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Application of Virtual Reality and its effects on the perception of university students

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ABSTRACT

This quasi-experimental, correlational study (N=391) explores immersive virtual reality's (VR) impact on immersion, motivation, and learning outcomes in academic settings. Two groups of university students participated, with the control group receiving VR usability explanations and the experimental group engaging in VR activities via 360-degree videos on mobile devices. Applying the Unified Theory of Technology Acceptance and Use 2 (UTAUT2) model, we measured prospective teachers' behavioural intention towards immersive VR. Results revealed the experimental group scored lower than the control on Hedonic Motivation, Social Influence, and Price Value, indicating repeated VR use may diminish perceived enjoyment, social pressure, and value for money of the technology. The intraclass correlation coefficient (ICC) and Levene's *t*-test affirmed inconsistencies and significant differences between groups on these factors. Conversely, the experimental group scored higher on Effort Expectancy and Facilitating Conditions, suggesting increased perceived ease of use and resource availability. However, no significant differences emerged in Performance Expectancy and Habit, implying the VR intervention had no impact on perceived usefulness and habitual use of VR. These findings highlight the importance of sustaining positive VR perceptions and optimizing its benefits for enhanced learning experiences.

Keywords: virtual reality, immersive reality, motivation, teacher training, higher education.

Aplicación de la Realidad Virtual y sus efectos en la percepción del alumnado universitario

RESUMEN

Este estudio cuasiexperimental y correlacional (N=391) examina el impacto de la realidad virtual (RV) inmersiva en la inmersión, motivación y resultados académicos. Participaron dos grupos de estudiantes universitarios: el grupo de control recibió explicaciones sobre la usabilidad de la RV, mientras que el grupo experimental participó en actividades con videos 360º en dispositivos móviles. Utilizando el modelo UTAUT2, medimos la intención de futuros docentes hacia la RV inmersiva. Los resultados indican que el grupo experimental puntuó más bajo en Motivación Hedónica, Influencia Social y Valor Precio, sugiriendo que el uso repetido de la RV podría reducir el disfrute percibido, la presión social y el valor de la tecnología. El coeficiente de correlación intraclase (CCI) y la prueba *t* de Levene confirmaron inconsistencias y diferencias significativas en estos factores. En contraste, el grupo experimental puntuó más alto en Expectativa de Esfuerzo y Condiciones Facilitadoras, sugiriendo mayor facilidad de uso y recursos disponibles. Sin embargo, no hubo diferencias significativas en Expectativa de Rendimiento y Hábito, indicando que la intervención de RV no afectó la utilidad percibida y el uso habitual. Estos hallazgos destacan la importancia de mantener percepciones positivas de la RV y optimizar sus beneficios para mejorar las experiencias de aprendizaje.

Palabras Clave: realidad virtual, realidad inmersiva, motivación, formación del profesorado, enseñanza superior.

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1. Introduction

Immersive Virtual Reality (IVR) allows users to immerse themselves in a specific context, providing them with multimodal sensations. Users can visualise the environment through 360º images and surround sound (Hamilton *et al.*, 2021). In traditional teaching, the immersive sensation was restricted to visits that students and teachers could make to certain places under study (Häfner *et al.*, 2018). However, with the advent of head-mounted displays (HMDs) and mobile devices, it is now possible to experientially access scenarios that would be impossible for students to visit due to factors such as accessibility, safety or danger (Marks & Thomas, 2022).

The immersive 360º resource has potential in terms of teacher training by facilitating selective viewing and providing engaging immersive sound. Thus, motivation is an important factor in the use of virtual reality as an educational resource, especially due to the novelty of this technology (Lege & Bonner, 2020). This novel aspect of the virtual reality environment can increase students' interest in the activity in the initial use, generating educational benefits (Diwakar *et al.*, 2023; Kim *et al.*, 2022; Sattar *et al.*, 2020). Also, the motivation for the enjoyment and fun produced by virtual reality can increase interest in the use of this resource in the didactic field (Bower *et al.*, 2020). Motivation from other agents can socially influence the use of virtual reality, especially the vision of other colleagues (Boel *et al.*, 2023; Bower *et al.*, 2020). In addition, Social Influence can be both positive and negative. For instance, family members who reject technology can negatively influence the use of virtual reality (Lange *et al.*, 2020). This type of methodology can improve the consolidation of short-term learning (Figols Pedrosa *et al.*, 2023). Even so, motivation for the resource may decrease over time due to factors such as repetitive use or increased experience (Bower & Sturman, 2015; Tamilmani *et al.*, 2021; Venkatesh *et al.*, 2012).

The use of virtual reality as an educational resource has been applied to the field of computer science and engineering and, less frequently, in the area of Social Sciences (Kılınç *et al.*, 2017). In the field of education, we find examples of its use in terms of reflecting on educational situations and analysing teaching practices themselves (Walshe & Driver, 2019), observing educational environments without altering their functioning (Reyna, 2018) and transferring the immersive experience to situations of online distance education (Zolfaghari *et al.*, 2020; Kılınç *et al.*, 2017), among others. Distance education, which makes it possible to bring training to groups of people who cannot access studies due to geographical, economic, or other reasons, can benefit from the possibilities of virtual reality for this learning modality, as it can reduce the limitations of distance or online education (Lege & Bonner, 2020). In this type of educational modality, communication between teachers and students is often limited, and the transmission of information can be difficult. This can lead to greater demotivation in students compared to the face-to-face modality, which can be mitigated with the use of virtual reality (Kim *et al.*, 2022).

The investment required to use virtual reality technology in education depends on the cost of materials and the number of potential beneficiaries. Universities are using this technology because its benefits have been proven and it has the potential to reach a large number of users (Marks & Thomas, 2022). Moreover, the decreasing cost of head-mounted devices, like Oculus, makes them viable for different stages of educational institutions (Hodgson *et al.*, 2015). Additionally, low-budget HMDs that can be used on mobile phones, such as those offered by Google, allow for experimentation with 360º scenarios (Aznar-Díaz *et al.*, 2018; Radianti *et al.*, 2020; Reyna, 2018). This type of content is easy to use and intuitive, which is necessary for it to be perceived as useful and not generate rejection among potential users (Pletz, 2021). Nevertheless, there are also problems related to the continuous change and evolution in terms of hardware and software innovations, which can make the resource more expensive and force the obsolescence of many devices (Frazier *et al.*, 2019).

However, obtaining personalised material can be challenging, and developing interactive reality can be expensive and complex (Marrero-Galván & Hernández-Padrón, 2022). Yet, HMD 360º video is a promising resource that allows for more realistic immersion than computer-generated environments and is easier to create and adapt to the needs of teachers and students (Hamilton *et al.*, 2021). 360º video is one of the basic contents in educational applications of IVR and can be used to reinforce master presentations and other methodologies in the classroom (Radianti *et al.*, 2020). To use IVR as mediational content for an exhibition, reflective observation, experimentation, and learning by discovery, among others, it is necessary to have associated pedagogical support (Walker *et al.*, 2020).

Further research is needed to deepen our understanding of the use of 360º videos as an educational resource (Evens *et al.*, 2023). As described, the use of this resource in teaching offers benefits and positive effects on learning. The purpose of this study is to compare two groups of university students: one group that only observes a demonstration of the operation of virtual reality, and another group that experiments with this resource by carrying out an activity. The study aims to verify whether the usability of virtual reality in the educational process influences the perception of various factors related to usability, such as social influence, motivation, and value for money.

2. Method

2.1. Design

To achieve the purpose of this research, a quantitative, quasi-experimental, and correlational method was used in a natural setting (Campbell & Stanley, 1979).

2.2. Participants

The study sample consisted of 391 students intentionally selected and divided into two groups: a face-to-face or onsite group (G1) and an e-learning group (G2). The onsite group, which comprised 193 students (49.4% of the sample), served as the control group. They received an introductory class on the benefits and characteristics of virtual reality as a learning tool and the procedure of using this resource, but they only watched the demonstration without applying it. The e-learning group, which included 198 students (50.6% of the sample), was the experimental group. They actively interacted with virtual reality by performing an activity using virtual reality through a scalable device such as the mobile phone.

To ensure that the sample size is appropriate, we have used the mathematical formula for sampling calculation of finite populations (Fernández García & Mayor Gallego, 1995; Hernández Sampieri, *et al.*, 2008; Rodríguez Osuna, 1991, 1993). For a confidence level of 95%, a heterogeneity of 50%, and a margin of error of 5%, we need a sample size of at least 378 students, given that N = 20,000 students (University of Las Palmas de Gran Canaria [ULPGC], 2023), Z = 1.96, p = 0.5, q = 0.5, and e = 0.05.

The distribution of the sample shows that 23.3% are men (n = 91), while 76.7% are women (n = 300), whose ages range from 18 to more than 40 years, although the percentage values reveal that the age range 18 to 24 years is the one that concentrates most of the sample (65.2%); It is followed by 25 to 30 years old with 14.3%.

Regarding the variables "I am studying" and "course", 244 students (62.4%) stated that they were being trained in Primary Education, and 303 students (77.5%) stated that they were in the first year. Tables 1 and 2 show the descriptive statistics and frequencies of these variables.

Table 1.
Descriptive statistics, frequencies, of the variable "I am studying". Authors' own work.

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Philology	61	15.6	15.6	15.6
	Primary education	244	62.4	62.4	78.0
	CLIL master's degree	17	4.3	4.3	82.4
	Engineering	7	1.8	1.8	84.1
	Computer science	1	0.3	0.3	84.4
	Community education	29	7.4	7.4	91.8
	Early Childhood Education	5	1.3	1.3	93.1
	Other	27	6.9	6.9	100
	Total	391	100	100	

Table 2.
Descriptive statistics, frequencies, of the variable "course". Authors' own work.

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Year 4 (BA)	8	2.0	2.0	2.0
	Master's degree	38	9.7	9.7	11.8
	Year 1 (BA)	303	77.5	77.5	89.3
	Year 2 (BA)	15	3.8	3.8	93.1
	Year 3 (BA)	27	6.9	6.9	100
	Total	391	100	100	

In terms of the "level of use" and "level of knowledge" of virtual reality, overall, the highest percentages are between the "not at all" and "somewhat agree" options, 90.3% and 80.8% respectively. In the same way, similar results are also reflected depending on the type of study; the mean scores obtained in both groups tend towards the answer options "little or somewhat agree" on a seven-point interval scale: G1 "face-to-face modality": level of use (M = 2.15), level of knowledge (M = 2.83); G2 "e-learning modality": level of use (M = 2.26), level of knowledge (M = 2.83).

In terms of the "level of use" and the "level of knowledge" of virtual reality, the results show that most participants chose the options of "not at all" or "somewhat agree", with 90.3% and 80.8% respectively. However, the mean scores for both groups indicate a slightly higher level of knowledge (M = 2.83) than the level of use (M = 2.15 for G1 and M = 2.26 for G2) on a seven-point interval scale, regardless of the type of study (G1 "face-to-face modality" or G2 "e-learning modality").

2.3. Instruments

We applied the Unified Theory of Technology Acceptance and Use 2 (UTAUT2) model (Bower *et al.*, 2020) to evaluate the concordance of perceptions between the two groups of students. We wanted to verify the stability and internal consistency of the scores obtained from both groups completing the questionnaire. Therefore, we considered the estimation of the intraclass correlation coefficient (ICC) and the Levene *t*-test for independent samples for our analysis.

The UTAUT2 model is a measurement instrument for the behavioural intention of future teachers to use immersive virtual reality. It consists of 28 items that have a factorial structure of eight dimensions: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), Hedonic Motivation (HM), Price Value (PV), Habit (H) and Behavioural Intention (BI). Respondents provide their feedback using a seven-point Likert scale, ranging from "1" denoting "strongly disagree" to "7" representing "strongly agree". In addition, this instrument has a series of sociodemographic variables related to age, sex, study modality, level of use and knowledge of virtual reality, among others. As shown in Table 3, the items that make up each construct of the model are as follows:

Table 3
Factors and items of the UTAUT2 Model. Authors' own work.

Performance Expectancy (PE)
(PE1) I think Virtual Reality is useful for teaching in schools.
(PE2) Using Virtual Reality increases my chances of achieving my teaching goals.
(PE3) Using Virtual Reality is helpful for accomplishing things more quickly in teaching.
(PE4) Using Virtual Reality helps increase my teaching productivity.

Effort Expectancy (EE)	
(EE1)	Learning how to use Virtual Reality is easy for me.
(EE2)	My interaction with Virtual Reality technology is clear and understandable.
(EE3)	I find Virtual Reality easy to use.
(EE4)	It is easy for me to become skilful at using Virtual Reality.
Social Influence (SI)	
(SI1)	People who are important to me think that I should use Virtual Reality.
(SI2)	People who influence my behaviour think that I should use Virtual Reality.
(SI3)	People whose opinions I value suggest that I use Virtual Reality.
Facilitating Conditions (FC)	
(FC1)	I have the resources necessary to use Virtual Reality.
(FC2)	I have the knowledge necessary to use Virtual Reality.
(FC3)	Virtual Reality is compatible with other technologies I use.
(FC4)	I can get help from others when I have difficulties using Virtual Reality.
Hedonic Motivation (HM)	
(HM1)	Using Virtual Reality is fun.
(HM2)	Using Virtual Reality is enjoyable.
(HM3)	Using Virtual Reality is very entertaining.
Price Value (PV)	
(PV1)	Virtual reality is reasonably priced.
(PV2)	Virtual reality is a good value for the money.
(PV3)	At the current price, Virtual reality provides good value.
Habit (H)	
(H1)	The use of Virtual Reality has become a habit for me
(H2)	I am addicted to using Virtual Reality.
(H3)	I must use Virtual Reality.
(H4)	Using Virtual Reality has become natural to me.
Behavioural Intention (BI)	
(BI1)	I intend to continue using Virtual Reality in the future.
(BI2)	I will always try to use Virtual Reality in my teaching.
(BI3)	I plan to continue to use Virtual Reality frequently.

2.4. Data analysis

We applied the UTAUT2 model, which is an instrument that has a valid and reliable psychometric, empirical, and methodological structure. However, to ensure the applicability of this questionnaire to our specific research context, we need to analyse its factor structure and its internal consistency using indicators and multivariate analysis techniques. First, we checked the factorial structure of the instrument by performing an Exploratory Factor Analysis (EFA). To do this, we have used measures to verify that the correlation matrix can be factored: coefficient and levels of significance, determinant, KMO, and Bartlett's sphericity test. Then, we have used the method of extraction of principal components with varimax rotation. This has revealed the rotated factorial solution, the percentage of the total variance of this structure, and the eigenvalues greater than 1. We have also reported the extracted coefficients ordered by size and the factorial indices greater than 0.40. Along with the EFA, we have also analysed the reliability of the instrument and the reliability of the factors generated. To estimate internal consistency, we have used Cronbach's α statistic, with an acceptable threshold typically set at 0.70 (Nunnally, 1978; Kaplan & Sacuzzo, 2009).

We used the intraclass correlation coefficient (ICC) test and Levene's *t*-test for the equality of variances to analyse the agreement or stability established in the relationships between the factors. To do this, we compared the responses between the control group and the experimental group regarding whether the use and application of virtual reality is an adequate resource to improve learning. We used the values proposed by Landis and Koch (1977) to evaluate the consistency of the measurements of the applied instrument. According to them, the degree of agreement is good and statistically significant if the correlation coefficient = $p \geq 0.7$. It is moderate if $p \leq 0.7$- 0.41. It is fair or poor if $p < 0.40$. For this purpose, we developed the estimation of the ICC under the condition of a two-factor model, random effects, absolute agreement type, where the Concordance Index (CI) = 95% and the hypothesis test is at the true value 0.

Finally, regarding Levene's *t*-test for independent samples, we want to confirm whether the extracted factors have equal ($t > 0.05$) or different variances ($t < 0.05$) by using the indicator or assumption of homogeneity of variances. We performed the data analysis using IBM SPSS 21.0 and IBM SPSS AMOS 22.0 statistical programmes.

2.5. Procedure

The control group (G1) received a talk in a session about the resource, the characteristics of the use of virtual reality to support teaching and activities, and observed a demonstration of the possible applications in the university context of teaching and learning. This group did not make any practical application of IVR. After the talk, we administered the questionnaire to find out the perception of the participants. Instead, the experimental group (G2) performed a practical activity at home, for two weeks, with the use of virtual reality through a scalable mobile application resource, with the support of YouTube (Reyna, 2018). The exercise consisted of an observational activity in which the students had to use the information to answer questions related to the contents.

We determined an action protocol, agreed by the judges, so that the sample as a whole (G1 and G2) would receive the same information regarding the use and benefits of VR depending on the group in which it was. After the activity, the participants completed the questionnaire.

3. Results

3.1. Exploratory and Reliability Factor Analysis

The indicators or adjustment coefficients of the variables that make up the correlation matrix of the UTAUT2 model verify that the Exploratory Factor Analysis (EFA) can be performed. According to the results, the data obtained indicate the goodness of fit of the model: 1) p-value > 0.05 for normality assumptions (Kolmogorov-Smirnov and Shapiro-Wilk indicators); 2) p-value =0.000 for Bartlett's sphericity test; 3) determinant = 4.71E – 010, which supports the alternative hypothesis; 4) Kaiser-Meyer-Olkin (KMO) index or measure of sample adequacy = 0.899.

The EFA was conducted using the principal component estimation method and varimax rotation with Kaiser (eigenvalues >1 and factorial saturations > 0.40). According to the results, this analysis extracts a factorial solution of six factors that account for 72.389% of the total variance explained, which is a very significant percentage. Likewise, the internal consistency coefficient shows that α = 0.902 for the instrument as a whole, which is a very acceptable value. Regarding this analysis, the initial eight factors have been reduced to six, since both the Effort Expectancy (EE) and the Facilitating Conditions (FC) are related to the availability of resources for the achievement of the objectives. Similarly, Habit (H) and Behavioural Intention (BI) are related to aspects of behaviour towards the resource. As shown in Table 4, the resulting factor structure, the factor weights, the percentages that explain the variance of each factor and their reliability are as follows:

Table 4

Factor structure, factor indices, reliability and explained variance of the UTAUT2 model. Authors' own work.

Factors	Items	Factor Index	Cronbach's α	% Variance
(F1) Effort Expectancy and Facilitating Conditions	(EE3) I find Virtual Reality easy to use.	0.808	0.859	36.522
	(EE2) My interaction with Virtual Reality technology is clear and understandable.	0.800		
	(EE1) Learning how to use Virtual Reality is easy for me.	0.786		
	(EE4) It is easy for me to become skillful at using Virtual Reality.	0.777		
	(FC2) I have the knowledge necessary to use Virtual Reality.	0.737		
	(FC3) Virtual Reality is compatible with other technologies I use.	0.539		
	(FC1) I have the resources necessary to use Virtual Reality.	0.536		
	(FC4) I can get help from others when I have difficulties using Virtual Reality.	0.433		
(F2) Hedonic Motivation	(HM3) Using Virtual Reality is very entertaining.	0.848	0.906	10.399
	(HM2) Using Virtual Reality is enjoyable.	0.841		
	(HM1) Using Virtual Reality is fun.	0.836		
(F3) Performance Expec tancy	(PE3) Using Virtual Reality is helpful for accomplishing things more quickly in teaching.	0.845	0.886	8.697
	(PE4) Using Virtual Reality helps increase my teaching productivity.	0.824		
	(PE2) Using Virtual Reality increases my chances of achieving my teaching goals.	0.796		
	(PE1) I think Virtual Reality is useful for teaching in schools.	0.675		
(F4) Habit and Behavioural Intention	(H4) Using Virtual Reality has become natural to me.	0.738	0.874	7.422
	(H1) The use of Virtual Reality has become a habit for me.	0.721		
	(H2) I am addicted to using Virtual Reality.	0.691		
	(BI1) I intend to continue using Virtual Reality in the future.	0.555		
	(BI3) I plan to continue to use Virtual Reality frequently.	0.527		
	(H3) I must use Virtual Reality.	0.424		
	(BI2) I will always try to use Virtual Reality in my teaching.	0.407		
(F5) Social Influence	(SI2) People who influence my behaviour think that I should use Virtual Reality.	0.881	0.904	4.967
	(SI1) People who are important to me think that I should use Virtual Reality.	0.870		
	(SI3) People whose opinions I value suggest that I use Virtual Reality.	0.824		
(F6) Price Value	(PV2) Virtual reality is a good value for the money.	0.908	0.888	4.352
	(PV3) At the current price, Virtual Reality provides good value.	0.861		
	(PV1) Virtual reality is reasonably priced.	0.840		
			0.902	72.389

Extraction method: Principal component analysis.
Rotation method: Varimax normalization with Kaiser.

The extracted data verify that the factorial structure is parsimonious, which means that it rests on 6 factors or dimensions that explain most of the variance in the data. This indicates that the model is simple and efficient.

3.2. Intraclass Correlation Coefficient (ICC)

Table 5 shows the Intraclass Correlation Coefficients (ICC) obtained in the different factors that make up the model evaluated between the control group and the experimental group.

Table 5

Intraclass correlation coefficients (ICCs). Stability of the relationships in the factors of the UTAUT2 model. Control group-Experimental group. Authors' own work.

FACTORS	Intraclass correlation(a) Average Measurements 95% confidence interval	Test F with true value 0			
		Value	gl1	gl2	Sig.
(F1) Effort Expectancy and Facilitating Conditions	0.841	7.091	293	2051	0.000
(F2) Hedonic Motivation	0.633	15.670	390	780	0.038
(F3) Performance Expectancy	0.879	8.767	390	1170	0.000
(F4) Habit and Behavioural Intention	0.799	8.397	390	2340	0.000
(F5) Social Influence	0.593	17.778	356	712	0.042
(F6) Price Value	0.612	8.949	390	780	0.014

A two-factor random-effects model in which both the effects of people and the effects of measures are random.
a Type A intraclass correlation coefficients using an absolute agreement definition.
b The estimator is the same whether or not the interaction effect is present.

Of the six factors analysed, the data from this test reflect different degrees of agreement between the control group and the experimental group. As shown in Table 5, three factors have acceptable degrees of agreement (95% CI: F1, p = 0.841; F3, p = 0.879; F4, p = 0.799), which means that the ratings given by the two groups are consistent and reliable. However, the other three factors have not so good degrees of agreement (95% CI: F2, p = 0.633; F5, p = 0.593; F6, p = 0.612), which means that the ratings given by the two groups are more variable and less reliable. These latter estimates show confidence intervals that express moderate or weak relationships, which suggests that there are some differences in the perception of the two groups regarding these factors.

3.3. Levene's t-test for equality of variances. Independent samples

Table 6 presents the scores obtained by the students in the face-to-face modality (control group) and the e-learning modality (experimental group) in the factors that structure the UTAUT2 model.

Table 6

Levene's t-test. Homogeneity of variances between the measurements of the UTAUT2 model as a function of two independent samples: control group-experimental group. Authors' own work.

FACTORS	G1*		G2**		F	gl	Sig. (bilateral)***
	M	Dt	M	Dt			
Effort Expectancy and Facilitating Conditions							0.829
(EE3) I find Virtual Reality easy to use.	4.66	112	4.74	1.066	0.587	390	0.444
(EE2) My interaction with Virtual Reality technology is clear and understandable.	4.55	1.099	4.67	1.144	1.166	390	0.281
(EE1) Learning how to use Virtual Reality is easy for me.	4.75	1.216	4.83	1.016	0.525	390	0.469
(EE4) It is easy for me to become skilful at using Virtual Reality.	4.86	1.097	5.01	0.977	2.041	390	0.154
(FC2) I have the knowledge necessary to use Virtual Reality.	4.32	1.609	4.11	1.688	1.289	293	0.257
(FC3) Virtual Reality is compatible with other technologies I use.	5.07	1.208	5.03	1.173	0.122	390	0.727
(FC1) I have the resources necessary to use Virtual Reality.	3.66	1.632	4.11	1.720	6.816	390	0.009
(FC4) I can get help from others when I have difficulties using Virtual Reality.	4.65	1.242	4.63	1.488	0.024	390	0.878
Hedonic Motivation							0.035
(HM3) Using Virtual Reality is very entertaining.	5.45	1.113	5.45	1.069	0.000	390	0.191

FACTORS	G1*		G2**		F	gl	Sig. (bilateral)***
	M	Dt	M	Dt			
(HM1) Using Virtual Reality is fun.	5.52	1.169	5.02	1.132	1.143	390	0.032
Performance Expectancy							0.261
(PE3) Using Virtual Reality is helpful for accomplishing things more quickly in teaching.	4.78	1.103	5.01	1.018	4.715	389	0.031
(PE4) Using Virtual Reality helps increase my teaching productivity.	4.71	1.159	4.88	1.077	2.368	390	0.125
(PE2) Using Virtual Reality increases my chances of achieving my teaching goals.	4.69	1.068	4.88	0.919	3.545	390	0.60
(PE1) I think Virtual Reality is useful for teaching in schools.	5.07	1.168	5.20	0.888	1.530	390	0.217
Habit and Behavioural Intention							0.619
(H4) Using Virtual Reality has become natural to me.	2.63	1.573	2.62	1.647	0.001	390	0.972
(H1) The use of Virtual Reality has become a habit for me.	2.31	1.417	2.57	1.509	2.959	390	0.086
(H2) I am addicted to using Virtual Reality.	1.59	1.106	1.70	1.166	0.940	390	0.333
(BI1) I intend to continue using Virtual Reality in the future.	4.17	1.457	4.15	1.468	0.027	390	0.868
(BI3) I plan to continue to use Virtual Reality frequently.	3.94	1.351	4.03	1.336	0.413	390	0·521
(H3) I must use Virtual Reality.	4.23	1.343	4.20	1.317	0.054	390	0.817
(BI2) I will always try to use Virtual Reality in my teaching.	4.32	1.472	4.32	1.423	0.000	390	0.983
Social Influence							0.044
(SI1) The people who are important to me think I should use Virtual Reality.	3.58	1.533	3.98	1.131	8.049	356	0.005
(SI3) People whose opinions I value suggest that I use Virtual Reality.	3.63	1.413	4.01	1.254	8.053	390	0.005
Price Value							0.049
(PV2) Virtual reality is a good value for the money.	3.57	1.253	3.27	1.280	5.566	390	0.019
(PV3) At the current price, Virtual Reality provides good value.	3.63	1.223	3.29	1.235	7.437	390	0.007
(PV1) Virtual reality is reasonably priced.	3.26	1.391	3.01	1.280	3.678	390	0.056

Interval scale: 1=strongly disagree; 2= disagree; 3 = somewhat disagree; 4 = neither agree nor disagree; 5 = somewhat agree; 6= agree; 7= Strongly agree
*G1= Control Group
**G2= Experimental Group
***It is significant at the p<.05 (bil) level.

The results confirm that the learning modality (face-to-face vs. online) has a statistically significant effect on three factors of the UTAUT2 model: Hedonic Motivation, Social Influence, and Price Value. We applied Levene's *t*-test for two independent groups to these variables, which are continuous and normal, and assumed equal variances. We found that $p(t) < 0.05$ in the three factors, which means that the mean scores of the control group and the experimental group are different enough to reject the null hypothesis. Therefore, we accept the alternative hypothesis that there are differences between the groups in these factors. We applied the same test to these variables and found that $p(t) > 0.05$ in the three factors, which means that the mean scores of the control group and the experimental group are not different enough to reject the null hypothesis. Therefore, we accept the null hypothesis that there are no differences between the groups in these factors.

Divergent perceptions of Hedonic Motivation between the G1 and G2 groups are evident in the results. The control group (G1) has a somewhat more positive perception of the use of this resource in relation to the entertainment and fun they generate. They scored higher on the items that measure the pleasantness and enjoyment of the resource. On the other hand, the experimental group (G2) shows results that tend towards a more neutral perception of the aspects related to the pleasantness and fun of the resource. They scored lower on the same items. The experience of practical use, on the part of the experimental group, generates a vision that is somewhat less entertaining and more linked to the peculiarities of the didactic point of view. This suggests that the use of virtual reality may not be as motivating or engaging as expected by the experimental group.

In relation to Social Influence, there are results in the perception that indicate that the experimental group shows more influence from the context than what the control group indicates. The experimental group scored higher on the items that measure the extent to which they perceive that important others believe they should use the resource. In contrast,

the lower scores on the same items in the control group imply that the experimental group may be more susceptible to the opinions or expectations of their peers, teachers, or family concerning the use of virtual reality.

The results in terms of the perception of the Price Value of the resource, and the possibilities it has, are shown in a disparate way in G1 and G2. The experimental group has a negative perception of the price of HMD devices. They scored lower on the items that measure the extent to which they perceive that the resource is worth the cost. The control group scored higher on the same items. This suggests that the experimental group may be more aware of the economic barriers or limitations of using virtual reality. However, the control group's results tend towards 4, the neutral option on the interval scale, indicating a lack of a clear or informed opinion on the price value of the resource.

4. Discussion and conclusions

This paper investigates how university students perceive and value the use of immersive virtual reality (IVR) as an effective resource for teaching, and whether it improves immersion, spatial skills, empathy, motivation, and learning outcomes. We applied a measurement instrument that evaluates the behavioural intention of future teachers to use IVR in teaching and, then, compared the responses of two groups of students with different learning modalities (face-to-face vs. online). This allowed us to examine the variability of the intergroup estimates and to verify the stability of the students' perceptions in the factors or dimensions of the model.

The combined findings consistently indicate that both groups (G1 and G2) perceive virtual reality positively in terms of Effort Expectancy and Facilitating Conditions. Participants acknowledge that virtual reality is user-friendly and accessible, and that they can overcome any challenges related to its use. They also expect that virtual reality can enhance their learning outcomes and benefit schools, that is, they have high Performance Expectancy.

Regarding the perception of Hedonic Motivation, we observe some differences between G1 and G2. The control group has a slightly more positive perception of the resource, as they find it more entertaining and amusing. The experimental group, nonetheless, has a more neutral perception of the resource's pleasantness and fun. The practical use of the resource by the experimental group leads them to a less enjoyable and more didactic view. In this sense, we concur with Kim *et al.* (2022) that virtual reality has a positive effect on increasing students' interest in the content they learn. This resource, which is relatively new, generates a high level of interest due to its novelty in the classroom. However, this honeymoon effect (Lege & Bonner, 2020) should be considered, as excessive or repetitive use of virtual reality activities and familiarity with the resource may diminish the motivational effect (Bower & Sturman, 2015; Tamilmani *et al.*, 2021; Venkatesh *et al.*, 2012). Moreover, we should be aware that virtual reality may cause fatigue, eye strain, or dizziness, or that limited interaction during the learning process may affect the perception of the resource (Gao *et al.*, 2023; Kim *et al.*, 2022; Theelen *et al.*, 2019).

The perception results show that the experimental group was more influenced by the context than the control group in terms of Social Influence. G2 used the resource at home, which implies that their family's attitude towards technology may have affected their perception. Lange *et al.* (2020) suggested that family members can have a negative influence if they reject technology. Nevertheless, in this case, G2 had a more positive perception of Social Influence than G1, who used the resource in the classroom with their peers.

There is a notable difference in the perception of the resource's Price Value and its potential between the experimental group and the control group. G2 had a negative perception of the device price, while G1 rated it closer to 4 on a scale of 1 to 7. This may be due to the different levels of knowledge and experience with the resource. G1 may have only seen the benefits of the resource, while G2 may have realised that it was too costly for what it offered from an educational perspective. G2 used a low-cost resource on a mobile device, which had more positive effects than other 2D formats (Alamäki *et al.*, 2021), but lacked the high performance of glasses like the Oculus model. The high cost of these glasses can be a major barrier for schools or families to adopt them (Roche *et al.*, 2021). Moreover, the rapid changes and innovations in technology, both in hardware and software, can hinder the widespread use of virtual reality (Frazier *et al.*, 2019). Frequent updates and limited use for research purposes can lead to negative perceptions of value for money (Bower *et al.*, 2020).

This research has some limitations. One of them is that it would be appropriate to demonstrate the applicability of the estimates of the intraclass correlation analysis with other procedures such as the consistency of the judges, or the test-retest. These procedures are especially useful to check the temporal stability and concordance of the measures in research that requires longitudinal or follow-up studies, with the same sample and at different times. For future studies, we plan to conduct a regression analysis to determine the effects of the dimensions of the UTAUT2 model to explain and analyse people's technology acceptance behaviour, as possible predictors of the application of immersive virtual reality in teaching.

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