was selected for the following reasons:

- The virtual space, which can be built by its users and the number of prims (primitive shapes such as cubes, spheres, cylinders, cones, etc.) created in this platform are both unlimited. However, a huge number of prims, scripts or sims has immediate effect on the systems’ performance, which has to be managed by the grid configuration.

<table>
<thead>
<tr>
<th>Sessions</th>
<th>Rooms</th>
<th>Skills</th>
<th>Goal</th>
<th>Dynamic</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2</td>
<td>(Level 0) Meeting room</td>
<td>General Communication skills</td>
<td>Attend to students’ questions</td>
<td>Individual tutoring</td>
<td>Depends on individual needs</td>
</tr>
<tr>
<td></td>
<td>(Level 1) Training room</td>
<td>Listening comprehension</td>
<td>Activate and widen previous knowledge</td>
<td>Individual training</td>
<td>15–20 min</td>
</tr>
<tr>
<td>3–5</td>
<td>(Level 2) Quiz-room</td>
<td>Listening comprehension</td>
<td>Check the acquired knowledge</td>
<td>Teamwork, competition</td>
<td>10 min</td>
</tr>
<tr>
<td></td>
<td>(Level 3) Amusement arcade</td>
<td>Listening comprehension, reading</td>
<td>Consolidate oral comprehension and widen reading skills</td>
<td>Individual, competition</td>
<td>15–25 min</td>
</tr>
<tr>
<td></td>
<td>(Level 4) Supermarket</td>
<td>Reading</td>
<td>Check and consolidate reading skills</td>
<td>Individual, competition</td>
<td>20–40 min</td>
</tr>
</tbody>
</table>

**Table 1**

Description of the supermarket-game structure and levels.
Usually VW platforms are public virtual places that cannot be fully configured in order to provide an educational environment that is exclusively controlled by its users. This means that in addition to our own students, other external users would be able to visit our buildings and possibly interfere in the course proceedings and dynamic.

Information related to student behaviour, such as student–teacher and student–student interactions or chat records cannot be easily retrieved from external VW platforms. Consequently it is not possible to make a data analysis of the student behaviour.

And finally, as OpenSim is an open-source software, it permits administrators as well as teachers to modify the program whenever they want. Such modifications might aim at the storage of player’s behaviour within a database system or, even the inclusion of a mechanism, which can detect individual learner problems, in order to focus specifically on these.

All of these characteristics make the OpenSim platform the most appropriate for our research and educational purposes. The above mentioned features, together with the previously described modules make VirtUAM a unique platform where different educational approaches can easily be used in 3D environments like VW.

Although some parts of our VW could have been implemented by using other technologies, such as Flash/HTML5 applications, we decided to design the whole game in OpenSim in order to lodge the entire learning process within the same platform. In this way we guarantee that students would not get confused by using different technologies and graphical user interfaces. With our approach of creating both the learning process and the evaluation process within the VW, students take part in a totally immersive 3D environment that covers both processes.

By using our platform, we can design game-like applications with different levels. This means that a game-like application is usually composed of a set of interconnected islands. The number of islands employed for the game depends mainly on the created objects within it, as well as its complexity. The more complex the game is, the more objects are created, and thus the more number of islands are needed.

Fig. 2 shows an example of the distribution of the different levels of The supermarket game.

2.2. Game-like VW design

During the game students move with their avatar through different rooms (or levels) facing new challenges in each of them. As Table 1 shows, the game is based on five rooms which aim to train the learner’s listening and reading skills through several activities. The game itself is built on the bottom-up principle, focussing first on providing the necessary input and then on the performance of the final task. As the following more detailed description will show, the final task requires the skills trained in levels 1–3.

By the additional integration of a score-system we want to invite students to train their language skills before proceeding to the next level and to increase their motivation. As highlighted in previous works, (Berns et al., 2011a, 2011b) motivation is enhanced particularly through
competition as it makes learners challenge themselves in order to win the game. Competition is understood, in this sense, to be a highly attractive game feature to be explored as far as possible in the teaching and learning process.

2.2.1. Level 0. Meeting room
This room was created as a central meeting point in order to give players every kind of necessary support related to the game performance. Therefore, during the whole game, a minimum of one teacher or tutor would always be available in the meeting room. The room itself can be reached easily from every other game-room, as those are all built around the meeting-room. This room can be observed in Fig. 3.

2.2.2. Level 1. Training room
As the main goal of the game is to prepare the learners to do shopping in a virtual supermarket, the first level focuses on the introduction and training of the basic vocabulary related to several supermarket products. In order to familiarize students with the necessary vocabulary, they are given in this room (Fig. 4) the opportunity to activate and widen the knowledge previously acquired in face-to-face teaching. With regard to the design of the first level it is divided into four walls, each one representing a different category: vegetables, beverages, fruit and general food. The vocabulary is introduced by means of photos in combination with audio recordings. It is the students’ task to train themselves (individually or in pairs) by clicking on the photos and thus practising the related vocabulary as long as s/he needs. Unlike the other levels, the first level is not based on a score-system, as it aims basically to introduce the learner to the game-vocabulary.

2.2.3. Level 2. Quiz-room
The second level provides a quiz-like activity to be performed in teamwork, competing with two other teams. This level is shown in Fig. 5. The goal is to test the students’ listening skills acquired in the first level. Therefore the teacher welcomes each team to sit down in front of the main screen, on which selected vocabulary from the first level is displayed. In addition to this, a variety of related questions are included in the form of audio recordings. During this quiz-like activity each team takes turns to activate the questions displayed and match them with the correct answers on the screen. The activity is done through competition between the three enrolled teams. In order to make the quiz more dynamic and challenging we included several tools such as a time-limit, a score-system and individual feedback delivered by the database. All of these tools aimed at creating a game atmosphere and motivating the players to do their best.

2.2.4. Level 3. Practice room or amusement arcade
Level 3 is designed for individual training but through competition with other players. In order to reinforce students’ listening and reading skills, each student is invited to play on five different slot machines. These are designed as follows: slot machine one and two combine audio recordings with photos. By matching both, students have to showcase their vocabulary as well as their listening skills acquired in the Training and Quiz-room. In slot machines three and four the players are asked to match audio recordings with their corresponding words. The activity finally concludes with a fifth slot machine which aims to train and test the learners’ reading skills. Therefore we designed a slot machine based on selected vocabulary, which has to be identified by matching words with photos. Fig. 6 shows this level.
2.2.5. Level 4. Supermarket

Once the students have passed the levels 1–3 by getting a minimum of 65/100 points, they are invited to participate in the final level. If they did not achieve the minimum score, they have to go back and repeat the former activity. The aim of level 4 is to check the students’ vocabulary acquisition as well as their reading skills throughout the game. The reading skills were trained by exposing learners to the new vocabulary first orally, and then through its written form on some selected slot machines in the Amusement Arcade. In order to pass the final test students have to apply the acquired listening and reading skills to their virtual shopping. Therefore several shopping lists are displayed on the student’s personal monitor. During the activity students receive real-time feedback from the platform either awarding them or subtracting from them the corresponding scores. Fig. 7 shows an avatar performing the final task. The latter is based on several shopping lists which contain the products the avatar has to buy.

3. Experimental setup

The current case study is tutored by one lecturer and one language instructor as well as several external observers who analysed the data registered by the VirtUAM platform. The target group of the experiment is composed by 85 students for a degree in modern languages, economics or engineering. All students are used to being exposed solely to the target language from the very first moment of their language classes. Our main purpose, whilst taking into consideration the fact that our enrolled learners are at the beginner level, is to motivate them towards language learning and to reinforce their comprehension skills (listening and reading). Our focus is therefore mainly on giving them meaningful and motivating input instead of grammar and form training (Krashen, 2003).

During the experiments students are connected from home and invited to use the text chat by communicating only in the target language. Once the students become familiar with the game dynamic and learning tools, they are free to enter as often as they wanted. The game repetition is designed to give students the opportunity to reinforce their learning as well as to improve their scores.

Before students start playing The supermarket game, they must complete a test (henceforth “pre-test”) that evaluates their knowledge regarding The supermarket game vocabulary. The next step is to play the game. Once finished the game students are asked to answer the previous test (henceforth “post-test”). By comparing the results of the post-test with the ones of the pre-test, we know whether our game-like application is useful or not for learning purposes. Finally, at the end of this process, a questionnaire is given to the students. This questionnaire provides us the students’ opinion concerning VirtUAM and The supermarket game.

In this work we did not use control groups because the aim of this work is to determine whether the VirtUAM platform combined with game-like applications enhances students’ learning and motivation. In the case that students learn the concepts and find the platform interesting, our future work would focus on the evaluation of how much knowledge students acquire by using this platform in comparison with other approaches such as Moodle or traditional classes.

4. Experimental results and discussion

To measure the supermarket-games’ impact on student learning and motivation we designed, as previously mentioned, a four part pre- and post-test as well as a one general questionnaire to be completed by the student participants. In the following section we give a brief description of the results and data extracted from each of them.

With regard to the outcome of the questionnaires, Table 2 gives clear evidence of the positive impact on students learning as well as motivation. Students underline, first of all, the motivational aspect related to the fact that learning contents are embedded in a game-based environment. Thereby learning becomes easier and more entertaining for many learners than in traditional E-Learning environments. In addition to this learners report their remarkable improvement in terms of vocabulary, pronunciation, listening and writing comprehension. The writing was improved firstly, by the different gaming activities and secondly, by using the text chat to interact with the teacher as well as other players. Many learners made use of the text chat in order to exchange information related to the game or to practice their language skills through small talk with other players.

In order to know whether The supermarket game is useful or not, i.e. whether the students learn the different concepts, the same tests were given to the students before and after playing the game. Each test focused on different competences: listening, reading and writing. While the first three were multiple choice tests and focused on listening and reading (students have to match different objects with their
Table 2  
Results from the students’ evaluation of the game-like application.

<table>
<thead>
<tr>
<th>Question</th>
<th>% Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>The game helps me learn vocabulary</td>
<td>80</td>
</tr>
<tr>
<td>The game increases my motivation</td>
<td>86</td>
</tr>
<tr>
<td>The game makes learning easy</td>
<td>88</td>
</tr>
<tr>
<td>The game enhances the interaction with other players</td>
<td>80</td>
</tr>
<tr>
<td>The game makes me more active than in the classroom</td>
<td>40</td>
</tr>
<tr>
<td>The game makes me feel more relaxed than in the classroom</td>
<td>36</td>
</tr>
<tr>
<td>The game motivates me more to interact with others than LMS systems such as Moodle do</td>
<td>78</td>
</tr>
<tr>
<td>The game helps me improve my listening</td>
<td>69</td>
</tr>
<tr>
<td>The game helps me improve my writing</td>
<td>38</td>
</tr>
<tr>
<td>The game helps me improve my reading comprehension</td>
<td>65</td>
</tr>
<tr>
<td>The game helps me improve my pronunciation</td>
<td>74</td>
</tr>
<tr>
<td>The game permits me to practice my passive as well as active language knowledge</td>
<td>72</td>
</tr>
<tr>
<td>The game focuses mainly on the practice of passive language knowledge</td>
<td>28</td>
</tr>
<tr>
<td>The game offers opportunities to practice and improve communication skills</td>
<td>48</td>
</tr>
</tbody>
</table>

name as well as several audio recordings with their phonetic transcriptions or corresponding visual concepts), the fourth test focused on students’ writing skills. Fig. 8 shows different examples of some of the questions asked in the tests.

Fig. 9 shows the results of the tests. The results evidence not only the enormous game impact on students’ acquisition of new vocabulary, but also on their improvement in terms of listening comprehension. It is very significant that whilst most of the learners did not pass the pre-tests one, three and four, almost every student passed the same tests after playing the game.

The results from test 2 are less remarkable. The test focused on several phonetic problems, which are usually related to Spanish native speakers. For example, the difficulty in distinguishing between “v”, “w” and “b” in words such as “Birnen”, “Bier”, “Wein”, “Butter” or “Bohnen” or in distinguishing between “Sch” and “ch” in “Schinken” or “Milk”.

Nevertheless, from the results of test 2 it appears that the enrolled learners did not have the phonetic problems we expected them to have. That means that whilst 93% of the learners successfully passed the pre-test, 100% of them passed the post-test. This may be due to the fact that the designed test contained several aspects which made it easy for the students to guess the correct answer: firstly, the audio recordings were recorded very slowly, secondly students had to select between only two answers. Both aspects made it too easy to hit the correct answer, thus making the test unsuitable in terms of giving us genuine feedback about the real game impact on student listening and pronunciation skills.
The results from test 3 which focused on the students’ listening skills were also very significant. While 63% of the learners failed the pre-test, only 2% of them failed the post-test. Also, test 4 evidences the positive game impact on the students’ writing skills: whilst only 2% passed the pre-test, 40% of them succeeded in passing the same test after playing the game.

Finally the students’ scores (grouped in pre-test scores and post-test scores) are analysed by using the Wilcoxon signed-rank test (Wilcoxon, 1945). In the present work the Wilcoxon test is used to compare the distribution of pre-test and post-test scores. The aim is to know whether post-test scores are higher than pre-test scores. This is our alternative hypothesis, while the null hypothesis determines that post-test scores are lower or equal to pre-test scores. In order to accept, or reject, the null hypothesis the Wilcoxon test uses a parameter $W_0$ whose value depends on the significance level $\alpha$. The result of the test is described in Equation (1).

\[
\text{Null hypothesis will be } \begin{cases} \text{accepted if } & W_+ > W_0 \\ \text{rejected if } & W_+ \leq W_0 \end{cases} \tag{1}
\]

Table 3 shows the results of the Wilcoxon test for test 2, 3 and 4. The number of measurements, the value of $W_+$, the value of $W_0$ and the significance level is also shown in this table.

As can be seen in Table 3 for these three experiments the null hypothesis is rejected because of $W_+ \leq W_0$. This means that the post-test score is higher than the pre-test score, and thus students learn when they use our game-like application.
Finally, test 1 is not shown in Table 3 because the number of measurements is 58 and a normal approximation must be used. By using this approximation, the value for $Z$ is $-6.6235$ and $p(x < Z)$ is very close to 0 thus the null hypothesis is also rejected.

These Wilcoxon results allow us to conclude that the platform presented in this paper is useful for educational tasks because students learn when they use the platform.

5. Conclusions

The current paper is the result of an empirical research project designed within the VirtUAM platform applied to foreign language learning. We used the platform to explore the educational and motivational potential of VWs in combination with game-like applications. The idea to combine both was the result of our own teaching experience in recent years with LMS such as Moodle, BlackBoard and WebCT. As we outlined at the beginning of our work, many of our students do not make extensive use of the tools offered in LMS.

A few years ago we started to explore the educational potential of VWs in combination with game-like applications, taking into consideration the previous arguments. Our purpose was, first of all, to measure whether virtual environments combined with specific videogame features could enhance student motivation towards online learning and bridge the often emerging gap between the online and face-to-face teaching and learning process.

The results of our investigation, based on empiric research with different sets of students, were remarkable. In their evaluation of the game students underline the following aspects in particular:

- Games make learning easier and faster, as they provide real-time feedback and help players succeed in the different game activities. The immersive game environment and the fact that vocabulary is presented in context makes it easier to understand and learn.
- Games make learning entertaining and fun. Game features like competition and collaboration with others motivate students to be more active and encourage them to challenge themselves in order to win the game. Additionally many students emphasize that the game’s learning environment offers, as does face-to-face teaching, a lot of opportunities for interaction. But unlike face-to-face teaching, interaction in game-like applications is perceived to be free from the fear of failure.

Although we consider game-like applications and VWs highly interesting domains, for their motivating and effective learning environment, we believe they cannot totally replace the use of LMS platforms such as Moodle, Blackboard, etc… Rather than this, both approaches should be used as complementary platforms to face-face-teaching making use of the advantages of both platforms (Torrente, Moreno-Ger, Martinez-Ortiz, & Fernandez-Manjon, 2009).

The results presented here are part of a larger project which sets out to explore the positive impact of VW game-like applications on education in general. The study analyses OpenSim as a possible complementary environment for language teaching and learning and sets out an experiment that may shed some light on OpenSim appropriateness for that purpose. It is acknowledged that the proposed study still presents a number of limitations. Among those are the omission of voice chat, a need for more collaborative and meaningful tasks as well as the design of activities based on the adaptive learning principles.

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