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The effects of virtual and augmented reality on attitudes towards science in Mexican primary school students

Los efectos de la realidad virtual y la realidad aumentada en las actitudes hacia la ciencia en alumnos mexicanos de nivel primaria

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Abstract

The present study was carried out with elementary school students in Mexico, divided into two groups (control and experimental), and aimed to answer the question: What attitudinal effect will elementary school students have towards science if they experience learning scientific content through virtual and augmented reality? The intervention considered emerging technology because, in general terms, current students naturally speak a digital language and are characterized by thinking and processing information differently from their predecessors. It was identified through a pretest and posttest that the educational intervention in the experimental group was an important tool for helping students develop favorable attitudes towards science, such as enjoyment and fun ($p < 0.05$), while also influencing the possibility of pursuing a career in the scientific field.

Keywords: cience; virtual reality; augmented reality; technology; education.

Resumen

El presente estudio se efectuó con alumnos de primaria en México divididos en dos grupos (control y experimental), y pretendió dar respuesta a la pregunta ¿qué efecto actitudinal hacia la ciencia tendrán los alumnos de primaria si experimentan el aprendizaje de contenidos científicos mediante la realidad virtual y aumentada? La intervención contempló la tecnología emergente debido a que, en términos generales, los estudiantes actuales hablan un lenguaje digital de manera natural, además, se caracterizan por pensar y procesar información de forma diferente a sus predecesores. Con una preprueba y posprueba, se identificó que la intervención educativa en el grupo experimental fue una herramienta importante para lograr que los alumnos desarrollen actitudes favorables hacia la ciencia, como el gusto y la diversión ($p < 0.05$), a la par que influyó en la posibilidad de estudiar una carrera relacionada con el ámbito científico.

Palabras clave: *ciencia; realidad virtual; realidad aumentada; tecnología; educación.*

Introduction

The understanding of science and technology is important not only for those who work in these fields but also for any citizen who wishes to make informed decisions related to various topics. On a personal level, understanding these subjects can lead to making healthy life choices, and on a collective level, it can drive decisions and actions related to global concerns such as climate change.

Science education in primary and secondary schools must ensure that students graduate with an understanding of issues related to science and technology so that they can take an active stance in their environment. For this reason, the Organization for Economic Co-operation and Development (OECD, 2016) emphasizes the importance of designing curricula with a central focus on scientific understanding as a key component of youth education.

Similarly, the Primary Education Curriculum in Mexico mentions that the subject of Natural Sciences seeks to promote scientific education and the development of skills and attitudes toward science through four categories: scientific knowledge, applications of scientific knowledge and technology, skills associated with science, and attitudes associated with science (Secretaría de Educación Pública, SEP, 2011, p. 88). For the purposes of this project, emphasis was placed on the first and fourth categories. The graduate profile standards aim for students to acquire a basic scientific vocabulary, gradually using scientific language; develop the ability to interpret and represent processes and phenomena in nature; relate scientific knowledge transdisciplinarily; and apply what they have learned in various social and environmental contexts.

Likewise, the Peruvian Ministry of Education (2009) highlights that the aim of learning Science and Environment in primary education is to develop attitudes, competencies, knowledge, and skills through inquiry-based and experiential activities. Instruction begins with students' natural and sociocultural contexts and expands to the knowledge society through reflection and action, preparing them to face the new challenges of today and the future.

Koballa (1988) explains that there is a relationship between positive attitudes towards science lessons and the development of scientific skills. Thus, competence in science involves not only knowledge but also attitudes (OECD, 2016). Attitude can be perceived as a complex construct that includes sub-constructs such as interest, enjoyment, motivation, and perceived difficulty (Murphy et al., 2006). Simpson and Oliver (1990) note that attitude defines emotional tendencies in response to issues, people, places, events, or ideas.

Considering this, Pozo and Gómez (2009) stress the importance of fostering students' attitudes within science education. Some science teachers do not consider education in attitudes to be relevant, prioritizing the conceptual base instead. This hinders the development of curiosity and interest, thereby limiting the development of attitudes related to scientific knowledge. For the purposes of this project, student attitudes toward science were considered to include enjoyment of science classes, an inclination to study science-related careers, and personal motivation to explore specific science topics (Gutiérrez, 1998).

Additionally, the importance of developing digital skills standards among students (SEP, 2011) is highlighted, particularly regarding the use of media, tools, and digital environments to express ideas and data, interact with others, and solve problems in their surroundings. These standards are divided into the following fields: creativity and innovation; communication and collaboration; research and information management; critical thinking; problem-solving and decision-making; digital citizenship; and the functioning and concepts of information and communication technologies (ICT) (SEP, 2011).

For this project, a workshop course was designed for fourth- and fifth-grade primary school students on the Google Classroom platform. The course incorporated emerging technologies, such as virtual reality (VR) and augmented reality (AR), through applications like Chromville, Quiver, Merge Explorer, and Expeditions. Students accessed the Natural Sciences subject content through virtual reality glasses, an augmented reality cube, drawing templates, smartphones, and tablets. As a result, students were able to explore the inside of a volcano, manipulate an ecosystem, and observe the internal structure of lungs in 3D, among other activities.

The area of technology at the elementary school level

The various programs established by the Mexican Secretaría de Educación Pública (SEP) to improve infrastructure, equipment, and materials in schools have been inadequate or insufficient. This situation has led teachers who wish to incorporate new technologies to purchase the necessary materials with their own resources (Flores, 2012). To date, the promised support for teachers in the form of training or decent software and hardware equipment has not been fulfilled, nor has each student been provided with a computer or laptop with internet access.

One of the most notable failed attempts to integrate technology into basic education in Mexico was the Enciclomedia program, an online education system introduced in 2003. A few years later, in 2008, the Auditoría Superior de la Federación (2010) reported that there was no evidence of improved educational quality from this program and found irregularities in the management of the allocated budget. This pattern continued with subsequent programs like micompu.mx and @prende, which did not surpass the pilot testing phase and were only implemented with small samples of the student population.

One of the latest government-implemented educational technology programs was @prende 2.0, launched in 2016. The aim of this program was to promote digital inclusion, the development of digital skills, and computational thinking in children to prepare them for the productive society demanded by the 21st century. This new program includes six components: teacher training in ICT; strategic initiatives that foster digital inclusion and skill development, and computational thinking; equipment; digital educational resources; different connectivity models; and monitoring and evaluation strategies (SEP, 2016).

For an educational plan to have a societal impact, it must first gain the acceptance of political authorities, then be adopted by the bureaucracy, and finally receive approval from society in the planning process (Castrejón, 1973). It would also be worthwhile to add a step: analysis and validation by experts in the field of education. Many problems arise from the disconnect between the superficial understanding of the educational context by politicians and the daily educational reality experienced by classroom teachers.

Augmented reality

Augmented Reality (AR) is a technology that complements a user's perception and interaction with the real world. It consists of a superimposition of computer-generated graphics that implement or incorporate virtual objects into the real world, allowing the user to perceive both real and virtual objects in the same space (Buenfil et al., 2018). Majid et al. (2015) define AR as an interaction medium between a human and a computer that generates information in the real world.

Similarly, Kysela and Storková (2015) state that AR is a way of displaying digital content in the real world and enables possible interactions between the user and their surroundings. In the educational realm, AR can be used by teachers as a support tool to present content in an interactive and attractive manner. For students, it allows for active immersion in this technological platform, facilitating the construction of knowledge through interaction with virtual objects presented in the real world (David, 2011).

Blázquez (2017) highlights several benefits of using AR: it increases student motivation, encourages collaborative work through various applications, promotes knowledge-building through discovery and active learning, and, finally, supports the development of technological skills.

Taking all of this into account, it is possible to affirm that augmented reality "is a technology that can greatly aid pedagogical and didactic processes in the classroom" (Buenfil et al., 2018, p. 35). It would be wise to leverage the widespread acceptance of information and communication technologies (ICT) among contemporary students to provide new ways of guiding, interacting, and producing knowledge using such tools. Moreover, contrary to popular belief, most AR applications are free and can be used with a wide variety of mobile devices, such as smartphones or tablets.

Virtual reality

Virtual Reality (VR) is defined by Wan and Reid (2011) as the creation of simulated environments and situations using computer equipment that generates either real or virtual images. This environment is interactive, meaning that it allows the user to observe computer-generated images and objects and move freely in a space stimulated by the senses, creating the sensation of being immersed and directly participating in the experience. This technology requires a VR headset or goggles worn on the head to create the visual and auditory sensation of being immersed and interacting in a simulated world (Varnum, 2019).

Jennett et al. (2008) explain that when the goggles are put on, the proximity of the three-dimensional images tricks the brain into believing the user is immersed in a VR world, to the extent that users often lose track of time. People feel like they are inside this artificial world because they can navigate a 360-degree environment and even manipulate some objects (España et al., n.d.). In addition to allowing movement in space, VR provides the possibility of traveling to other times, leading to comparisons between VR and a time machine due to its increasingly believable realism (Martínez, 2011).

Methods and materials

It was observed that primary school students exhibited apathetic and negative attitudes towards science. To address this problem, a science course-workshop was implemented for fourth- and fifth-grade primary school students during the 2020-2021 school year. The goal was to use VR and AR technologies to foster enjoyment in the subject. This followed the proposal to adapt teaching to the new information society and cater to digital-native students, contributing to the renewal of educational culture. This project is considered innovative, as there are few studies in Mexico on the educational effects of using VR or AR, especially among primary school students.

The course-workshop was conducted between November and December 2020, complementing the regular classes. It consisted of 21 one-hour sessions, each accompanied by instructional videos lasting a maximum of five minutes. The topics covered included the solar system, body systems and functions, physical states of matter, the water cycle, food chains, plant nutrition, and volcanoes. The workshop was designed on the Google Classroom platform, which students were already familiar with after a year of online learning due to the COVID-19 pandemic. This allowed participants to complete activities from home at their convenience.

The instructional videos and materials were created using the Powtoon software and Google Slides presentations, while the applications used to access VR and AR content included Chromville, Quiver, Merge Explorer, and Expeditions. Mobile devices (tablets and smartphones) were used to access applications that allowed students to view VR content (immersion in a virtual world with VR goggles) and AR content (real-time interaction with the physical environment, augmented with virtual elements).

The project's hypothesis was to determine whether the students who participated in the "Digital Science" course-workshop would show a greater interest in science compared to the control group. To analyze whether the emerging technology employed changed attitudes towards science, the project focused on the affective component, considered by some authors as the most relevant when evaluating a positive or negative perception of an object or person (Marín, 1990).

In this context, Vázquez and Manassero (2008) identified that positive attitudes towards science tend to decline as students' progress through educational levels. Therefore, this study considered it important to establish an educational intervention with teaching strategies that incorporate VR and AR to spark and increase interest in science.

For the project, two groups were created: a control group and an experimental group. The experimental group participated in the extracurricular course-workshop, while the control group continued with their regular online classes. Both groups were given a pretest and a posttest to compare the results and identify similarities or differences in their attitudes toward science after the intervention.

In addition to the pretest and posttest, a qualitative evaluation tool was designed and applied after the intervention. Participants were asked to provide feedback on the methodological development of the project, including the course content, teaching strategies used, applications employed, and general comments on the experience. The responses were categorized and analyzed based on the themes and frequency of terms used.

Instruments

Since the primary interest of this research was to examine attitudes towards science, a questionnaire was designed to assess students' attitudes. This questionnaire was applied as a pre-test and post-test, aiming to contrast and identify whether the students' attitudes towards science changed after participating in the intervention project.

The instrument was created based on the Attitude towards Science Protocol (PAC) by Vázquez and Manassero (1997), the PISA 2015 test (OECD, 2016), and the instrument used by Hernández et al. (2011). The questionnaire was validated by four experts (two university-level researchers and two primary school teachers with more than 15 years of classroom experience), who evaluated the relevance, sufficiency, and clarity of each item and provided feedback and general recommendations. The validation of the test was carried out using three specific criteria:

- Relevance: Assessing whether the question helps measure the liking and/or interest in Natural Sciences.

- Sufficiency: Evaluating whether the included questions are necessary to measure the liking and/or interest in Natural Sciences.

- Clarity: Ensuring that the language used is clear and appropriate for primary school students.

Based on the review of these statements, it was determined which were valid for yielding accurate and efficient results, and the wording was modified to suit the students' age, ensuring the questions were relevant, sufficient, and clear.

Thus, in this study, students' attitudes towards science were measured through their responses to a set of statements. The magnitude of their attitudes was determined by their level of agreement or disagreement with each item. To verify the theoretical consistency of the instrument, Cronbach's Alpha was used to validate the 11 items that comprised the attitude scale towards science. The Cronbach's Alpha value was 0.877, validating the instrument's internal consistency.

Sample

This study utilized a quasi-experimental research design. The sampling was purposive, as participants were selected based on one criterion: their attitude towards science. As mentioned, the sample was divided into two groups. The experimental group consisted of 16 students—9 boys and 7 girls aged 9 to 10 years—while the control group also had 16 students with similar characteristics in terms of age, gender, and pre-test responses. In Table 1, it is shown that both groups behaved similarly in the pre-test, as their responses to all items had a similar trend. This is confirmed by the fact that none of the scores were below 0.50, and the average responses to each question were quite similar between the two groups.

Procedure and analysis

The experimental intervention in this study consisted of five stages (see Figure 1):

1. Pilot Test: This allowed adjustments to be made to the content of the videos and the wording of instructions in the educational intervention project.

2. Study Groups: Participants in both the control and experimental groups were defined. Both groups had the same number of students with similar characteristics in terms of age, gender, and pre-test responses.

3. Pre-test: A preliminary test to assess attitudes towards science was administered to both the experimental and control groups.

4. Educational Intervention: The experimental group participated in the "Digital Science" course for one month, which incorporated VR and AR technology, while the control group continued their regular lessons without the use of emerging technology.

5. Post-test: A follow-up test was administered to the students in both groups to measure any changes in attitudes towards science.

For the analysis of the data obtained, the Statistical Package for the Social Sciences, version 25 (SPSS 25), was used. The level of statistical significance was set at $p < 0.05$. A paired and independent T-test was also applied to compare the students' attitudes toward science in the experimental and control groups.

Results

First, a descriptive analysis is conducted, supported by graphs and tables that show the results of the items with the most significant differences between the pre-test and post-test (items 1, 3, and 9). Then, a comparison of paired T-tests between the pre-test and post-test of both groups is presented. In Table 2, we can see the response to Item 1, Do you like science? The "Always" response increased from 37.5% in the pre-test to 50% in the post-test for the experimental group. In contrast, in the control group, it decreased from 18.8% to 12.5% (see Graph 1).

In Item 3: Do you find science fun? the response “Always” increased in the experimental group, from 37.5% to 43.8%. In contrast, in the control group, the “Always” response decreased from 31.3% to 6.3%, while the “Very rarely” response increased from 6.3% to 25% (see Table 3 and Graph 2).

On the other hand, in item 9) Would you like to be a scientist when you grow up?, it was identified that the students in the experimental group had a change of opinion regarding the degree program they would like to study. At the beginning, 37.5% of the students said that they were not interested in this field, but in the post-test this answer was given by only 12.5%.

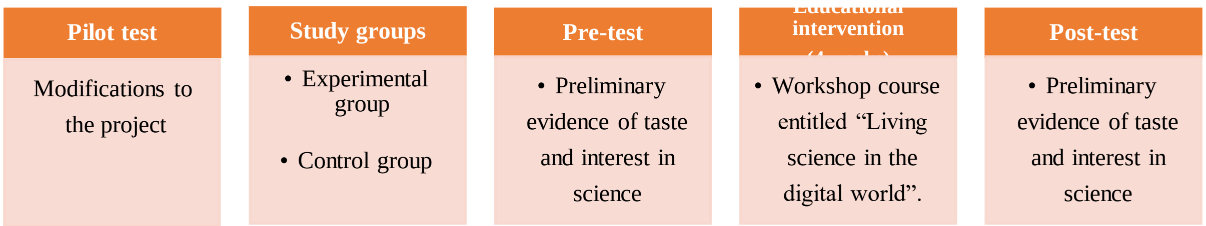
Table 1. Comparison between the control and experimental group in the test

Type of test			Levene's test for equality of variances		T-test for equality of means						
			F	Sig.	t	gl	Sig. (bilateral)	Difference in averages	Standard error of difference	95% Confidence interval for the difference	
										Inferior	Superior
Pre-test	1) Do you like science?	Equal variances have been assumed	.932	.342	1.868	30	.072	.625	.335	-.058	1.308
		Equal variances have not been assumed	-	-	1.868	28.996	.072	.625	.335	-.059	1.309
	2) Do you find science interesting?	Equal variances have been assumed	1.627	.212	1.344	30	.189	.438	.326	-.227	1.102
		Equal variances have not been assumed	-	-	1.344	26.947	.190	.438	.326	-.231	1.106
	3) Do you find science fun?	Equal variances have not been assumed	1.938	.174	1.048	30	.303	.375	.358	-.356	1.106
		Equal variances have not been assumed	-	-	1.048	26.459	.304	.375	.358	-.360	1.110
	4) How difficult do you find science?	Equal variances have been assumed	.254	.618	1.000	30	.325	.250	.250	-.261	.761

Type of test			Levene's test for equality of variances		T-test for equality of means						
			F	Sig.	t	gl	Sig. (bilateral)	Difference in averages	Standard error of difference	95% Confidence interval for the difference	
										Inferior	Superior
		Equal variances have not been assumed	-	-	1.000	29.867	.325	.250	.250	-.261	.761
	5) Do you enjoy asking questions about science?	Equal variances have been assumed	.007	.935	-1.155	30	.257	-.438	.379	-1.211	.336
		Equal variances have not been assumed	-	-	-1.155	29.995	.257	-.438	.379	-1.211	.336
	6) Are you curious about how the human body works?	Equal variances have been assumed	.004	.950	-.469	30	.643	-.188	.400	-1.005	.630
		Equal variances have not been assumed	-	-	-.469	29.385	.643	-.188	.400	-1.006	.631
	7) Are you curious to learn about living things?	Equal variances have been assumed	2.738	.108	.408	30	.686	.188	.460	-.751	1.126
		Equal variances have not been assumed	-	-	.408	27.027	.686	.188	.460	-.755	1.130

Type of test			Levene's test for equality of variances		T-test for equality of means						
			F	Sig.	t	gl	Sig. (bilateral)	Difference in averages	Standard error of difference	95% Confidence interval for the difference	
										Inferior	Superior
	8) Are you curious about the world and the universe?	Equal variances have been assumed	.000	1.000	-.785	30	.439	-.188	.239	-.675	.300
		Equal variances have not been assumed	-	-	-.785	29.483	.439	-.188	.239	-.676	.301
	9) Would you like to be a scientist when you grow up?	Equal variances have been assumed	.031	.861	-.439	30	.663	-.188	.427	-1.059	.684
		Equal variances have not been assumed	-	-	-.439	29.999	.663	-.188	.427	-1.059	.684
	10) Do you think science is useful?	Equal variances have been assumed	.034	.855	.243	30	.810	.063	.258	-.464	.589
		Equal variances have not been assumed	-	-	.243	30.000	.810	.063	.258	-.464	.589
	11) Does science help you in any way in your life?	Equal variances have been assumed	.439	.513	.634	30	.531	.250	.395	-.556	1.056
		Equal variances have not been assumed	-	-	.634	28.525	.531	.250	.395	-.558	1.058

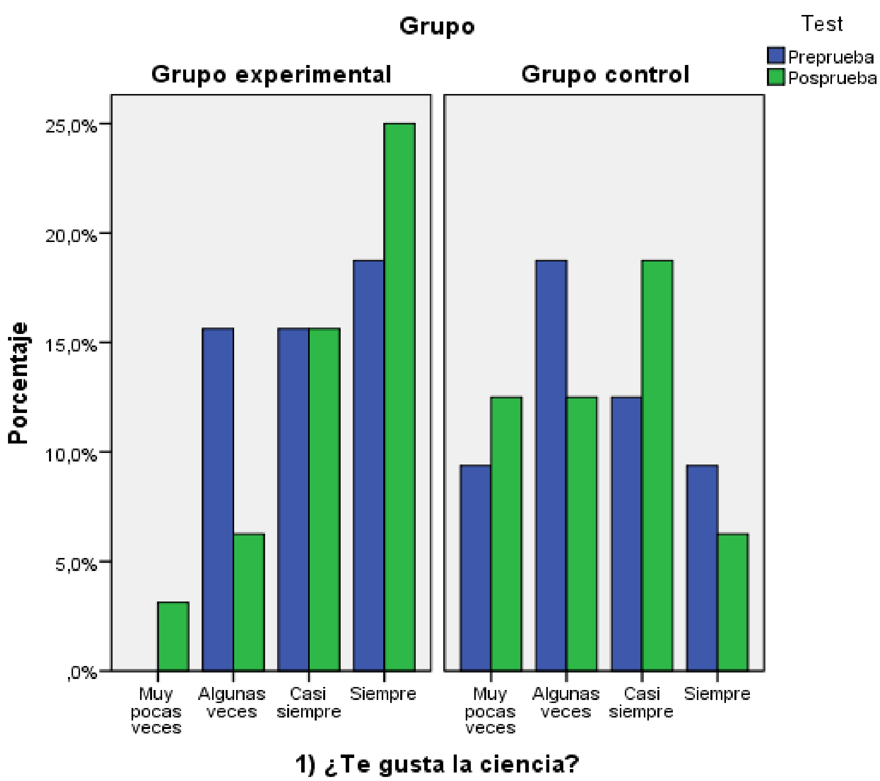
Figure 1. The intervention procedure of the study, 2020



Source: by the author.

Similarly, 18.8% of students had responded in the pre-test that they might like to become a scientist, and this number increased to 56.3% in the post-test. In contrast, the percentage of students in the control group who expressed no interest remained unchanged at 25.0%, while those who responded “Probably” decreased from 31.3% to 18.8% (see Table 4 and Graph 3).

Graphic 1. Percentage distribution of item 1 of the pre-test - post-test of attitude about science in the control and experimental groups.



Source: By the autor

Table 2. Crosstabulation of item 1) Do you like science?

Groupe				Test: Pretest	Test: Postest	Total
Experimental group	1) Do you like science?	Very few times	Recount	0	1	1
			% within Test	0.0%	6.3%	3.1%
		Sometimes	Recount	5	2	7
			% within Test	31.3%	12.5%	21.9%
		Almost always	Recount	5	5	10
			% within Test	31.3%	31.3%	31.3%
		Always	Recount	6	8	14
			% within Test	37.5%	50.0%	43.8%
	Total		Recount	16	16	32
			% within Test	100.0%	100.0%	100.0%
Control group	1) Do you like science?	Very few times	Recount	3	4	7
			% within Test	18.8%	25.0%	21.9%
		Sometimes	Recount	6	4	10
			% within Test	37.5%	25.0%	31.3%
		Almost always	Recount	4	6	10
			% within Test	25.0%	37.5%	31.3%
		Always	Recount	3	2	5
			% within Test	18.8%	12.5%	15.6%
	Total		Recount	16	16	32
			% within Test	100.0%	100.0%	100.0%

Source: by the author

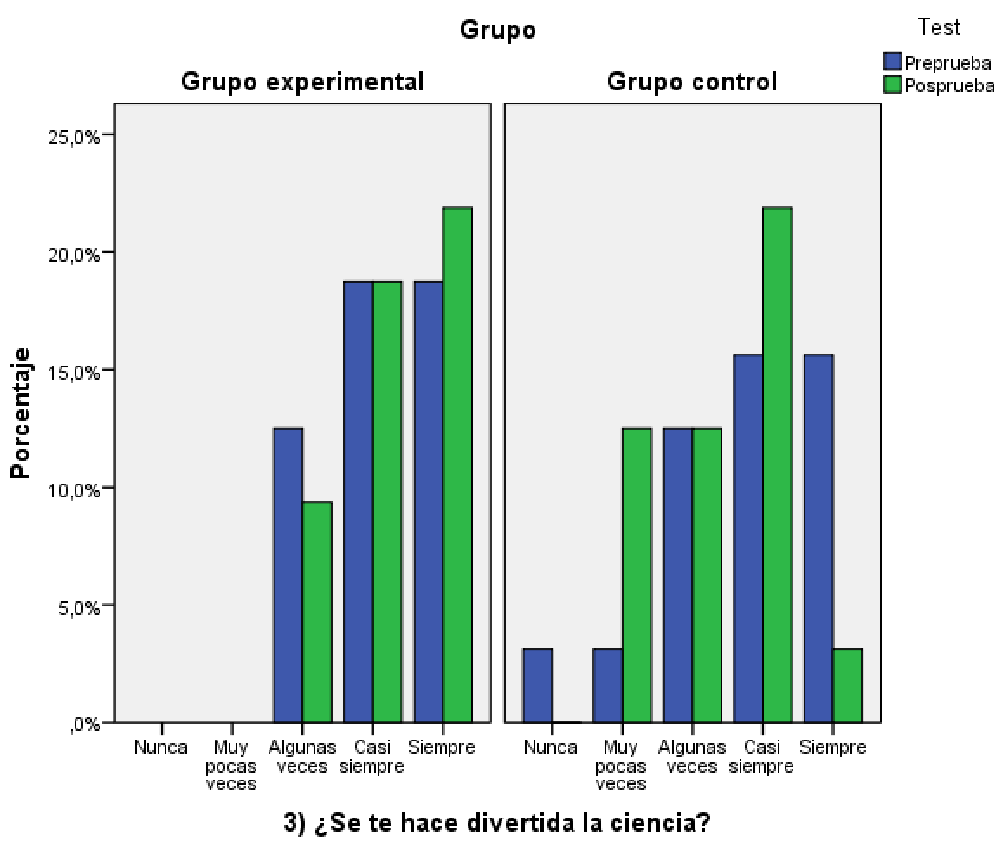
Tabla 3. Crosstabulation of item 3) Is science fun for you?

Groupe				Test: Pretest	Test: Postest	Total
Experimental group	3) Do you find science fun?	Very few times	Recount	4	3	7
			% within Test	25.0%	18.8%	21.9%
		Almost always	Recount	6	6	12
			% within Test	37.5%	37.5%	37.5%
		Always	Recount	6	7	13
			% within Test	37.5%	43.8%	40.6%
	Total		Recount	16	16	32
			% within Test	100.0%	100.0%	100.0%
Control group	3) Do you find science fun?	Never	Recount	1	0	1
			% within Test	6.3%	0.0%	3.1%
		Very few times	Recount	1	4	5
			% within Test	6.3%	25.0%	15.6%

		Sometimes	Recount	4	4	8
			% within Test	25.0%	25.0%	25.0%
		Almost always	Recount	5	7	12
			% within Test	31.3%	43.8%	37.5%
		Always	Recount	5	1	6
			% within Test	31.3%	6.3%	18.8%
	Total		Recount	16	16	32
			% within Test	100.0%	100.0%	100.0%

Source: by the author

Graphic 2. Percentage distribution of item 3 of the science attitude pre-test-post-test in the control and experimental groups.



Source: by the author

The average scores for each item in both the control and experimental groups are presented in Table 5. Both groups behave similarly in the pre-test, as the responses across all items show a similar trend. To determine if these averages are statistically significant, a T-test was conducted, and none of the items scored below 0.50, meaning that the average response per question is similar between the two groups in the pre-test. However, in the post-test, there is a noticeable difference between the groups in questions 1 (Do you like science?) and 3 (Do you find science fun?).

Table 4. Crosstabulation of item 9) Would you like to be a scientist when you grow up?

Groupe				Test: Pretest	Test: Postest	Total
Experimental group	9) Would you like to be a scientist when you grow up?	No	Recount	6	2	8
			% within Test	37.5%	12.5%	25.0%
		Probably no	Recount	0	2	2
			% within Test	0.0%	12.5%	6.3%
		Maybe yes, maybe no	Recount	7	3	10
			% within Test	43.8%	18.8%	31.3%
		Problaly	Recount	3	9	12
			% within Test	18.8%	56.3%	37.5%
	Total		Recount	16	16	32
			% within Test	100.0%	100.0%	100.0%
Control group	9) Would you like to be a scientist when you grow up?	No	Recount	4	4	8
			% within Test	25.0%	25.0%	25.0%
		Probably no	Recount	3	2	5
			% within Test	18.8%	12.5%	15.6%
		Maybe yes, maybe no	Recount	4	5	9
			% within Test	25.0%	31.3%	28.1%
		Problaly	Recount	5	3	8
			% within Test	31.3%	18.8%	25.0%
		Yes	Recount	0	2	2
			% within Test	0.0%	12.5%	6.3%
	Total		Recount	16	16	32
			% within Test	100.0%	100.0%	100.0%

Source: by the author

The second level of analysis includes the comparative paired T-tests. First, it is identified that between the pre-test and post-test in the experimental group (see Table 6), only one question showed significance below 0.05, which was Item 9: Would you like to be a scientist when you grow up? In other words, the students had a change of opinion regarding the career they would like to pursue.

In the paired T-test results for the control group (Table 7), none of the items had a significant difference, meaning that there was no notable change between the pre-test and post-test.

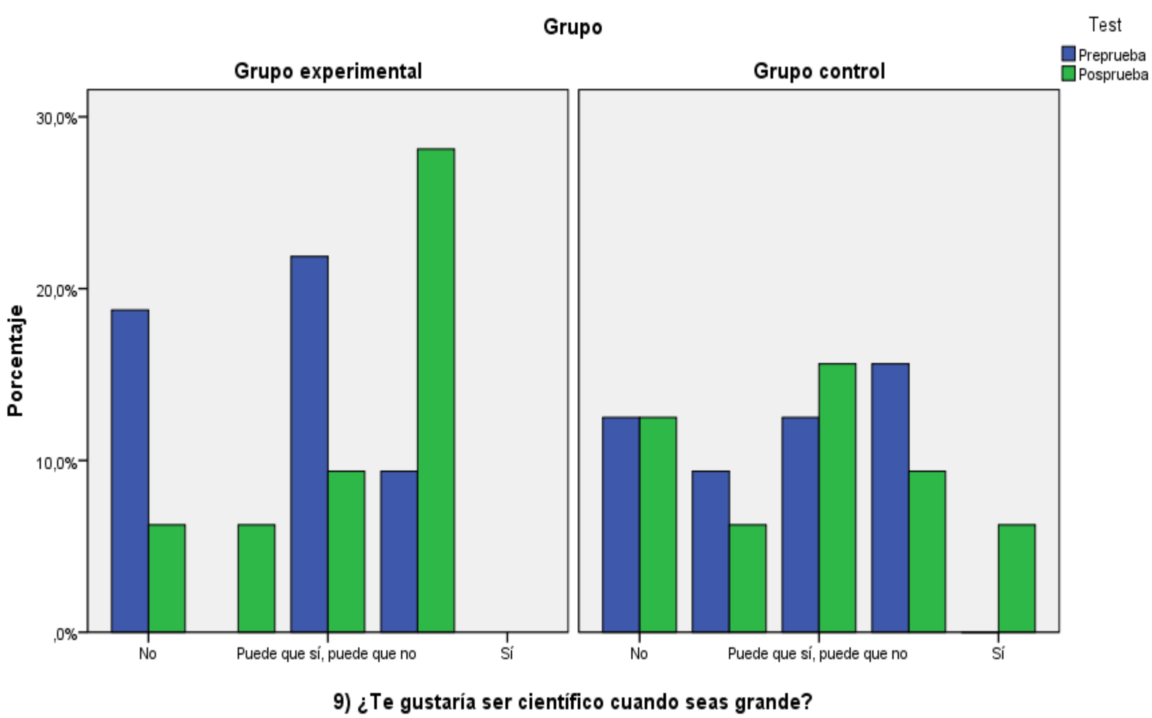
Discusion

This study shows that the implementation of an educational intervention using virtual reality (VR) and augmented reality (AR) in primary school positively impacted students' attitudes towards science, especially in terms of enjoyment and curiosity.

Item 9, Would you like to be a scientist when you grow up? showed the most significant change in students' opinions. In the pre-test, 37.5% of students from the experimental group were not interested in becoming scientists, but this number decreased to 12.5% after the intervention, while 56.3% of students responded "Probably" in the post-test, compared to only 18.8% in the pre-test. This change suggests that incorporating emerging technologies like VR and AR can inspire greater interest in scientific careers.

Another significant change was observed in Item 3, Do you find science fun? In the experimental group, 43.8% of students answered "Always" in the post-test compared to 37.5% in the pre-test, while in the control group, the percentage decreased from 31.3% to 6.3%. This highlights that the educational intervention made science more enjoyable for students, while traditional methods in the control group may have caused some decline in interest.

Graphic 3. Percentage distribution of item 9 of the science attitude test-posttest in the control and experimental groups.



Source: by the author

Table 5. Control and experimental group statistics

	Ítem	Groupe	N	Mean	Standard deviation.	Standard error of the mean
Pretest	1) Do you like science?	Experimental	16	4.06	.854	.213
		Control	16	3.44	1.031	.258
	2) Do you find science interesting?	Experimental	16	4.19	.750	.188
		Control	16	3.75	1.065	.266
	3) Do you find science fun?	Experimental	16	4.13	.806	.202
		Control	16	3.75	1.183	.296
	4) How difficult do you find science?	Experimental	16	3.50	.730	.183
		Control	16	3.25	.683	.171
	5) Do you enjoy asking questions about science?	Experimental	16	3.31	1.078	.270
		Control	16	3.75	1.065	.266
	6) Are you curious about how the human body works?	Experimental	16	3.81	1.047	.262
		Control	16	4.00	1.211	.303
	7) Are you curious to learn about living things?	Experimental	16	4.06	1.063	.266
		Control	16	3.88	1.500	.375
	8) Are you curious about the world and the universe?	Experimental	16	4.44	.629	.157
		Control	16	4.63	.719	.180
	9) Would you like to be a scientist when you grow up?	Experimental	16	2.44	1.209	.302
		Control	16	2.63	1.204	.301
	10.-Do you think science is useful?	Experimental	16	4.56	.727	.182
		Control	16	4.50	.730	.183
	11) Does science help you in any way in your life?	Experimental	16	4.19	.981	.245
		Control	16	3.94	1.237	.309
Postest	1) Do you like science?	Experimental	16	4.25	.931	.233
		Control	16	3.38	1.025	.256
	2) Do you find science interesting?	Experimental	16	4.19	.750	.188

	Ítem	Groupe	N	Mean	Standard deviation.	Standard error of the mean
		Control	16	3.69	1.138	.285
	3) Do you find science fun?	Experimental	16	4.25	.775	.194
		Control	16	3.31	.946	.237
	4) How difficult do you find science?	Experimental	16	3.63	1.204	.301
		Control	16	3.44	1.209	.302
	5) Do you enjoy asking questions about science?	Experimental	16	3.44	1.031	.258
		Control	16	3.13	1.310	.328
	6) Are you curious about how the human body works?	Experimental	16	3.63	.957	.239
		Control	16	3.94	1.526	.382
	7) Are you curious to learn about living things?	Experimental	16	4.19	.981	.245
		Control	16	4.19	1.377	.344
	8) Are you curious about the world and the universe?	Experimental	16	4.69	.479	.120
		Control	16	4.19	1.109	.277
	9) Would you like to be a scientist when you grow up?	Experimental	16	3.19	1.109	.277
		Control	16	2.81	1.377	.344
	10.-Do you think science is useful?	Experimental	16	4.56	.814	.203
		Control	16	4.56	.727	.182
	11) Does science help you in any way in your life?	Experimental	16	4.13	.885	.221
		Control	16	3.75	1.291	.323

Source: by the author

Table 6. Related samples pretest-posttest test of the experimental group

		Related differences					t	gl	Sig. (bila-teral)
		Mean	Standard deviation.	Standard error of the mean	95% Confidence interval for the difference				
					Inferior	Superior			
Par 1	1) Do you like science?	-.188	.750	.187	-.587	.212	-1.000	15	.333
Par 2	2) Do you find science interesting?	.000	.966	.242	-.515	.515	.000	15	1.000
Par 3	3) Do you find science fun?	-.125	1.025	.256	-.671	.421	-.488	15	.633
Par 4	4) How difficult do you find science?	-.125	1.025	.256	-.671	.421	-.488	15	.633
Par 5	5) Do you enjoy asking questions about science?	-.125	1.025	.256	-.671	.421	-.488	15	.633
Par 6	6) Are you curious about how the human body works?	.188	.911	.228	-.298	.673	.824	15	.423
Par 7	7) Are you curious to learn about living things?	-.125	1.088	.272	-.705	.455	-.460	15	.652
Par 8	8) Are you curious about the world and the universe?	-.250	.577	.144	-.558	.058	-1.732	15	.104
Par 9	9) Would you like to be a scientist when you grow up?	-.750	1.125	.281	-1.350	-.150	-2.666	15	.018
Par 10	10.-Do you think science is useful?	.000	1.095	.274	-.584	.584	.000	15	1.000
Par 11	11) Does science help you in any way in your life?	.063	.772	.193	-.349	.474	.324	15	.751

Source: by the author

In this regard, some of the comments from the students and parents in the session evidence were highlighted:

- I learned about the planets, I looked at how real it is, as if I could touch them, I really love that and to think that I can be an astronaut and admire the planets, this is very magical (student 16, session 21 survey, 2020).
- I was impressed with how the planets look, it's amazing to enjoy it with my family, such a wonderful experience, my mom loves it too (student 4, session 21 survey, 2020).
- It's a fun way to learn without being bored (parent 10, session 21 survey, 2020).
- "Thank you for this new experience of learning in a fun way for the children." (Parent 3, session 21 survey, 2020).

- "Thank you for the opportunity to learn and have fun." (Parent 7, session 21 survey, 2020).

Tabla 7. Related samples pretest-posttest control group test

		Related differences					t	gl	Sig. (bilateral)
		Mean	Standard deviation.	Standard error of the mean	95% Confidence interval for the difference				
					Inferior	Superior			
Par 1	1) Do you like science?	.063	1.063	.266	-.504	.629	.235	15	.817
Par 2	2) Do you find science interesting?	.063	.929	.232	-.432	.557	.269	15	.791
Par 3	3) Do you find science fun?	.438	1.315	.329	-.263	1.138	1.331	15	.203
Par 4	4) How difficult do you find science?	-.188	1.328	.332	-.895	.520	-.565	15	.580
Par 5	5) Do you enjoy asking questions about science?	.625	1.455	.364	-.150	1.400	1.718	15	.106
Par 6	6) Are you curious about how the human body works?	.063	1.482	.370	-.727	.852	.169	15	.868
Par 7	7) Are you curious to learn about living things?	-.313	1.852	.463	-1.299	.674	-.675	15	.510
Par 8	8) Are you curious about the world and the universe?	.438	.814	.203	.004	.871	2.150	15	.048
Par 9	9) Would you like to be a scientist when you grow up?	-.188	1.328	.332	-.895	.520	-.565	15	.580
Par 10	10.-Do you think science is useful?	-.063	.680	.170	-.425	.300	-.368	15	.718
Par 11	11) Does science help you in any way in your life?	.188	1.424	.356	-.572	.947	.527	15	.606

Source: by the author

It is important to note that authors like Murphy et al. (2006) consider attitude as a construct that encompasses interest, enjoyment, and motivation. Meanwhile, an evaluative response expresses a like or dislike (Fiske et al., 1998) towards something or someone; thus, fun can be considered an attitude of acceptance. For this reason, López (2010) concludes that if interest and enjoyment for science are stimulated from a young age, students will not only see it as something fun and useful but will also give it real and direct significance in their lives.

Additionally, the following hypothesis was established in the document: students who participated in the course-workshop would show a greater interest in science. Statistical analyses were revisited to analyze the similarities or differences in the attitude towards science shown by participants from each group. In the case of items 1, 3, and 9, it is observed that students' attitudes towards science are not the same for both groups between the pre-test and post-test. This means that aspects related to enjoyment and fun in science, as well as the interest in pursuing a scientific career, differ between the control and experimental groups after the educational intervention.

In the evaluation of the Digital Science course-workshop, a positive sense of gratitude stands out regarding the activities and applications that made up the educational intervention. Students noted that they learned not only about scientific content but also about the use of technology. This confirms what was proposed by Shreesha and Sanjay (2018): digital technology enhances the teaching-learning process, as ICT supports the refinement of information searching, school autonomy, self-discipline, and motivation to study. Furthermore, Blázquez (2017) adds that emerging technology encourages knowledge building through discovery and active learning, as well as contributing to the development of technological skills.

The activities carried out in the course-workshop sparked curiosity about how the human body, living beings, the world, and the universe work. A positive attitude towards science and experimentation was shown through simulations using 3D templates, VR glasses, and a holographic cube. Students experimented with elements they could hardly have interacted with directly and immediately, such as visiting a volcano or seeing lungs from the inside. This experience altered attitudes towards studying science, as shown in the post-test results, with more students leaning towards vocational interests in science.

It is important to emphasize that these data represent the students' perceptions immediately after completing the course-workshop, so it cannot be guaranteed that these positive attitudes will remain constant over time. Additionally, as is often the case with data collected in the context of a focus group, some participants may have been influenced by the attitudes expressed in other students' comments or by a desire to please the researcher.

Conclusions

The intervention project described implemented a workshop based on VR (Virtual Reality) and AR (Augmented Reality), where an instrument was developed to evaluate participants' attitudes towards science, and another to evaluate the project itself. The results showed that this approach is effective in improving students' attitudes towards science. The lack of interest in science among young people is a significant issue, as students gradually stop showing an exploratory attitude and curiosity towards science as they progress in their studies (Trujillo, 2001). This is also reflected in the low number of individuals who choose a career in science (Adúriz et al., 2011).

This situation is even more pronounced among women, as studies reveal that girls, from an early age, do not typically show interest in the fields of science, technology, engineering, and mathematics (STEM) (SEP and OECD, 2018; Montenegro et al., 2018). They tend to score lower in mathematics on the PISA test (SEP, 2017), and few opt for a career in science, as women represent only 28% of all researchers worldwide (UNESCO, 2019; INEGI, 2013). Therefore, it would be advisable for future research to further explore the ways in which men and women perceive science.

This study demonstrates that the use of virtual reality (VR) and augmented reality (AR) in the teaching of Natural Sciences in primary education has the potential to improve students' attitudes towards science. Specifically, the experimental group showed a significant increase in positive attitudes towards science, such as enjoyment, curiosity, and interest in pursuing a scientific career, compared to the control group, where these changes were not observed.

The fact that students who participated in the intervention began to view science as more enjoyable and fun suggests that the use of emerging technologies, like VR and AR, can make learning more engaging and effective. By immersing students in interactive experiences, such as exploring the inside of a volcano or manipulating ecosystems in three dimensions, the technology stimulates curiosity and provides a more profound understanding of scientific concepts. This contrasts with traditional educational methods that may not always capture students' attention or interest.

Furthermore, the notable increase in the experimental group's interest in becoming scientists demonstrates that integrating technology into education can have long-term effects on career aspirations. As the world becomes increasingly digital, the ability to use and understand new technologies will be crucial in various fields, including science.

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