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The Impact of Virtual Reality on Learning Strategies: An Innovative Approach to Education

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Abstract

This study addresses the lack of virtual reality devices in the process of higher education in experimental and technology-related careers. OBJECTIVE: The objective of this study is to estimate the impact caused by the implementation of Virtual Reality when considering it as a useful resource to reinforce teaching methods in students of the Regional University Amazonian Ikiam, of the careers of Hydrology, Biotechnology and Experimental Sciences. METHODOLOGY: The methodology used presented a quantitative research design with a comparative and explanatory approach because it aims to identify the level of impact caused by VR in learning strategies, with a sample of 241 students who were subdivided into an experimental group and a control group. RESULTS: The results showed that students who experienced the use of VR artifacts had a greater positive impact on their learning process and learning strategies in contrast to the control group. CONCLUSIONS: In addition, it was concluded that virtual reality has a substantially higher impact on learning strategies than traditional technologies.

Keywords: *Education; Virtual reality; Perceived learning; Learning strategies.*

Introduction

In the contemporary era, technology has entered all aspects of daily life, transforming the way people interact, communicate, and learn. In this context, the importance of VR in learning strategies is imperative in the current educational landscape. The use of this tool presents a unique and unparalleled opportunity to revolutionize the way students acquire knowledge, providing them with immersive experiences that transcend conventional methods. It is essential to understand how this technology influences learning strategies to optimize its integration into educational environments.

This innovative approach not only fosters student motivation and engagement but also creates new perspectives for personalizing learning and improving information retention. In the context of rapid and continuous change, VR has emerged as a technological tool that radically redefines the learning experience. This study examines the intersection between education and VR, exploring the impact of the latter on learning strategies with a particular focus on its innovative character.

VR, defined as a computer-generated modelled environment that simulates reality, has evolved significantly over the past decade, and has become a powerful tool in various fields, including education. The scientific literature reveals that VR not only provides an immersive experience but can also improve information retention and foster deeper learning (Toala-Palma et al., 2020). This paradigm shift in education has sparked growing interest in understanding how VR impacts learning strategies.

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The appeal of VR in education lies in its ability to create virtual environments that can simulate real-world situations. This immersive approach allows students to learn hands-on concepts and experiencing abstract concepts in a more tangible context. Recent research indicates that the application of VR in the classroom not only motivates students but also enhances the understanding of complex concepts and promotes a more active and participatory approach to the learning process (López Belmonte et al., 2019).

Incorporating VR into learning strategies opens a range of possibilities, from realistic medical simulations to three-dimensional historical explorations. This innovative approach not only diversifies ways of presenting information but also allows educators to customize learning to meet the individual needs of students (Mariscal et al., 2020). VR, by providing more authentic learning experiences, can transform education from a teacher-centered model to a student-centered model.

When considering the impact of VR on learning strategies, it is crucial to analyze how this technology influences students' cognition and engagement. Neuroeducational research suggests that immersion in virtual environments can activate areas of the brain related to memory and attention, which could translate into more effective learning (Martínez & Galván, 2020). In addition, the feeling of presence in virtual environments can increase students' engagement and motivation, which are key factors in the success of the educational process (Calderón et al., 2020).

The convergence of VR and education has been the focus of increasing conceptual interest over the last decade. The fusion of these two spheres is framed within the theory of constructivism, which postulates that learning is an active and contextualized process. From this perspective, VR is presented as a tool that facilitates knowledge construction by providing immersive environments that allow students to explore and learn experientially (Stefanoni et al., 2020).

The conceptual background of this theme is also intertwined with situated learning theory, which emphasizes the importance of learning in authentic contexts. By simulating real-world situations, VR offers students the opportunity to apply knowledge in a practical way, enhancing the transfer of skills and concepts to real situations (Serrano et al., 2020). In addition, the theory of presence in VR plays a crucial role in understanding conceptual impacts. The feeling of "being there" in virtual environments can influence motivation, attention, and information retention, which are fundamental aspects of learning strategies.

Conceptual framework

Virtual reality

VR redefines the educational experience by immersing students in three-dimensional simulated environments. This revolutionary technology not only provides a visual and auditory representation of educational content but also enables active hands-on interactions. The ability to explore virtual contexts promotes experiential learning, in which students can apply knowledge in a tangible way. By providing total immersion, VR stimulates engagement and information retention, making it a powerful and transformative educational resource (Tabash-Pérez & Sandoval-Poveda, 2021).

Learning strategies

Learning strategies are redefined with the integration of VR. Personalization of learning becomes more attainable as VR allows educational experiences to be tailored to the individual needs of learners. Active participation is encouraged through interactions with the virtual environment, which enables experiential learning. This transformation in learning strategies highlights the versatility and potential of VR to cater to diverse learning styles (Camizán García et al., 2021).

Perceived learning

The concept of perceived learning is central to understanding how students experience and value the learning process in virtual environments. It focuses on students' perceptions and attitudes toward VR as an educational tool. Investigating perceived learning involves exploring how students perceive the usefulness, ease of use, enjoyment, and effectiveness of VR compared with traditional methods (Urquidi Martin et al., 2019). Understanding these perceptions provides crucial insights into the acceptance and effectiveness of VR in the educational context, enabling adjustments and improvements that optimize the learning experience for students.

Educational innovation

VR represents an educational innovation that transcends the conventional methods. VR challenges traditional teaching and learning paradigms by offering immersive and contextually relevant experience. Educators can adopt more dynamic, learner-centered approaches, leveraging technology to inspire curiosity and engagement. This educational innovation not only diversifies pedagogical strategies, but also establishes new ways of connecting teachers and students, creating a more stimulating educational environment tailored to the demands of the 21st century (Prendes Espinosa & Cerdán Cartagena, 2020).

Impact of virtual reality on the educational process

VR integration positively impacts the educational process by improving academic performance and knowledge retention. Immersion in virtual environments facilitates a deeper understanding of abstract concepts, whereas interactivity stimulates active participation. Research indicates that VR can improve memory and attention, thereby generating more effective and sustainable learning (Riascos-Erazo et al., 2009). This impact on the educational process highlights the relevance and transformative potential of VR in improving academic outcomes and cognitive development.

Information and communication technologies and education

VR as an educational resource represents the effective convergence of Information and Communication Technologies (ICT) in education. The synergy between VR and ICT offers an integrated approach to enhance learning. ICT provides the necessary infrastructure for effective implementation of VR in educational environments, facilitating connectivity, access to resources, and collaboration. This synergistic integration not only maximizes the impact of VR but also places education at the forefront of technological innovation, preparing students for an increasingly digitized and demanding world (Tumino & Bournissen, 2020).

After all the above mentioned, the objective of this research is to estimate the impact caused by the implementation of VR as a useful resource to reinforce teaching methods in students of the Universidad Regional Amazónica Ikiam, in the careers of Hydrology, Biotechnology and Experimental Sciences. In other words, we sought to analyze how the integration of VR in educational environments influences pedagogical strategies, student participation, and learning outcomes. This study aims to provide a comprehensive view of the benefits and challenges associated with the use of VR as an educational resource, with the purpose of contributing to the development of more effective pedagogical practices adapted to contemporary educational demands.

Methodology

The present study employed a quantitative research design with a comparative and explanatory approach because it aims to identify the level of impact that implementing VR has on learning strategies between an experimental group and a control group.

The methodological justification is based on the research conducted by Calderón, et al. (2020) entitled "Virtual reality: impact on the perceived learning of Health Sciences students". The same is based on an analysis to determine whether the implementation of VR as a method to strengthen teaching strategies and the perceived learning of university students has a significant impact. In addition, it used a questionnaire composed of 20 items, of which two were eliminated for the convenience of the researcher, since it argues the presence of factorial complexity, resulting in a total of 18 items with a Likert-type scale in order to evaluate the possible statistical differences in the impact of using VR in the learning processes at the higher level.

Analysis unit

The Universidad Regional Amazónica Ikiam was selected as the institution of higher education where the research was carried out, taking into account a population of 647 students belonging to the careers: Hydrology, Biotechnology and Experimental Sciences. Then, to optimize resources and time, a sample of students was calculated using the statistical technique of non-probabilistic sampling. According to Sampieri et al. (2010) this sampling method collects data, deviates from the conventional random sampling approach, and can be valuable in situations where researchers face restricted entry into the designated population. The calculation was performed using the following formula:

$$n = \frac{z^2 \cdot N \cdot p \cdot q}{e^2 \cdot (N-1) + (z^2 \cdot p \cdot q)}$$

n= Sample size

N= Population Size

z= Confidence Level

e= Maximum accepted estimation error

p= Percentage of the population having the desired characteristic

q= 1-p= Percentage of the population that does not have the desired characteristic

Thus, considering a confidence level of 95% (1.96), 50% of the population has the desired characteristics and a margin of error of 5%, with a sample of 241 students belonging to the careers of: Hydrology, Biotechnology and Experimental Sciences. In addition, Table 1 provides a summary of the students' contributions for each career and the corresponding percentages they constitute.

Table 1. Sample of the study population

University Careers	Students	%
Hydrology	77	32,00%
Biotechnology	84	34,90%
Experimental Sciences	80	33,10%
Total	241	100%

Source: Author’s elaboration (2023).

The selected sample was subdivided into two groups: an experimental group and a control group. Although both groups were administered the questionnaire, only the experimental group was evaluated using the VR equipment. The following table summarizes the composition of each group and its percentage representation.

Table 2. Control group and experimental group

Group	Students	%
Control	132	54,80%
Experimental	109	45,20%
Total	241	100%

Source: Author's elaboration (2023).

Instrument

In order to evaluate the impact of implementing VR in the learning process and new strategies for learning, thus measuring the academic results obtained by the selected students, a questionnaire developed by Abdalá (2004) called: "Level of impact of Information and Communication Technologies (ICT) in the classroom" was used.

This instrument consists of 20 items and has a two-dimensional model that measures the learning factor and learning strategies factor. The questionnaire is consigned with a Likert scale to determine the score per item.

Cronbach's alpha

According to Rodriguez & Reguant (2020) Cronbach's Alpha coefficient is widely used to evaluate the internal consistency of a scale or questionnaire; it serves as a measure of reliability. Thus, it allows to evaluate the extent to which items consistently capture the same attribute or construct. To confirm the reliability of the scale, a minimum coefficient of 0.70 has been established, whose recommended formula for its calculation is as follows:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \Sigma_i^2}{S_T^2}\right)$$

k = number of items in the questionnaire

Si = standard deviation of each item

ST = total standard deviation of scores obtained from the questionnaire.

Mann-Whitney U test

Also known as the Wilcoxon-Mann-Whitney test, it is a non-parametric statistical test. It is used to compare two independent samples to determine whether they are from the same population or have equal probability distributions. This particular test is considered appropriate when the data do not meet the assumptions of normality, which are essential for parametric tests such as Student's t-test. Instead of comparing the means of the two samples, the Mann-Whitney U test examines whether the distributions of the two samples show statistically significant differences (Romero, 2013). This technique responds to the following formulas:

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

U1 and U2 = Mann-Whitney U statistic values

n1 = sample size of group 1

n2 = sample size for group 2

R1 = sum of the ranks of group 1

R2 = sum of the ranks of group 2

The procedure involves assigning ranks to all data combined and summing the ranks for each sample. The statistical test is based on the difference between these rank sums and compared to a table of critical values to determine if the difference is statistically significant.

t-test for independent samples

The statistical analysis known as Student's t-test for independent samples is commonly used to evaluate the differences between the means of two different groups that are not related. This test is classified as parametric because it is based on specific assumptions about the data, namely the normal distribution of the data within each group and the equal dispersion of variances. This is useful when determining whether there is a statistically significant difference between the means of two independent populations or groups (Molina et al., 2020).

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

$\bar{x}1$ = average value of group 1

$\bar{x}2$ = average value of group 2

n1 = sample size of group 1

n2 = group 2 sample size

S1 = standard deviation of group 1

S2 = standard deviation of group 2

Its calculation involves identifying the difference between the means of the two groups and comparing the difference with the variability observed in the data. The t-test generates a statistical t-value that is compared with a critical value in a student’s t-table or with a p-value, which indicates the probability of obtaining a difference as large (or larger) between the groups' means if there is no real difference.

Results

The development of the research, the experiments used and the statistical analyses that were performed on the study yielded the following results:

Table 3. Reliability of the instrument and its various scales

Scale	Specifications	Cronbach’s Alpha coefficient
Dimension 1	Learning factor	0,9183
Dimension 2	Learning strategies factor	0,9512
ICT in the classroom impact level instrument		0,9496

Source: Author’s elaboration (2023).

The table determines the reliability of the instrument that measures the impact of implementing Information and Communication Technologies in the classroom, taking into account two scales: one that evaluates the learning factor and the other that evaluates the learning strategies factor.

Since both scales present a Cronbach's alpha coefficient value higher than 0.70 Cronbach's, these factors have good consistency in the items that measure their respective sections. In addition, the instrument as a whole shows that it has a Cronbach's alpha coefficient of 0.9496, which shows the high reliability of its application.

On the other hand, Table 4 presents an analysis of the Mann-Whitney U test that aims to measure the difference of average ranges (RP) of impact on the learning process, considering the two groups under study.

Table 4. Mann-Whitney U test

Group	Average Range	p < 0,05
Control	34,43	Yes
Experimental	79,33	Yes

Source: Author's elaboration (2023).

A significant difference was observed between the average range of impact on the learning of higher-level students. In the control group, a lower PR is indicated in comparison to the PR of 79.33 presented in the experimental group.

Finally, Table 5 used a t-test for independent samples, also known as Student's t-test for different groups, to find statistical differences that are significant and yield robust results for the research.

Table 5. t-test for independent samples

Impact factors	$t_{(239)}$	r	Group	Average	Standard deviation
Learning	16,03	0,61	Control	3,29	0,84
			Experimental	4,73	0,45
Learning strategies	19,17	0,74	Control	3,21	0,83
			Experimental	4,85	0,49

Source: Author's elaboration (2023).

As previously mentioned, the statistical technique of the t-test for independent samples is used to find significant differences in impact means between two groups; in this research, a statistical finding was generated showing that the mean impact on learning perceived by Ikiam students resulted higher in the experimental group, with a mean impact of 4.73 and standard deviation of 0.45; compared to the control group that reflected a mean impact of 3.29 and a deviation of 0.84.

Similarly, in the analysis of the learning strategies factor, it was the group of students who experimented with the implementation of VR who presented a higher mean of perceived learning strategies with a 4.85 and deviation of 0.49; in contrast to the control group that reached a mean of 3.21 and a deviation of 0.49; with respect to the aforementioned factor.

Finally, it was evidenced that the effect size is large for both impact factors and in each t-test, thus explaining more than 25% of the total variance in the impact levels. In the first factor, r=0.61 and in the second factor, r=0.74, which reveals that implementing VR artifacts in the laboratories of the Universidad Regional Amazónica Ikiam can serve as a means to improve the learning perceived by its students and the learning strategies developed in the educational environment.

Discussion and conclusions

It is recorded that in recent times technology has been incorporated into the field of education, thus providing advantageous aids in the form of strategic tools to facilitate the acquisition of knowledge during the teaching and learning process. However, it should be noted that the effectiveness of these efforts, from a pedagogical perspective, depends largely on educators' competence to develop teaching programs that seamlessly integrate technology into personalized and collaborative learning encounters.

From the analysis of the acquired data, it has been determined that there is a statistically notable disparity in the average impacts, both in terms of perceived learning and perceived learning strategies, between the two groups examined. The cohort, consisting of 132 students who had never been in contact with VR equipment, obtained a mean score of 3.29 on the perceived learning dimension, accompanied by a standard deviation of 0.84. In contrast, the group of 109 students who had the opportunity to use a VR equipment obtained a mean score of 4.73 on the same dimension, with a standard deviation of 0.45. With respect to the perceived learning strategies dimension, it was found that the initial cohort of 132 students obtained a mean score of 3.21, accompanied by a standard deviation of 0.83. On the other hand, the second cohort of 109 students obtained a mean score of 4.85, with a standard deviation of 0.49.

Thus, the results of the present study align with those of previous research, consolidating the evidence on the benefits of VR in the educational setting. Consistent findings such as those of Toala-Palma et al. (2020) support the idea that VR provides an immersive experience that stimulates information retention and promotes deeper learning. This consistency suggests that VR, by providing virtual environments, enhances the understanding of abstract concepts and encourages a more active approach to learning.

Coinciding with the findings of López Belmonte et al. (2019) the results indicate that VR not only arouses students' motivation, but also positively influences their active participation. This correlation reinforces the idea that the feeling of presence in a virtual environment contributes to a more engaged and meaningful educational experience. Furthermore, there is convergence with the studies of Martínez and Galván (2017) in identifying the need to address challenges related to accessibility and equity in the implementation of VR in educational environments. However, it also highlights the importance of teacher training as an aspect highlighted in previous research, such as that of Calderón et al. (2020), which states the need to train educators to take full advantage of the potential of VR, suggesting that the effective integration of this technology requires a change in pedagogical practices and proactive adoption by teachers.

It is established that the results of this research "The Impact of Virtual Reality on Learning Strategies: An Innovative Approach in Education" align with the trends observed in previous studies, consolidating the position of VR as an innovative educational resource with positive impact on learning strategies. This consistency strengthens the validity of the findings and contributes to the body of knowledge regarding the role of VR in transforming education.

In conclusion, the results of this research strongly support that VR has a substantially superior impact on learning strategies compared to traditional technologies, this is established thanks to the analysis and application of the questionnaire "Level of impact of Information and Communication Technologies (ICT) in the classroom" to both an experimental group that used VR and a control group that followed the traditional method of learning. It has been established that immersion in virtual environments provides a unique educational experience, fostering deeper and more meaningful learning. The sensation of presence in VR improves information retention and stimulates students' active participation, thus contributing to a more effective and enriching educational process.

However, it is important to recognize the limitations of this study. VR implementation may face challenges in terms of accessibility and equity, which deserve further exploration. Additionally, the specific sample and context could influence the generalizability of the results. Future research could address these limitations using a broader approach that includes diverse student populations and educational contexts.

Also, considering the results of this study, there are several opportunities for future research. Teacher training in effective VR integration could be a fruitful area to explore, focusing on how to prepare educators to maximize the benefits of this technology. In addition, research could delve into specific strategies within VR that further optimize learning, such as personalizing content and adapting it to diverse learning styles. The intersection between VR and educational equity also deserves additional attention. Detailed research could explore how to ensure that all students, regardless of location or socioeconomic status, have access to high-quality VR educational experience. In addition, a direct comparison of the performance and retention between VR and traditional technologies could provide a more complete understanding of the relative merits of each approach.

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