Percepciones de estudiantes universitarios sobre la realidad virtual como recurso didáctico: un estudio preexperimental con un grupo de control y experimental

Perceptions of university students about virtual reality as a didactic resource: a pre-experimental study with a control and experimental group

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RESUMEN.
En este artículo se presentan los resultados de un estudio sobre el impacto de la incorporación de *Second Life* en la didáctica de una asignatura de grado universitario así como en la satisfacción del alumnado, realizando una encuesta a dos grupos de alumnos matriculados en la misma asignatura mediante un cuestionario de 24 ítems puntuados en una escala Likert de 5 puntos para la recopilación de datos. Los sujetos comprendieron 75 estudiantes que utilizaron el modelo tradicional y 75 estudiantes que utilizaron un modelo de realidad virtual. Para verificar las hipótesis, el análisis de datos se centró en la estadística descriptiva mediante una comparación de las puntuaciones medias para las variables dependientes de cada uno de los grupos, y con la verificación de supuestos paramétricos, se aplicó inferencia estadística para determinar la significancia de las varianzas mediante Prueba *t de Student.* Los resultados muestran que los estudiantes perciben ventajas específicas vinculadas al diseño de actividades de RV en realidad virtual. De ahí que se confirme el potencial de la realidad virtual para mejorar el proceso de enseñanza. Este estudio lleva a la conclusión de que los estudiantes de la Universidad Don Bosco valoran mucho el proceso de enseñanza aprendizaje mediado por la realidad virtual.

PALABRAS CLAVE.
Educación, tecnologia Educacional, innovación pedagógica, estrategia de enseñanza.

ABSTRACT.
This article presents the results of a study of the impact of incorporating *Second Life* on the didactics of a university degree subject as well as on student satisfaction, administering a

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survey to two groups of students enrolled in the same subject through a 24-item questionnaire scored on a 5-point Likert scale for data collection. Subjects comprised 75 students who used the traditional model and 75 students who used a virtual reality model. To verify the hypotheses, the data analysis focused on the descriptive statistics through a comparison of the mean scores for the dependent variables of each of the groups, and with the verification of parametric assumptions, statistical inference was applied to determine the significance of the variances through Student's *t*-test. The results show that students perceive specific advantages linked to the design of VR activities in virtual reality. Hence, the potential of virtual reality for improving the teaching process is confirmed. This study leads to the conclusion that students at Universidad Don Bosco greatly value the teaching learning process mediated by virtual reality.

KEY WORDS.
Education, educational technology, pedagogical innovation, teaching strategy.

1. Introduction.

The development and application of information and communication technologies involve significant social, economic, and cultural transformations. Knowledge is not an exception. People consume increasing amounts of information through different technological means and generate knowledge and resources that they share on the Internet (García & Martínez, 2015). The education area thrives on these double-profile users who act as producers and consumers. Many teachers design their own teaching resources using flexible, interactive approaches adapted to students' characteristics and preferences (Torres et al., 2019), resulting in a diversity of resources related to a variety of needs and contexts. However, there is a leading methodology in this area: gamification (Antonaci et al., 2019; Sánchez-Rivas et al., 2019). Video games focused on developing social skills, problem-solving, and decision-making strategies among students belonging to different educational levels have been considered an ideal resource for developing 21st-century skills and innovations in learning environments (Lozano-Abad et al., 2019). One of the resources used to design gamified didactic experiences is virtual reality (Dyer et al., 2018); it is defined as "various multimedia sequences that simulate reality in an almost reliable way, generated by human beings by using information and communication technologies, requiring specific hardware for their use" (Campos Soto et al., 2020, p. 48).

The virtual reality–gamification duo constitutes the basis of the didactic experience analyzed in this study. Educational technology resources fit very well with active methodologies. This complementary nature is connected to students' need to develop digital skills using strategies that involve experimenting with resources and generating experiences (Gamboa & Gómez, 2009). For this reason, virtual reality is currently on the upswing in training contexts (Rockstroh et al., 2019).

Virtual reality helps overcome the limitations of classroom physical space and transcends the face-to-face modality (Alexander et al., 2019). By doing so, it manages to effectively support student learning (Jamil et al., 2019) and thus improve accessibility by providing more inclusive environments (Nijman et al., 2019).

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Virtual reality, such as *Second Life* used in this study, is defined as an immersive and interactive experience conveyed through graphic 3D images that are generated in real time by a computer. This allows human senses such as touch, sight, and hearing to experienced artificial environments (Blanco, 2002), which provide appropriate communicative scenarios through their text and speech resources (Robles Ávila & Díaz Bravo, 2017).

In addition, virtual reality can provide collaborative space. According to Churchill et al. (2001), the generated virtual world must provide areas for collective meetings, allow interactions between participants, and adapt to the different perspectives that each individual procures through their experiences.

The aforementioned teaching possibilities explain why virtual reality has become a highly recognized didactic resource in the field of educational technology (Panerai et al., 2018).

Different platforms can be used to design virtual reality worlds. Some of the most widely used are *Actice Worlds, Manyland, Smeet, Furcadia, Avakin Life, Twinity*, and *Sansar.* Among these, *Second Life* was selected for this study. This is an open platform launched in 2003. Users can access their corresponding playing environment through a graphic interface (or viewers), which allows users to interact using avatars. In this way, users can explore the virtual reality world where their avatars are developing activities and communicating with other users in their virtual community. The pedagogic potential of *Second Life* lies in its flexibility in simulating educational contexts based on exploration, simulation, role playing, interaction, and experimentation. Users express their characteristics and preferences through avatars (Bowers et al., 2009).

Second Life is the most widely used virtual platform in educational and training contexts (Checa García, 2011; Warburton, 2009), as it provides constructivist spaces for discovery and creative learning (Lorenzo Álvarez et al., 2018; Boulos et al., 2007; Schwaab et al., 2011; Kidd et al., 2012; Melús-Palazón et al., 2012; Wiecha et al., 2010; Richardson et al., 2011; DeMers, 2010; Stewart et al., 2009).

Evaluating the integration of *Second Life* as a didactic resource in the teaching–learning process allows us to understand its pedagogical potential for the development of collaborative virtual environments (Rubio Tamayo & Gértrudix Barrio, 2016). Within these collaborative workspaces, students can resolve different challenges that are present in their environments. Activities such as studying specific, actual, or simulated cases, project preparation, decision-making, personal skills, leadership skills, and the ability to work in an interdisciplinary team and solve problems, can be strengthened through virtual reality scenarios (Franco & González, 2011).

In terms of didactic planning development, *Second Life* offers vast potential for designing and integrating three-dimensional activities, thus promoting discovery learning by collaborating among equals without the need to be together in person, as virtual reality is projected as a communication and interaction system with different levels of immersion (Rubio Tamayo & Gértrudix Barrio, 2016). For this reason, virtual reality has gradually become more significant in the field of education and is perceived as a didactic tool that successfully motivates students and leads them to interact in their learning spaces (Cantón et al., 2017) by providing more natural learning models that positively impact the teaching–learning process.

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In the last few years, two world-class databases (Scopus and WOS) have collected a vast amount of literature by the scientific community reviewing the integration of virtual reality through *Second Life* with education (Andalia et al., 2010; Hernández-González et al., 2016; Moreta et al., 2020; Reverter-Masia et al., 2016). These studies have focused on the pedagogic potential and innovative didactic feature of this 3D technology (Robles Ávila & Díaz Bravo, 2017; Quinche & González, 2011).

Based on this scientific context, this first case study was applied in El Salvador, where virtual reality is incorporated as a didactic resource using the *Second Life* platform.

1.1. Research objectives.

Research suggests that virtual reality resources and *Second Life* in particular hold vast pedagogical potential. Taking this study context as reference, a significant research question is posed of students' perception of the implementation of *Second Life* applications in their learning process, as well as how the perception of this new didactic context generated with *Second Life* compared to that of other contexts in which this pedagogical resource was not used. What is the impact of incorporating *Second Life* on the didactics of a university course and student satisfaction? Does the incorporation of *Second Life* and the organizational and methodological changes entailed lead to improvements over traditional didactic processes used in university education?

These research questions give rise to a conjectural answer in the form of a working hypothesis structured around a series of dependent and independent variables (DV and IV, respectively) summarized as follows:

Incorporating *Second Life* in a degree course (IV) improves students' perceptions of the use of class time (DV1), their participation (DV2), their motivation in the course (DV3), and their academic progress (DV4) compared to traditional activities. In addition, it achieves ubiquity; learning continues after the face-to-face class is over (DV5) and, in general, improves the students' satisfaction with the subject (DV6).

To reduce the incidence of unknown variables, the study was conducted in the same undergraduate course, i.e., "Oral and Written Expression," involving the same thematic focus.

Considering the abovementioned hypothesis, this study is understood as an initial exploratory approach to implementing educational technology resources linked to virtual reality in university teaching. Based on the analysis of the students' perception of the training experience with *Second Life*, the following objectives are proposed:

- ✓ To learn the students' perception of the impact of implementing the resource on the following specific aspects of the teaching methodology: use of class time, participation, motivation, academic performance, and ubiquity.
- ✓ To determine the level of student satisfaction with the new didactic conditions generated by organizing teaching and learning situations based on *Second Life*.
- ✓ To establish a comparison of the didactic aspects related to *Second Life* with those of traditional teaching based on the students' own perceptions of each model.

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2. Materials and Methods.

2.1. Experimental design.

Considering the nature of the proposed objectives, a questionnaire survey was conducted with the students, who were divided into two groups A and B for data collection.

The research procedure employed the model proposed by Cohen et al. (1990) as a reference to establish a survey study. In this sense, the actions developed by researchers were structured into the following three phases:

P1 Approach. The virtual reality platform *Second Life* was selected because the Universidad Don Bosco online program administrates a 64,000-m^2 virtual reality island to study the academic use of this emergent technology in fields such as Oral and Written Expression, Digital Marketing, Languages, Aeronautics, Orthesis, and Prothesis. In this sense, the online program develops specialized classrooms, experiments, lab practices, educational games, and videoconferences. Based on this background, this phase began by analyzing the options to implement virtual reality in the university education-related learning design through the *Second Life* island.

P2. Didactic Intervention and Data Collection. Determining the options in the theoretical plane led to the design of the adaptations (see Table 1) and the virtual reality experience development in the "Oral and Written Expression" course, which was taught in other groups using traditional didactics that facilitated the comparison between didactics adapted to virtual reality and traditional didactics.

Table 1. Comparison between traditional and virtual reality-based teaching activities in Second Life

	Group A	**Group B**
Didactic action	**Traditional teaching activities**	**Virtual reality-based teaching activities in *Second Life***
Presentation of course activities	The teacher made the educational material available through the moodle platform.	The teacher conducted a synchronous meeting on the *Second Life* island to explain the course activities.
Presentation of tasks	The teacher enabled the homework module on moodle.	The teacher provided the task instructions in virtual reality settings.
Completing collaborative activities	Students used email and forums to complete their activities.	Students met on the *Second Life* island to complete their activities.
Submitting activities	The teacher received assignments in Word or PDF format through moodle.	The teacher received assignments through *Second Life* notes, videos, and screenshots.

Source: Created by the authors.

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P3. Data Analysis and Reflection. Once the activities were completed by the participants of Groups A and B, the questionnaire was administered. Based on the results of the questionnaire, reflection sessions were organized to develop study conclusions.

2.2. Participants.

The purpose of this study was to describe the variables defined for the entire reference population: students taking the "Oral and Written Expression" Course at Universidad Don Bosco Virtual (El Salvador) transversally and virtually taught in all academic degree programs. Students who take the "Oral and Written Expression" courses usually take the first academic semester. Therefore, this course is taught in Spanish and is mandatory for engineering, arts, economics, and social sciences. The course's main goal is to develop verbal and non-verbal techniques to carry out oral presentations successfully, as well as to communicate in a professional context with confidence and assertiveness, including the correct usage of register, writing, and spelling.

The total number of participants included in this study was 150. They were divided into two equal groups. Group A continued to follow the traditional teaching approach, while Group B used a teaching approach based on the use of virtual reality with *Second Life*.

Regarding the sample, it is worth noting that participants belonged to two different groups of the same university degree course. The sample size was determined based on the group's inherent composition (accidental sampling). The didactic experience with *Second Life* was developed within an online class context, and it required students to have Internet access. To guarantee this condition, all participants were loaned portable devices by Universidad Don Bosco. In addition, all participants assigned to Group B received audio–visual material on how to install and use *Second Life*.

Participants completed a written participation consent form stating that they were willing to participate. In addition, the researchers used the standard ethical practice of warranting privacy and anonymity by using pseudonyms (Márquez, 2014). In this sense, students selected the avatar name to enter the *Second Life* platform. The learning activities developed by the students were shared only with the teacher's avatar, and they used the pseudonyms selected by the students.

2.3. Data collection instrument.

To collect data on the study's areas of interest, a 24-item questionnaire that included the use of class time, participation, motivation, progress, ubiquity, and satisfaction categories was used with a 5-point Likert scale (5 = *Always*, 4 = *Frequently*, 3 = *Sometimes*, 2 = *Rarely*, and 1 = *Never*), each of which corresponds to a DV identified in the hypothesis (Table 2). It is important to note that this data collection instrument was not exempt from the influence of validity threat elements. This influence may come from the research team itself (due to its status as implementer) and from the previous experiences of the participants (students of the Oral and Written Expression course) in virtual learning environments.

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Table 2. Structure of the questionnaire

Area of interest	Associated DV	Items
Use of class time	DV1	1–4
Participation	DV2	5–8
Motivation	DV3	9–12
Progress	DV4	13–16
Ubiquity	DV5	17–20
Satisfaction	DV6	21–24

Source: Created by the authors.

The questionnaire employed in this study was an ad hoc instrument; its design was based on a qualitative strategy, that is, group discussion, following León and Montero's (2003) recommendations. The resulting instrument was submitted to the expert consultation system and revised based on the results of a pilot test, thereby achieving a high degree of validity regarding the survey's subject. Its reliability was also analyzed using Cronbach's alpha coefficient; the score achieved was 0.914, which in turn aided in establishing the instrument's quality of internal consistency (Andrés, 2004). Once the questionnaire was structured, the tool was digitized using Cognito Forms. The link to the questionnaire was sent to the participants, and confirmation of receipt was received.

2.4. Data analysis.

The data obtained were analyzed using the SPSS statistical software (Version 23). The first action regarding data was the analysis focused on descriptive statistics, which was based on two parameters: average scores and typical deviation. The obtained results allowed researchers to develop preliminary conclusions. Then, the comparison of average scores reached by Groups A and B for the DVs was further assessed.

The first stage of this comparative analysis was developed for the individual items. The second stage grouped the item scores based on the context or area to which they belonged (use of class time, participation, motivation, academic progress, ubiquity, and satisfaction). In this way, the researchers determined the value participants provided to each dependent variable in the study.

The next step in data analysis was the application of inferential statistics tests to determine whether the differences that had been identified through the descriptive analysis were significant when analyzed statistically.

Once the parametric assumptions of the sample size, normality (Shapiro-Wilk test), and homoscedasticity (Levene test) were checked, a bivariate analysis was applied to determine the significance of the variance established between the two types of activities (traditional activities and virtual reality activities with *Second Life*). Considering the sample and nature of the study, Student's *t*-test proved to be more reliable. The confidence level was set at $p = .05$; that is, a difference was deemed statistically significant when the *p*-value was equal to or less than .05.

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3. Results.

Data from the exploratory statistical analysis are presented in Table 3, illustrating the average scores corresponding to the participants of the traditional teaching model and the virtual reality-based teaching model using *Second Life* for each of the items. When comparing the scores by items, the values corresponding to virtual-reality-based teaching components were found to be markedly higher than the traditional ones. The most significant differences were found in items 1–4, 7, 8, 11–17, 20, and 24.

Table 3. Average scores and standard deviations (SD) grouped by item and activity

			Traditional teaching		Virtual reality-based teaching using *Second Life*	
			Average	*SD*	Average	*SD*
Use of class time						
1	The activities employed in This item contributed to…	experiencing quality learning in class.	4.51	0.68	4.80	0.40
2		having time to bring up questions and concerns.	4.49	0.70	4.83	0.44
3		reflecting on and organizing ideas for my submissions.	4.55	0.70	4.83	0.41
4		making progress in developing my deliverables.	4.44	0.79	4.84	0.40
Participation						
5	The activities employed in This item contributed to…	working effectively with my team.	4.27	1.01	4.53	0.85
6		feeling that I have the opportunity to express my viewpoints in virtual meetings.	4.51	0.82	4.75	0.57
7		having the opportunity to interact with the teacher.	4.39	0.91	4.83	0.44
8		having the teacher check my progress and provide feedback	4.48	0.84	4.85	0.35
Motivation						
9	The activities employed in This item contributed to…	improving my disposition toward learning as lessons go by.	4.57	0.73	4.79	0.44
10		my perception of the usefulness of learning for my professional future.	4.61	0.75	4.88	0.36
11		making the teaching–learning process interesting.	4.52	0.86	4.87	0.34
12		making the teaching–learning process enjoyable.	4.59	0.79	4.83	0.41

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Progress						
13	The activities employed in This item contributed to…	having the opportunity to apply the theory in practical cases.	4.49	0.77	4.80	0.43
14		understanding the concepts and procedures addressed.	4.49	0.84	4.81	0.45
15		my learning being proportional to my effort.	4.51	0.82	4.84	0.36
16		developing my professional competence.	4.49	0.89	4.92	0.31
Ubiquity						
17	The activities employed in This item contributed to…	accessing the theoretical content when I needed it.	4.61	0.75	4.91	0.29
18		reviewing the guidelines for my task when I had questions.	4.63	0.69	4.76	0.63
19		extending participation in topics beyond class.	4.44	1.0	4.72	0.58
20		checking the work of other teams at any time.	3.88	1.5	4.47	0.96
Satisfaction						
21	The activities employed in This item contributed to…	making the training process intellectually stimulating.	4.57	0.80	4.78	0.55
22		the programing being consistent with pedagogical innovation.	4.61	0.73	4.88	0.32
23		the possibility of participating in the construction of my learning.	4.75	0.61	4.85	0.35
24		achieving quality learning.	4.59	0.82	4.84	0.36

Source: Created by the authors.

At the descriptive level, differences in the average scores for each DV could be observed as a function of the connection between the responses to traditional or virtual reality-based teaching activities (see Figure 1).

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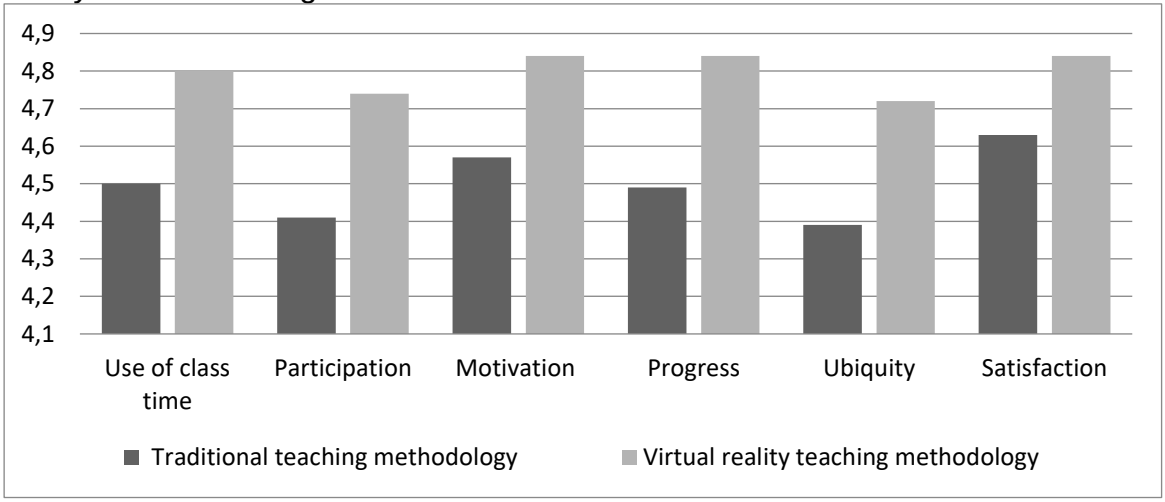
Figure 1. Average scores for each dependent variable related to the traditional vs. virtual reality-based teaching activities



Source: Created by the authors.

The average scores shown in Figure 1 suggest that students perceived virtual-reality-based teaching using *Second Life* as better than traditional teaching. Significant differences were noted in the participation and progress variables.

Considering that the descriptive statistics indicated the existence of differences in student perception compared to the variables observed in the two didactic models, a parametric assumptions test was recommended to apply statistical inference and determine the significance of variance through the Student's *t*-test (Table 4).

Table 4. Parametric assumptions and Student's t-test results

Area of interest	DV	Type of activity	Sample size	Shapiro–Wilk		Levene		Student's t	
				Statistical	Significance	Statistical	Significance	Statistical	Significance
Use of class time	DV1	Traditional	75	0.99	0.97	2.06	0.20	−13.39	0.00
		Virtual reality	75	0.84	0.19			−13.39	0.00
Participation	DV2	Traditional	75	0.92	0.58	0.21	0.65	−3.60	0.01
		Virtual reality	75	0.84	0.20			−3.60	0.01
Motivation	DV3	Traditional	75	0.94	0.71	0.13	0.73	−9.67	0.00
		Virtual reality	75	0.92	0.56			−9.67	0.00
Progress	DV4	Traditional	75	0.63	0.00	3.98	0.09	−12.56	0.00
		Virtual reality	75	0.86	0.26			−12.56	0.01
Ubiquity	DV5	Traditional	75	0.80	0.10	1.41	0.27	−1.64	0.15
		Virtual reality	75	0.95	0.74			−1.64	0.16
Satisfaction	DV6	Traditional	75	0.80	0.11	1.54	0.26	−4.52	0.00
		Virtual reality	75	0.93	0.65			−4.52	0.00

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The results obtained confirmed the following parametric assumptions:

- The sample size was greater than 30 subjects in each group.
- The significance levels obtained by the Shapiro–Wilk test were above 0.05, thus ensuring the normal distribution of the DV values in the sample.
- The Levene test value was also considered significant, as it was above 0.05 in all cases. Therefore, the variances of each DV were confirmed to be homogeneous within the acceptability parameters for the samples being compared.

The confirmation of these parametric assumptions further led to a bivariate analysis.

The results of the factorial analysis of variance performed using Student's *t*-test corroborated the existence of statistical significance in the differences found between traditional and virtual reality-based teaching activities using *Second Life.* Based on the criteria stated by Weaver and Etxeberria (2005), only differences found in the following variables were considered valid for the application of parametric tests: use of class time (DV1), participation (DV2), motivation (DV3), academic performance (DV4), and satisfaction (DV6). The existence of statistically significant differences in ubiquity (DV5) was not considered (Table 5).

4. Discussion.

This study closely analyzed students' perceptions of two pedagogical models, one based on traditional teaching and the other on implementing virtual reality-based teaching using *Second Life*, in a course taught at Universidad Don Bosco in El Salvador.

Previous studies have shown that the implementation of educational technology didactic resources in training processes leads to methodological changes that university students perceive as positive compared to traditional teaching and learning situations (Sánchez-Rivas, Ruiz-Palmero, et al., 2019; Sánchez-Rivas, Sánchez-Rodríguez, et al., 2019).

When comparing the learning process with *Second Life* to the traditional learning process, the results also indicated that students perceived that achievement indicators defined in the research improved.

In the realm of virtual reality, research focused on students' perceptions of teaching approaches and virtual reality offers similar conclusions, considering that its use can have a positive effect on the teaching–learning process. Students typically perceive it as a didactic resource that supports their training process, thus being able to stimulate their learning (Calderón et al., 2020; Fernández-Sagredo et al., 2020; Flores Cruz et al., 2014; Miguélez-Juan et al., 2019).

There was a discussion element found in the media that made it possible for virtual reality teaching to occur. In this experience, we opted for virtual worlds. However, there are other options that can be studied. De Antonio et al. (2000) discussed didactic alternatives based on virtual immersion through virtual reality helmets or glasses. Juca et al. (2020) emphasized the educational potential of visualizing parts of the real world through a mobile device with graphic information added by it (augmented reality).

This study contributed to enhanced learning through specific advantages for the didactic field as a consequence of the introduction of virtual reality applications. These results allowed us to determine the variables for which the perception of students who have experienced learning with *Second Life* has improved. The students' positive perceptions were associated with the

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methodology used by the teacher. Hence, it is important to recognize the need to strengthen pedagogical knowledge in order to incorporate new technological resources into virtual reality learning environments, which will increase teachers' ability to identify the pedagogical opportunities that technological resources afford education.

At the didactic level, the effects of a virtual reality experience using *Second Life* have been studied in relation to the following variables: use of class time, participation, motivation, and academic progress. The results obtained provide evidence that the use of virtual reality in our educational context improves some of the different aspects under analysis. The next section discusses these findings by contrasting them with the conclusions of previous studies.

Regarding the use of class time, Figure 1 illustrates that considerable improvement was observed in Group B, which employed the virtual reality-based teaching approach. This result is significant in conjunction with the factorial analysis of variance, which suggests that the differences reflected are statistically significant (Table 4).

The improvement in the use of class time was noted by Bailenson et al. (2008), who highlighted that, contrary to what seems to be the case, virtual reality environments eliminate distractions and help students focus their attention on the teaching objectives. Similarly, Makransky and Lilleholt (2018) demonstrated that working in a virtual world improves students' commitment to content.

Participation is another didactic component that reveals differences when virtual reality is introduced. Descriptive statistics showed a greater interaction between students and teachers (Table 3), which could be explained by the fact that virtual reality scenarios promote encounters and teamwork. Student's *t*-test confirmed that these differences were statistically significant (Table 4).

Miguélez-Juan et al. (2019) have already confirmed that the use of virtual reality in education supports interaction between students and, in particular, the involvement of individuals who would not voluntarily participate in face-to-face teaching situations.

In their study of medical students, Lorenzo-Álvarez et al. (2019) drew conclusions along the same lines and identified participation as one of the most notable possibilities for virtual reality in university contexts. They also found that the students were less afraid of being wrong and more often dared to share their viewpoints.

In addition, students have been observed to overcome their fear of making mistakes. This can lead to the promotion of creativity, as already noted by Robinson (2015) and Yang et al. (2019) in relation to virtual reality. Without a doubt, despite being an area that has not been explored in this study, future research is highly recommended.

Participation is driven by motivation; therefore, both variables are expected to have similar behaviors. This aspect was confirmed at the descriptive level (Table 3), which revealed that students who conduct activities in virtual reality are highly motivated. Student's *t*-test also confirmed statistical significance for this aspect (Table 4).

Motivation is the most analyzed possibility with respect to the pedagogical use of virtual reality. Many previous studies have shown that virtual worlds are highly attractive to today's students, stimulating their desire to learn in a new virtual world that captures their attention (Ho *et al.,* 2019; Kim & Hall, 2019; Lin et al., 2020; Sattar et al., 2019).

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Greater motivation to learn should lead to improvements in results. In the variable of academic progress, the researchers expected improvement to be associated with virtual reality, which was confirmed by the results. From the viewpoint of descriptive statistics (Table 3), students who complete activities through virtual reality perceive an improved academic performance, and based on their better understanding of the concepts, they develop the competence established in the subject and procure efforts-based results. This finding, in contrast to the results of statistical inference (Table 4), has already been indicated by Ortega and Romans-Roca (2010) in relation to language learning. Later, other studies concluded, stating identical results, that students' performance improves through learning experiences linked to virtual reality (Cagiltay et al., 2019; Manzey et al., 2011; Topalli et al., 2019).

In summary, considering the didactic aspects, there is evidence to suggest that implementing virtual reality resources has a positive effect for students, thereby identifying improvement regarding the use of class time, participation, motivation, and perceived improvement in academic progress.

Ubiquity is another dimension mentioned in this hypothesis. However, the students did not perceive learning beyond the classroom in the VR teaching activities.

When reviewing the average scores (Table 3), some elements suggest that ubiquity in virtual reality-based teaching activities is assessed in relation to the possibility of checking work by other teams at any time. However, no differences were observed in the other aspects observed.

This situation has been determined to occur because students, within their professional major, take various courses in hybrid and virtual modalities through a university's distance learning platform. In that sense, they do not perceive that virtual reality activities allow them to learn beyond the classroom any differently from what could already be achieved. Although ubiquity has not been analyzed in relation to virtual reality, its connection to other educational technology resources has been studied, showing that students connect to the Internet using their laptops and cell phones at any time to complete academic activities, prepare assignments, study, search for information, and exchange notes (Sevillano García *et al.,* 2016). For this reason, we recommend that further studies be conducted along this line of research.

Improved teaching leads to greater student satisfaction (Díaz et al., 2017; Fernández Rico et al., 2007; Folgueiras Bertomeu et al., 2013), and this study confirms this as well, finding differences that favor activities designed in virtual reality using *Second Life*. The students recognized being more satisfied with the development of virtual reality-based teaching activities using *Second Life* than those who completed traditional activities. The responses obtained in the questionnaire (Table 3) showed that the group that completed virtual reality-based teaching activities using *Second Life* perceived their training process as more stimulating. The group also perceived the programing as consistent with pedagogical innovation, and they valued participation because they constructed their own learning, which was determined to be high-quality. Student's *t*-test confirmed that these differences were statistically significant (Table 4).

Cambra and Viniegra (2016) also concluded that virtual reality improves students' satisfaction, expectations, and interests. In that sense, similar to what has been confirmed by Kawulich

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and D'Alba (2019), we verified that the design of virtual reality-based teaching activities using *Second Life* has a positive effect on student satisfaction compared to traditional activities.

From a critical point of view, the researchers recognize that this study may lack the analysis of some other didactic aspects, such as emotions. It would be pertinent to ponder how dehumanizing education based on virtual reality can be, as well as its impact on students' socioemotional development.

Another important aspect to remember is the high cost of virtual reality resources necessary for teaching, which can impact equity in terms of access for students.

Torres et al. (2019, p. 16) also highlighted this fact with respect to Mexico and Colombia:

> Developing countries are notably lagging in terms of virtual tools, and emphasis is placed on traditional teaching–learning processes, without the incorporation of new technologies or methodologies. (…) The use of information and communication technologies is limited to access to the Internet and computers. Virtual islands, avatars, and school simulators are still inconceivable.

As a result, new pedagogical experiences should be undertaken based on virtual reality in university teaching, particularly in countries where the implementation of educational technology is emerging. In the same manner, the scientific community should continue to generate knowledge and create awareness regarding the contributions that virtual reality can make in terms of quality in such countries.

5. Conclusions.

- This study contributes to a better understanding of the students' perception of organized didactics based on virtual worlds designed by their teachers and their comparison with traditional classroom settings.
- The students at Universidad Don Bosco perceived that the integration of the virtual reality application *Second Life* with education improved significant aspects related to the learning process, such as use of class time, student participation, motivation, progress, ubiquity, and satisfaction.
- The students who participated in this study prefer integration to virtual reality through Second Life in the learning process of the university courses they take.
- The students at Universidad Don Bosco greatly value the teaching learning process mediated by virtual reality. This result raises a new research question: Is the positive perception of students inherently related to the technological resource, or is it related to the pedagogical changes that the integration of virtual reality entails? The speculative answer considers pedagogy (rather than technology) as the aspect that leads to learning process improvement. However, it is important to acknowledge that the use of a given technology such as VR involves significant changes in terms of the teaching approach.
- When placing this study's conclusions in context, the researchers discovered a widespread lack of didactic experiences and research related to the pedagogical use of virtual reality in El Salvador, reflecting a gap with other countries.

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- This research shows that virtual reality is an emerging technology that can be beneficial for higher education.

6. Contribution of the authors.

The lead author carried out the process of conceptualization, data conversions, formal analysis, and research. The co-authors contributed the methodology, writing-original draft and writing-review and editing.

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