International Journal of Instruction *July 2024 ● Vol.17, No.3*
e-ISSN: 1308-1470 ● www.e-iji.net *p-ISSN: 1694-609X*
pp. 19-36

Article submission code: 20230807071546
Received: 07/08/2023 Revision: 25/12/2023
Accepted: 10/01/2024 OnlineFirst: 01/04/2024

Arts Professors' Perception of the Didactic Use of Virtual Reality

Álvaro Antón-Sancho
Technology, Instruction and Design in Engineering and Education Research Group, Catholic University of Avila, Spain, *alvaro.anton@ucavila.es*

Pablo Fernández-Arias
Technology, Instruction and Design in Engineering and Education Research Group, Catholic University of Avila, Spain, *pablo.fernandezarias@ucavila.es*

Diego Vergara
Technology, Instruction and Design in Engineering and Education Research Group, Catholic University of Avila, Spain, *diego.vergara@ucavila.es*

Virtual reality (VR) technologies have proven to be effective teaching tools in higher education, particularly in arts education. Likewise, the analysis of the assessment that professors make of these technologies helps to understand their reception and to design strategies for their implementation in universities. In this work, quantitative research is carried out to analyze the perception of university arts professors on different technical and didactic aspects of virtual reality (VR), as well as its limitations and its future projection. Specifically, significant differences are identified in these evaluations according to the tenure (private or public) of the university where the professors teach. For this purpose, a validated questionnaire is used, which was responded by 291 arts professors from 13 different Latin American countries. The results show low levels of digital skills for the use of VR. There is also a strong gap between private and public universities with respect to the digital competence of arts professors and their assessment of VR. It is suggested that universities increase the necessary equipment to integrate VR technology in arts education, as well as carry out specific faculty training sessions on the use of VR technologies and their integration into arts education.

Keywords: virtual reality, arts education, higher education, digital learning environments, digital competence

INTRODUCTION

Digital technologies have been introduced into the different dimensions of social, educational, or work life in modern society, characterized as a knowledge and information society (Kali et al., 2019). This digital revolution has strongly impacted the world of education because it provides technologies that allow access, processing, and representation of data with many formative potentialities (Lin et al., 2020; Do-Amaral

Citation: Antón-Sancho, A., Fernández-Arias, P., & Vergara, D. (2024). Arts professors' perception of the didactic use of virtual reality. *International Journal of Instruction*, *17*(3), 19-36. https://doi.org/10.29333/iji.2024.1732a

et al., 2023; Neswary & Prahani, 2023). Specifically, virtual reality (VR) has developed a great growth of its development expectations in recent years (Vergara et al., 2021). From a technical perspective, VR is a technology that allows the development of virtual environments in three dimensions where users interact with a certain degree of immersion. The use of VR technologies in online training environments have proven to be effective for the acquisition of knowledge and the development of skills related to interaction and cooperative work in confinement contexts such as the covid-19 pandemic (Setuowati et al., 2023).

A digital learning environment is an environment hosted in a virtual classroom that carries out learning activities (Veletsianos, 2016). Therefore, the use of digital learning environments involves the use of digital technologies, like VR, which can generate the necessary interaction between the learners and the learning objects or the teacher (Vázquez-Villegas et al., 2023). To the extent that these digital technologies are mediators of learning in digital learning environments, they can be considered didactic resources, in this case of a digital type. Although VR technologies can be used in education in various areas of knowledge, VR applications vary according to the object of knowledge and the needs of each area (Radianti et al., 2020; Amprasi et al., 2022).

The present work is contextualized in the field of arts education, understood as the set of techniques, resources and methodologies for the development of different artistic skills in students, particularly related to painting, sculpture, film, or music (Clapp & Ho, 2022). The specific educational level at which the study is contextualized is the university level, i.e., higher education. In the case of arts education, VR technologies help to teach the shapes and proportions linked to artistic works, as well as the formal differences between different styles and artistic compositions (Zhang et al., 2022). It is also a useful technology to generate immersive experiences in students that allow them to visualize artistic works or museums that are far away (Lin et al., 2020; Zhou et al., 2022; Bachiller et al., 2023). In addition, it has been verified that the use of VR technologies in artistic education allows increasing some transversal skills, such as problem-solving and communication skills (Kim et al., 2022).

The successful use of VR in arts education requires the development of a certain level of digital competence, understood as the set of skills, techniques, and knowledge for the use of digital technologies with educational applications (Zhao et al., 2021). The assessment made by professors, in general, of their digital competence for the use of VR and of the VR technologies themselves, decisively influence their reception and incorporation into the lessons (Radianti et al., 2020). This has led to the existence of a fruitful line of research around the assessment of university professors on the didactic use of VR (Vergara et al., 2021). There are studies that analyze the perception of professors in specific areas of knowledge about the use of VR. The contextualized studies in Engineering (Vergara et al., 2022) and Health Sciences (Botden et al., 2008; Fernández-Arias et al., 2023) professors stand out because they are the areas in which there are more VR designs applied to education (Fernández-Arias et al., 2023). As far as it has been possible to explore, there are no studies that analyze the assessment made by art professors of VR, despite its applicability and the difference between areas of knowledge regarding the use of VR. This occurs despite the suggestion of the

specialized literature about reinforcing research in this regard, given that the reception of some forms of VR, such as immersive VR, among art professors is scarce (Jiawei & Mokmin, 2023).

Likewise, it has been shown that the identification of influential factors in professors' perception of digital technologies and their application in the classroom is a fruitful line of research (Antón-Sancho et al., 2021). This is because it allows a better understanding of the process of receiving digital technologies in higher education and provides keys to design strategies aimed at optimal teacher training (Antón-Sancho et al., 2021). Thus, numerous factors have been identified that influence the assessment of digital technologies and, specifically, VR. Some of these factors are sociological, such as gender or age (Botden et al., 2008; Ancheta-Arrabal, 2021; Antón-Sancho, Fernández-Arias, & Vergara, 2023), others involve geographic location and the digitalization level of the countries (Antón-Sancho et al., 2023), and others are academic, such as the area of expertise of the professors (Fernández-Arias et al., 2023). In the specific region of Latin America, which is precisely the region in which this study is contextualized, a very influential factor turns out to be the tenure (private or public) of the university in which the professors teach (Vergara et al., 2022; Fernández-Arias et al., 2023). Indeed, the digitalization process of the different dimensions of social life in Latin America is intense and growing, but uneven in many ways (Katz et al., 2013; Criado, 2021). One of these senses is the digitalization of higher education, which is, in general, greater in private universities than in public ones (Argüelles-Cruz et al., 2021; Romero, 2022). This fact is explained because private universities have a large proportion of online students, which forces them to innovate their methodological strategies (González-Pérez et al., 2021). This difference between private and public universities significantly affects the self-concept of digital competence that professors have, which is, in general, greater in private universities (Jorge-Vázquez et al., 2021), and to the assessment of VR, which is higher in private universities (Vergara et al., 2022).

Thus, the general objective of this research is to carry out a quantitative, descriptive and correlational study on the influence of university tenure on the assessments made by Latin American university professors of the didactic use of VR and their didactic ability to use it. Specifically, the following objectives are pursued: (i) measure the perception that the participating arts professors have about their own skills for the use of VR technologies in the higher education classroom; (ii) describe the perceptions about the different dimensions –technical, usability, future projection, and didactic– of the participating arts professors; (iii) to identify differences in the above perceptions according to the university tenure –private or public– of the participants; (iv) to analyze the behavior of possible gender and age gaps in the perceptions expressed by the participants of each type of university –private or public–.

Literature Review

The gradual but unstoppable incorporation of digital learning environments in higher education entails the appearance of very important differences in the design of didactic situations with respect to traditional classes (Alter, 2014). These differences are mainly based on the renunciation of face-to-face interaction to give greater prominence to

interaction with the (virtual) learning object (Alter, 2014). The literature reveals that the use of VR increases student engagement in classroom activities (Vázquez-Villegas et al., 2023) and that the main formative benefits of the inclusion of digital learning environments in the specific field of arts education are the increase of students' motivation and the ease of designing cooperative didactic situations (Quinn, 2011). From the point of view of art learning, the literature identifies that the most effective digital learning environments in arts education are environments that allow interactive simulations of art objects and, particularly, virtual environments (González-Zamar et al., 2020).

In the arts fields, digital resources and specifically VR have been used in the most diverse disciplines, such as: (i) literature (Chen et al., 2021); (ii) painting (Lin et al., 2020); (iii) sculpture (Cecotti, 2022); (iv) music (Popp & Murphy, 2022); (v) film (Xie, 2020); and (vi) architecture (Scorpio et al., 2020). It is therefore a mode of expression that combines specific knowledge, based on techniques and processes, with different soft skills (Fernández-Arias et al., 2022) such as: (i) creativity; (ii) imagination; (iii) spatial vision; (iv) abstract thinking; (v) bodily expressiveness; or (vi) communication skills. This combination of skills and knowledge that occurs in art, allows the artist to question other alternatives and even transform reality in some way. It is here, where VR plays a fundamental role, as it facilitates the artist to create new alternatives or realities (Hui et al., 2022). Professors related to the different disciplines of art in higher education should show a predisposition towards the use of digital learning environments and the incorporation of disruptive technologies into them such as VR in arts education, because of the didactic benefits they have proven to have for the development of the above specific competencies (Cabero-Almenara et al., 2022).

For the use of digital learning environments in higher education and for integrating VR into them, countries need to work to ensure an overall level of digitization that is sufficient (Antón-Sancho et al., 2023), and professors must acquire the necessary digital competence (Vergara et al., 2023). As far as it has been possible to analyze, there are no works that examine the digital competence for the use of VR of arts professors in Latin America. However, some authors have analyzed the digital competence of university professors in more restricted geographic areas, such as Latin American countries with a low level of digitalization (Antón-Sancho et al., 2021), while others have highlighted the importance of fostering the development of digital competence among arts and design educators in other geographic regions, such as Africa (Tusiime et al., 2019), China (Yiping, 2021), or Europe (De-Eça & Saldanha, 2023). Thus, two areas of development of digital competence among arts professors have been identified (Tusiime et al., 2019): (i) the formal environment, specific to the academic training of professors and their permanent and continuing education; and (ii) the informal environment, specific to the use of digital tools for communication and other daily activities. In these two areas of development, it is important that the digital training of arts professors is not only carried out from a cognitive point of view (acquisition of new knowledge), but also requires that this knowledge is actively generated, that motivation towards the use of digital tools in teaching activities is encouraged, and that professors are provided with tools to evaluate their own process of integrating technologies into their work (Yiping, 2021). The self-concept of digital skills for the use of virtual tools has also been studied

among Latin American technical education professors (Fernández-Arias et al., 2022), which the literature recognizes as better than those corresponding to professors in other areas such as health sciences (Fernández-Arias et al., 2023). The preceding literature also establishes that it is a priority to train arts professors in digital competence to ensure an adequate process of integration of technologies in arts education (De-Eça & Saldanha, 2023), as it is for all university faculty to be adequately trained in the design of materials and the creation of content through digital learning resources (Antón-Sancho et al., 2021). This suggests the need for studies of self-concept analysis of digital competence specific to arts professors.

About the professors' assessments of VR seen as a didactic resource in higher education, the literature includes assessments by engineering professors (Vergara et al., 2022) and health sciences professors (Vergara et al., 2021). In both cases, professors give high ratings to VR as a didactic resource for learning in their respective disciplines through digital learning environments, mainly in its technical, didactic, and usability aspects, with engineering professors giving higher ratings for the technical aspects of VR (Vergara et al., 2022). Engineering and health sciences professors also highlight the existence of limitations for the use of VR in their lectures, mainly the high costs that, in their opinion, are involved in the use of these technologies and the lack of specific training for their use by the faculty (Vergara et al., 2022).

An aspect typically discussed in the literature and that affects the purposes of the present research is that the speed with which public universities are integrating digital technologies is, in general, lower than that of private universities (Rasimah et al., 2011). In the case of the Latin American region, a strong gap is identified in the digitization process of higher education institutions by university tenure, due, in part, to the fact that private universities have a higher proportion of online or non-face-to-face students than public universities, which forces the former to have more sophisticated digital learning environments (Rama, 2014; Fernández-Arias et al., 2023).

Likewise, in the Latin American and Caribbean region there is a consolidated gender gap that affects access to and use of digital technologies, which is less frequent in females (Acosta-Vargas et al., 2018; García-Holgado et al., 2019). This gender gap, which is originated by strongly rooted social and cultural conventions, also affects the digital skills of university faculty and their valuations of digital technologies, particularly VR (Rodríguez-Abitia et al., 2020). The digital age gap, present in many parts of the world (Marmani, 2022), also affects Latin American faculty (Basantes-Andrade et al., 2020). Thus, the lesser training in digitization that, in general, older professors present leads them to give lower evaluations to digital technologies, especially in terms of their technical aspects (Antón-Sancho et al., 2022).

METHOD

Participants

The participants were chosen by a non-probabilistic convenience sampling process from among the professors participating in a training course on the didactic use of VR in higher education given by the authors and repeated every two weeks from January to

June 2022. In this course the following contents were developed: (i) basic concepts of VR, technical characteristics, didactic applicability, and types of VR according to the degree of immersiveness (immersive and non-immersive VR); (ii) digital skills for the use of VR; and (iii) techno-pedagogical skills, or didactic application of VR technologies in the higher education classroom. This course was developed in the master class modality, without the assistants developing practical activities. The formative course was open to the participation, upon registration, of active professors from Latin American universities. Therefore, the target population was made up of the 439 professors who registered and attended this training session. After the training, the attendees received the questionnaire that was used as a research instrument and were informed about its research purposes, as well as the free, voluntary, and anonymous nature of their participation. The criteria for inclusion were the following: (i) being a professor in active teaching at a Latin American university; (ii) being a specialist in arts, which includes fine, performing, graphic, and audiovisual arts, design, and craft skills, and teaching in higher education degrees in one of these areas; and (iii) having attended the training session given by the authors. A total of 302 responses were obtained, of which 291 were considered valid, in the sense that they were complete responses.

Research variables and hypotheses

The main explanatory variable considered in this study is university tenure, which is nominal dichotomous and whose possible values are private or public. The following secondary explanatory variables are also considered: (i) gender –nominal dichotomous, with values female or male–; and (ii) age –quantitative ordinal–. The following 6 explanatory variables are also defined, all of them measured on a quantitative Likert scale from 1 to 5: (i) professors' self-concept of digital skills for the didactic use of VR technologies; (ii) assessment of the technical characteristics of VR; (iii) assessment of employability of VR technologies in arts education; (iv) level of perceived disadvantages of VR didactic use in arts education; (v) level of future projection perceived of the use of VR in arts education; and (vi) assessment of the didactic aspects of VR in arts education. The values of the Likert scale on which all these variables have been measured are: 1 – null; 2 – low; 3 – moderate; 4 – high; 5 – very high.

This study aims to verify the following research hypotheses (which are formulated as null hypotheses):

H1. There are no significant differences between the VR assessments of professors from private and public universities.

H2. There are no significant differences between private and public universities in terms of gender gaps in the VR assessments of participating professors.

H3. There are no significant differences between private and public universities in terms of the behavior of the VR assessments according to the age of the participants.

Instrument

To achieve the purposes of the present research, a previously used and validated questionnaire on the assessment of university professors about the use of VR in higher

education has been used (Vergara et al., 2022). This questionnaire consists of 22 questions, which are distributed in 6 families, corresponding to the 6 factors that explain the questionnaire, according to the exploratory factor analysis performed on the questionnaire (Vergara et al., 2022). These 6 factors or response families correspond exactly to the explained variables defined above. The questions in the questionnaire request the assessment of each of the following aspects or dimensions of VR, which are presented here, already grouped according to the families identified in the factorial analysis: (i) digital skills on the use of VR –digital competence, VR knowledge, and training received on VR use– (3 questions); (ii) usability aspects of VR –interaction, user experience, and employability– (3 questions); technical aspects of VR –3D design, immersiveness, and realism– (3 questions); (iv) level of disadvantages of VR use –costs, space requirements, technical requirements, faculty training requirements, and technological obsolescence of equipment– (5 questions); (v) future projection of didactic use of VR –immersive VR, and non-immersive VR– (2 questions); and (vi) didactic aspects of VR –didactic usefulness, possibilities of implementation in the professor's university, student acceptance, academic performance, student motivation increasing, and improvement in the progress of the lectures– (6 questions). All assessments have been measured on a 1 to 5 Likert scale, where 1 expresses the lowest rating and 5 corresponds to the highest, for the assessment of each aspect asked about.

Statistical analysis

The distribution of participants by gender, country, and the tenure of their universities has been analyzed by applying the Pearson goodness-of-fit test to a homogeneous distribution. Likewise, confirmatory factor analysis has been used to corroborate the validation of the construct of the instrument and the reliability of the responses has been computed using Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) statistics. The statistical analysis carried out on the responses to the questionnaire was based on the computation of the main descriptive statistics –of centralization and variation– of the distributions of the responses and on the application of mean comparison tests and the computation of linear regression models to test the statistical significance of the gaps in the responses obtained by university tenure and gender and to verify the dependence of these responses on the age of the participants. The t-test for independent samples with Welch's correction without assuming equal variances was used to test the gaps in the responses by university tenure of the professors. The multifactor analysis of variance (MANOVA) test was used to analyze the behavior of the gender gaps in the responses in private and public universities and whether this behavior is different according to university tenure. Finally, the linear regression models of the different families of responses with respect to the age of the participants, both in private and public universities, were computed to analyze the age gaps in each of the university tenures. All hypothesis testing was performed at the 0.05 level of significance.

FINDINGS

Distribution of participants

A total of 291 arts professors participated in the study (57.73% females and 42.27% males), among whom there is a slight but statistically significant majority of females (chi-square = 6.9588, p-value = 0.0083). The mean age of the participants is 45.91 years old (sd = 9.86, skewness = 0.06). There are participants from 13 different Latin American countries: 48 from Argentina, 27 from Bolivia, 33 from Colombia, 3 from Costa Rica, 18 from Ecuador, 15 from Guatemala, 72 from Mexico, 9 from Dominican Republic, 9 from Nicaragua, 3 from Panama, 45 from Peru, 3 from Uruguay, and 6 from Venezuela. The distribution of participants by country is not homogeneous (chi-square = 239.41, p-value < 0.0001).

The distribution of participants by university tenure shows that there is a slight majority of participants from public universities (59.79%) compared to private universities (40.21%), this difference being statistically significant (chi-square = 11.1650, p-value = 0.0008). This majority of females versus males occurs in both private universities (59.0% females and 41.0% males) and public universities (56.9% females and 43.1% males), without significant differences in the distribution of participants by gender between the two types of universities (chi-square = 0.1238, p-value = 0.7250). The mean age of participating professors from private universities is 45.38 years (sd = 9.33, skewness = 0.27, median = 50). Likewise, the mean age of participants from public universities is 46.26 (sd =10.21, skewness = –0.07, median age = 49).

Instrument validity

From the Cronbach's alpha, CR, and AVE parameters, it can be deduced that the theoretical model that emerges from the factor analysis gives rise to a set of families of questions that have high levels of internal consistency (Table 1). Likewise, the statistics of the confirmatory factorial analysis confirm this theoretical model, since the incremental fit indices are adequate (AGFI = 0.7817; NFI = 0.7817; TLI = 0.7485; CFI = 0.7048; IFI = 0.7081), and the absolute fit indices are also good (GFI = 0.7559; RMSEA = 0.1321; AIC = 1197.0370; chi-square/df = 6.0102).

Table 1
Cronbach's alpha, composite reliability (CR) and average variance extracted (AVE) parameters of the different families of responses of the questionnaire

Factor	Cronbach's alpha	CR	AVE
Digital skills	0.7778	0.75	0.52
Usability of VR	0.7258	0.72	0.50
Technical aspects	0.8593	0.84	0.65
Disadvantages	0.8445	0.84	0.64
Future projection of VR	0.7922	0.78	0.56
Didactic usefulness of VR	0.7273	0.72	0.51

Responses

Arts professors give intermediate ratings (between 3 and 4 out of 5) to the technical, didactic, and future projection characteristics of VR, ratings that are at the same level as the perceived disadvantages (Table 2). The usability of the VR reaches a high average rating (12.36% higher than the level of disadvantages, 9.07% higher than the rating of the didactic aspects, and 3.02% higher than the rating of the didactic aspects) and the digital skills are considered low, at an average level, by the participants, although this family of responses is the one that presents a greater relative dispersion, therefore, a higher level of dispersion (Table 2).

Table 2
Descriptive statistics of the responses

Factor	Mean (out of 5)	Std. Deviation (out of 5)	Coefficient of variation (%)
Digital skills	2.77	1.19	42.94
Usability of VR	4.09	0.96	23.57
Technical aspects	3.75	1.04	27.62
Disadvantages	3.64	1.22	33.62
Future projection of VR	3.67	1.04	28.43
Didactic usefulness of VR	3.97	1.02	25.70

There are significant differences between the responses of arts professors from private and public universities in the variables of digital skills and the valuations of the technical aspects, usability, and disadvantages of VR, as can be deduced from the t-test statistics for independent samples (Table 3). Arts professors from private universities show a level 7.43% above the level of digital skills of professors from public universities. It is also private university professors who express higher ratings for usability (5% higher than public university professors) and, above all, for technical aspects (10.56% higher than public university professors). In addition, arts professors at private universities give an average rating 4.80% lower than that of professors at public universities. On the other hand, the ratings of the future projection of the VR and of the didactic aspects given by the professors at both university tenures are similar (Table 3). Therefore, the alternative hypothesis of H1 is confirmed (university tenure significantly influences the evaluations that the participating professors make of the VR).

Table 3
Mean responses (out of 5) and statistics of the t-test test for comparison of means with Welch correction, when participants are differentiated by university tenure (*p<0.05)

	Mean Private (out of 5)	Mean Public (out of 5)	t-value	p-value
Skills	2.89	2.69	2.48	0.0132*
Usability	4.21	4.01	3.17	0.0016*
Technical	3.98	3.60	5.62	<0.0001*
Disadvantages	3.54	3.71	–2.66	0.0079*
Future	3.67	3.67	–0.06	0.9486
Didactic	3.96	3.98	–0.40	0.6866

There are gender gaps in the ratings of the usability and technical aspects of VR and of the disadvantages of its use, and the behavior of these gender gaps is, moreover, different according to the university tenure (Table 4). Indeed, in private universities, female professors give lower ratings of the usability and higher ratings of the technical aspects than male professors. However, in public universities, female professors rate usability higher and technical features of VR lower than males. In addition, females in private universities find fewer disadvantages in the use of VR than males, while, in public universities, females find a higher level of disadvantages than males. Consequently, the alternative hypothesis of H2 is confirmed (the university tenure significantly influences the gender gaps that exist in the evaluations that the participating professors make of the VR).

Table 4
Mean responses (out of 5) and statistics of the MANOVA test, when the sample is differentiated by the university tenure of professors and their gender (*p<0.05)

	Private		Public		F-statistic	p-value
	Female	Male	Female	Male		
Skills	2.83	2.98	2.59	2.82	0.2654	0.6066
Usability	4.20	4.23	4.07	3.93	9.1726	0.0025*
Technical	4.03	3.92	3.49	3.73	6.0829	0.0138*
Disadvantages	3.49	3.61	3.90	3.47	17.5645	<0.0001*
Future	3.67	3.66	3.58	3.80	1.8322	0.1764
Didactic	3.89	4.05	3.93	4.03	0.3753	0.5402

The linear regression models of the responses with respect to the age yield R^2 values very close to 0, so the linear models explain a small proportion of the variability of the responses (Table 5 and Table 6). However, increasing or decreasing trends of ratings with respect to age are guaranteed by the sign, positive or negative, respectively, of the model slope, since the corresponding p-value is less than 0.05. In public universities, the ratings admit an age gap (Table 5). Indeed, the ratings given by arts professors decrease as their age increases in terms of the digital skills expressed and the assessment of usability, future projection of VR, and of its disadvantages (Table 5). This gap is not significant in the variables that measure the valuation of the technical and didactic aspects of VR. This age gap, which is detrimental to older arts professors, has been corrected in private universities, where the linear regression model does not find significant dependencies in the evaluations of VR with respect to age, except in the evaluation of the technical aspects, disadvantages, and future projection of VR, in which older professors give higher evaluations than younger ones (Table 6). Therefore, the way in which the assessments depend on age differs if professors teach at private or public universities, so the alternative hypothesis of H3 is confirmed.

Table 5
Statistics of the linear regression model of the families of questions with respect to the age of the participants, among professors from public universities (*p<0.05)

Variable		Estimate	Error	*t*-value	*p*-value	R^2
Skills	Slope	–0.0117	0.0052	–2.239	0.0256*	0.0096
	Indep. term	3.2267	0.2465	13.091	<0.0001*	
Usability	Slope	–0.0163	0.0044	–3.721	0.0002*	0.0259
	Indep. term	4.7637	0.2070	23.017	<0.0001*	
Technical	Slope	–0.0027	0.0046	–0.587	0.5573	0.0007
	Indep. term	3.7230	0.2185	17.040	<0.0001*	
Disadvantages	Slope	–0.0158	0.0040	–3.981	<0.0001*	0.0179
	Indep. term	4.4450	0.1881	23.634	<0.0001*	
Future	Slope	–0.0155	0.0053	–2.898	0.0040*	0.0237
	Indep. term	4.3880	0.2529	17.353	<0.0001*	
Didactic	Slope	0.0001	0.0032	0.035	0.9720	0.0000
	Indep. term	3.9718	0.1521	26.116	<0.0001*	

Table 6
Statistics of the linear regression model of the families of questions with respect to the age of the participants, among professors from private universities (*p<0.05)

Variable		Estimate	Error	*t*-value	*p*-value	R^2
Skills	Slope	–0.0069	0.0065	–1.058	0.2907	0.0032
	Indep. term	3.2032	0.3032	10.566	<0.0001*	
Usability	Slope	0.0045	0.0049	0.923	0.3566	0.0024
	Indep. term	4.0099	0.2253	17.796	<0.0001*	
Technical	Slope	0.0110	0.0053	2.051	0.0411*	0.0119
	Indep. term	3.4855	0.2476	14.078	<0.0001*	
Disadvantages	Slope	0.0323	0.0054	5.982	<0.0001*	0.0578
	Indep. term	2.0712	0.2504	8.273	<0.0001*	
Future	Slope	0.0178	0.0075	–2.384	0.0179*	0.0239
	Indep. term	4.4749	0.3460	12.934	<0.0001*	
Didactic	Slope	–0.0057	0.0039	23.256	<0.0001*	0.0031
	Indep. term	4.2180	0.1814	–1.468	0.1430	

DISCUSSION

The level of digital skills expressed by arts professors for the use of VR technologies is low (Table 2). Previous works indicate that the digital competence of arts professors is insufficient and that it is necessary to increase it through trainings that combine theoretical training with practical applications and self-assessment activities (De-Eça & Saldanha, 2023). In other works where the digital competence of university professors in general is studied, it is concluded that faculty skills for the use of digital technologies are intermediate or low, but the results obtained here are below the results exposed by the literature for university faculty (Antón-Sancho et al., 2021) and are notably lower than the results offered by professors in technical areas (Fernández-Arias et al., 2022). Comparing the results obtained here with those of other works that specifically analyze the digital skills of professors for the use of VR technologies in other areas of knowledge –the literature mainly analyzes professors of Engineering (Vergara et al.,

2022) and Health Sciences (Vergara et al., 2021) – it can be deduced that arts professors are also those who present less developed digital skills for the use of VR.

On the other hand, the ratings that Latin American arts professors offer on the technical, didactic and usability characteristics of VR and on its future projection are intermediate (between 3 and 4 points out of 5) (Table 2). There is a significant gap in the VR assessments analyzed by university tenure of the participating arts professors (Table 3). This proves that the null hypothesis H1 (no existence of gaps by university tenure in the VR assessment) should be rejected and the corresponding alternative hypothesis (existence of gaps by university tenure in the VR assessment) should be assumed. Professors from private universities express better digital skills than their colleagues from public universities. This can be explained by the greater degree of digitization of private universities in the region compared to public universities (Argüelles-Cruz et al., 2021; Romero, 2022). Consequently, they also express higher ratings of the technical and usability aspects of VR, as these variables are positively correlated with digital skills. Arts professors from private universities also express lower ratings of the level of disadvantages of VR than those from public universities (Table 3). The literature finds that this is not a fact specific to arts professors, but that the same phenomenon occurs, for example, with engineering professors, although the latter's assessments of VR do not depend so much on the digital skills expressed (Vergara et al., 2022). Consequently, there must be some other factor, beyond digital competence, that explains the gap in the ratings of VR given by arts professors from private and public universities. In this sense, the literature indicates that, in the specific region in which this work is developed –Latin America and the Caribbean–, the main reason would be that digital technologies are more weakly implemented in public universities than in private universities, whose commitment to digitization is greater (Rasimah et al., 2011; Rama, 2014).

The behavior of the gender gap in the assessments of VR, which, in general, occurs in terms of access and use of digital technologies (Acosta-Vargas et al., 2018; García-Holgado et al., 2019), is different according to the university tenure of the participating arts professors. This proves that the null hypothesis H2 (no differences in the gender gaps) should be rejected and the alternative hypothesis (existence of differences in the gender gaps between private and public universities) is therefore assumed. Specifically, in private universities females value more the didactic aspects and less the usability of VR than males, but in public universities, it is the males who rate more the technical aspects of VR and less the usability (Table 4). Therefore, the digital gap in terms of knowledge, use, and assessment of technical aspects is detrimental to females in public universities, as had already been observed in the literature among university faculty in general (Rodríguez-Abitia et al., 2020) and technical (Vergara et al., 2022) or health (Vergara et al., 2021) in particular. The main novelty of this study lies in the finding that this different behavior of gender gaps between private and public universities occurs among arts professors, concentrating mainly on the technical aspects of VR. Probably, these differences in the behavior of the gender gaps are once again because the greater digitization of private universities has also led to a greater effort in training professors in digital skills compared to public universities (Argüelles-Cruz et al., 2021; Romero, 2022). This training is the one that has probably led to a correction of the

gender gaps that, within the region, favor the males in terms of access to digital technologies (Ancheta-Arrabal et al., 2021).

It has also been shown that in Latin American public universities a detrimental digital gap persists for older arts professors (Table 5), something that has been corrected in private universities in the same region (Table 6). Therefore, the null hypothesis H3 (no differences in the age gaps) is rejected and the alternative hypothesis (existence of differences in the age gaps between private and public universities) is assumed. This constitutes a new original result of the present study that had not been explored in the preceding literature, although the presence of a detrimental digital divide for older professors in terms of digital competence (Basantes-Andrade et al., 2020), and the assessment of digital technologies in the Latin American region (Antón-Sancho et al., 2022) had been noted.

CONCLUSION

There is a strong gap between private and public universities with respect to arts professors' self-concept of digital competence and their assessments of VR technologies. Specifically, arts professors from private universities rate 10.6% higher the technical aspects, 5.0% higher the usability features, and 5.0% lower the disadvantages of VR than their colleagues from private universities, with the former's digital skills for VR use being 7.4% higher. These ratings differ by gender and age of arts professors, so that the behavior of these gender and age gaps is different in private and public universities. Therefore, the null hypotheses H1, H2, and H3 posed in the study should be rejected and the corresponding alternative hypotheses (respectively, existence of gaps by university tenure in VR assessments; differences in gender gaps in VR assessments by university tenure; and differences in age gaps in VR assessments by university tenure) should be assumed. Specifically, in public universities persist, both a gender gap that penalizes females in terms of rating the technical aspects of VR, and an age gap that penalizes older professors. Both gaps have been corrected in private universities.

It is suggested that universities increase the necessary equipment to integrate VR tools in arts education lectures. It is also recommended to carry out specific training sessions for professors on the use of VR technologies and their integration in arts education lectures. The increase in the digital training of arts professors will favor the reception of educational technologies such as VR. It is suggested that this training incorporate practical activities, to promote the development of techno-pedagogical skills of professors. Finally, it is recommended that universities design implementation plans for digital technologies, such as VR, providing specific implementation protocols to professors, to encourage their use in lessons.

REFERENCES

Acosta-Vargas, P., Acosta, T., & Luján-Mora, S. (2018). Challenges to assess accessibility in higher education websites: A comparative study of Latin America universities. *IEEE Access*, *6*, 36500–36508. https://doi.org/10.1109/ACCESS.2018.2848978

Alter, F. (2014). The experience of teaching tertiary visual arts education in a purely online learning environment. *Australian Art Education, 36*(1), 48–64. https://search.informit.org/doi/10.3316/aeipt.205713

Amprasi, E., Vernadakis, N., Zetou, E., & Antoniou, P. (2022). Effect of a full immersive virtual reality intervention on selective attention in children. *International Journal of Instruction, 15*(1), 565–582. https://doi.org/10.29333/iji.2022.15132a

Ancheta-Arrabal, A., Pulido-Montes, C., & Carvajal-Mardones, V. (2021). Gender digital divide and education in Latin America: A literature review. *Education Sciences, 11*, 804. https://doi.org/10.3390/educsci11120804

Antón-Sancho, A., Fernández-Arias, P., & Vergara, D. (2022). Assessment of virtual reality among university professors: Influence of the digital generation. *Computers, 11*(6), 92. https://doi.org/10.3390/computers11060092

Antón-Sancho, Á., Fernández-Arias, P., & Vergara, D. (2023). Impact of the digitalization level on the assessment of virtual reality in higher education. *International Journal of Online Pedagogy and Course Design (IJOPCD), 13*(1), 1–19. http://doi.org/10.4018/IJOPCD.314153

Antón-Sancho, A., Vergara, D., Lamas-Álvarez, V. E., & Fernández-Arias, P. (2021). Digital content creation tools: American university teachers' perception. *Applied Sciences, 11*, 11649. https://doi.org/10.3390/app112411649

Argüelles-Cruz, A. J., García-Peñalvo, F. J., & Ramírez-Montoya, M. S. (2021). Education in Latin America: Toward the digital transformation in universities. In D. Burgos, & J.W. Branch (Eds.), *Radical Solutions for Digital Transformation in Latin American Universities* (pp. 93–108). Lecture Notes in Educational Technology. Springer, Singapore. https://doi.org/10.1007/978-981-16-3941-8_6

Bachiller, C., Monzo, J. M., & Rey, B. (2023). Augmented and virtual reality to enhance the didactical experience of technological heritage museums. *Applied Sciences, 13*, 3539. https://doi.org/10.3390/app13063539

Basantes-Andrade, A., Cabezas-González, M., & Casillas-Martín, S. (2020). Digital competences relationship between gender and generation of university professors. *International Journal on Advanced Science, Engineering and Information Technology (IJASEIT), 10*(1), 205. https://doi.org/10.18517/ijaseit.10.1.10806

Botden, S. M. B. I., Buzink, S. N., Schijven, M. P., & Jakimowicz, J. J. (2008). ProMIS Augmented reality training of laparoscopic procedures face validity. *Simulation in Healthcare: The Journal of the Society for Simulation in Healthcare, 3*(2), 97–102. https://doi.org/10.1097/SIH.0b013e3181659e91

Cabero-Almenara, J., Llorente-Cejudo, C., & Martinez-Roig, R. (2022). The use of mixed, augmented and virtual reality in history of art teaching: A case study. *Applied System Innovation, 5*(3), 44. https://doi.org/10.3390/asi5030044

Cecotti, H. (2022). Cultural heritage in fully immersive virtual reality. *Virtual Worlds, 1*(1), 82–102. https://doi.org/10.3390/virtualworlds1010006

Chen, M., Chai, C. S., Jong, M. S. Y., & Jiang, M. Y. C. (2021). Teachers' conceptions of teaching Chinese descriptive composition with interactive spherical video-based virtual reality. *Frontiers in Psychology, 12*, 591708. https://doi.org/10.3389/fpsyg.2021.591708

Clapp, E.P. & Ho, C.K.N. (2022). Arts education. In: V.P. Glăveanu (Ed.), *The Palgrave Encyclopedia of the Possible*. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-90913-0_56

Criado, J. I. (2021), Digital public administration in Latin America: Digitalization, public innovation, and the future of technologies in the public sector. In B.G. Peters, C.A. Tercedor, & C. Ramos (Eds.), *The Emerald Handbook of Public Administration in Latin America* (pp. 343–374). Emerald Publishing Limited, Bingley. https://doi.org/10.1108/978-1-83982-676-420201014

De-Eça, T. T. & Saldanha, Â. (2023). Digital media and arts education: The eEuropean digital competence framework. In A. D. Knochel and O. Sahara (Eds.), *Global Media Arts Education* (pp. 149–163), Palgrave Studies in Educational Futures, Palgrave Macmillan, Cham.

Do-Amaral, J. A. A., & Vargas, J. T. (2023). Uncovering the dynamics that drive non-formal online educational activities: The beaver scouts case study. *Anatolian Journal of Education, 8*(1), 1–12. https://doi.org/10.29333/aje.2023.811a

Fernández-Arias, P., Antón-Sancho, A., Barrientos-Fernández, A., & Vergara-Rodríguez, D. (2022). Soft skills of Latin American engineering professors: Gender gap. *IEEE Transactions on Education*, *66*(3), 211–217. https://doi.org/10.1109/TE.2022.3215114

Fernández-Arias, P., Antón-Sancho, A., Sánchez-Jiménez, M., & Vergara, D. (2023). Statistical analysis of professors' assessment regarding the didactic use of virtual reality: Engineering vs. Health. *Electronics*, *12*, 1366. https://doi.org/10.3390/electronics12061366

García-Holgado, A., Camacho-Díaz, A., & García-Peñalvo, F. J. (2019). Engaging women into STEM in Latin America: W-STEM project. *Proc. 7th International Conference on Technological Ecosystems for Enhancing Multiculturality*, 232–239.

González-Pérez, M. A., Cordova, M., Hermans, M., Nava-Aguirre, K. M., Monje-Cueto, F., Mingo, S., Tobon, S., Rodriguez, C. A., Salvaj, E. H., & Floriani, D. E. (2021). Crises conducting stakeholder salience: shifts in the evolution of private universities' governance in Latin America. *Corporate Governance*, *21*(6), 1194–1214. https://doi.org/10.1108/CG-09-2020-0397

González-Zamar, M.-D. & Abad-Segura, E. (2020). Implications of virtual reality in arts education: research analysis in the context of higher education. *Education Sciences*, *10*(9), 225. https://doi.org/10.3390/educsci10090225

González-Zamar, M.-D., Abad-Segura, E., Luque-de-la-Rosa, A., & López-Meneses, E. (2020). Digital education and artistic-visual learning in flexible university

environments: Research analysis. *Education Sciences, 10*, 294. https://doi.org/10.3390/educsci10110294

Jiawei, W., & Mokmin, N. A. M. (2023). Virtual reality technology in art education with visual communication design in higher education: a systematic literature review. *Education & Information Technologies*. In press. https://doi.org/10.1007/s10639-023-11845-y

Jorge-Vázquez, J., Náñez-Alonso, S. L., Fierro-Saltos, W. R., & Pacheco-Mendoza, S. (2021). Assessment of digital competencies of university faculty and their conditioning factors: Case study in a technological adoption context. *Education Sciences, 11*, 637. https://doi.org/10.3390/educsci11100637

Hui, J., Zhou, Y., Oubibi, M., Di, W., Zhang, L., & Zhang, S. (2022). Research on art teaching practice supported by virtual reality (VR) technology in the primary schools. *Sustainability, 14*(3), 1246. https://doi.org/10.3390/su14031246

Kali, Y., Sagy, O., Benichou, M., Atias, O., & Levin-Peled, R. (2019). Teaching expertise reconsidered: The Technology, Pedagogy, Content and Space (TPeCS) knowledge framework. *British Journal of Educational Technology, 50*, 2162–2177. https://doi.org/10.1111/bjet.12847

Katz, R. L., Koutroumpis, P. & Callorda, F. (2013). The Latin American path towards digitization, *Info, 15*(3), 6–24. https://doi.org/10.1108/14636691311327098

Kim, H., So, H.-J., & Park, J.-Y. (2022). Examining the effect of socially engaged art education with virtual reality on creative problem solving. *Educational Technology & Society, 25*(2), 117–129.

Lin, C.-L., Chen, S.-J., & Lin, R. (2020). Efficacy of virtual reality in painting art exhibitions appreciation. *Applied Sciences, 10*, 3012. https://doi.org/10.3390/app10093012

Marmani, F. (2022). Creating gender equality in the educational system. *Anatolian Journal of Education, 7*(1), 57-72. https://doi.org/10.29333/aje.2022.715a

Neswary, S.B.A., & Prahani, B. K. (2023). The use of digital pocketbooks to support Merdeka curriculum in physics learning: literature review. *Anatolian Journal of Education, 8*(2), 135-146. https://doi.org/10.29333/aje.2023.829a

Peters, O. (2000). Digital learning environments: New possibilities and opportunities. *International Review of Research in Open and Distributed Learning, 1*(1), 1–19. https://doi.org/10.19173/irrodl.v1i1.3

Popp, C. & Murphy, D.T. (2022) Creating audio object-focused acoustic environments for room-scale virtual reality. *Applied Sciences, 12*(14), 7306. https://doi.org/10.3390/app12147306

Quinn, R.D. (2011). E-learning in art education: Collaborative meaning making through digital art production. *Art Education, 64*(4), 18–24. https://doi.org/10.1080/00043125.2011.11519132

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Rama, C. (2014). University virtualisation in Latin America. *International Journal of Educational Technology in Higher Education*, *11*, 32–41. http://dx.doi.org/10.7238/rusc.v11i3.1729

Rasimah, C. M. Y., Ahmad, A., & Zaman, H. B. (2011). Evaluation of user acceptance of mixed reality technology. *Australasian Journal of Educational Technology*, *27*, 1369–1387. https://doi.org/10.14742/ajet.899

Rodríguez-Abitia, G., Martínez-Pérez, S., Ramírez-Montoya, M. S., & López-Caudana, E. (2020). Digital gap in universities and challenges for quality education: A diagnostic study in Mexico and Spain. *Sustainability*, *12*, 9069. https://doi.org/10.3390/su12219069

Romero, M. A. M. (2022). Legal framework for hasty digitization in educational institutions of Latin American countries during the Covid-19 epidemic. *Journal of Positive School Psychology*, *6*(4), 5392–5404. https://orcid.org/0000-0003-4067-2816

Scorpio, M., Laffi, R., Masullo, M., Ciampi, G., Rosato, A., Maffei, L., & Sibilio, S. (2020). Virtual reality for smart urban lighting design: Review, applications and opportunities. *Energies, 13*(15), 3809. https://doi.org/10.3390/en13153809

Setyowati, R. R., Rochmat, S., Aman., & Nugroho, A. N. P. (2023). Virtual reality on contextual learning during Covid-19 to improve students' learning outcomes and participation. *International Journal of Instruction, 16*(1), 173–190. https://doi.org/10.29333/iji.2023.16110a

Tusiime, W., Johannesen, M., & Gudmundsdottir, G. (2019). Developing teachers' digital competence: approaches for art and design teacher educators in Uganda. *International Journal of Education and Development using ICT*, *15*(1), 133–149.

Vázquez-Villegas, P., Garay-Rondero, C., Deng, B., Mejía-Manzano, L.A., Chen, D., & Membrillo-Hernández, J. (2023). Effect of extended reality learning experience on student engagement in science and engineering courses. *International Journal of Instruction, 16*(4), 939-964. https://doi.org/10.29333/iji.2023.16452a

Vergara, D., Antón-Sancho, A., Dávila, L. P., & Fernández-Arias, P. (2022). Virtual reality as a didactic resource from the perspective of engineering teachers. *Computer Applications in Engineering Education*, *30*(4), 1086–1101. https://doi.org/10.1002/cae.22504

Vergara, D., Antón-Sancho, A., Extremera, J., & Fernández-Arias, P. (2021). Assessment of virtual reality as a didactic resource in higher education. *Sustainability*, *13*, 12730. https://doi.org/10.3390/su132212730

Vergara, D., Antón-Sancho, Á. & Fernández-Arias, P. (2023) Engineering professors' habits: didactic use of Information and Communication Technologies (ICT). *Education and Information Technologies*, In press. https://doi.org/10.1007/s10639-023-12110-y

Xie, Z. (2020). The symmetries in film and television production areas based on virtual reality and internet of things technology. *Symmetry*, *12*(8), 1377. https://doi.org/10.3390/sym12081377

Yiping, J. (2021). Methods of formation of digital competence of future teachers of art disciplines in higher education institutions of China. *Professional Education: Methodology, Theory and Technologies, 13*, 125–137. https://doi.org/10.31470/2415-3729-2021-13-125-137

Zhang, W., Shankar, A., & Antonidoss, A. (2022). Modern art education and teaching based on artificial intelligence. *Journal of Interconnection Networks, 22*(Supp01). https://doi.org/10.1142/S021926592141005X

Zhao, Y., Pinto-Llorente, A.M., & Sánchez-Gómez, M.C. (2021). Digital competence in higher education research: A systematic literature review. *Computers & Education, 168*, 104212. https://doi.org/10.1016/j.compedu.2021.104212

Zhou, Y., Chen, J., & Wang, M. (2022). A meta-analytic review on incorporating virtual and augmented reality in museum learning. *Educational Research Review, 36*, 100454. https://doi.org/10.1016/j.edurev.2022.100454