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Views of secondary education teachers on the use of mixed reality

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The advance of the so-called emergent technologies in the field of education goes hand in hand with the previous experiences and beliefs of teachers, or lack thereof, with and about them. Among all the digital resources available, Mixed Reality (MR) is currently awakening the interest of educators, given that it combines virtual and augmented reality. Although both of these technologies are already present in many mixed methodologies utilized for teaching and learning processes, this is not the case of MR. Thus, it is necessary to discover the perspectives of educators on the use of MR, to be able to forecast its successful implementation in classrooms. Thus, the present article shows data obtained from a study with 219 Secondary Education pre-service teachers in Spain. The data collected through a 31-item *ad hoc* questionnaire pointed to differences in the perception of Mixed Reality in the teaching process as a function of gender, with women considering that it will make the classroom methodology more communicative, also believing that it will promote the reading comprehension of the texts that are utilized in each school subject. Thus, we can conclude that mixed reality is defined as a tool that promotes the learning process of secondary school students.

KEYWORDS

virtual reality, augmented reality, mixed reality, teachers, training, emergent technologies

Introduction

Presently, moving forward in the digital world must be understood by citizens as a right and a responsibility. With respect to a right, it implies the inclusion of all collectives in the construction of life in a society in general, and their immediate surroundings in particular (Restrepo and Gómez, 2020), where the main objective is to promote the inclusion of everyone into the idea of creating shared progress that benefits the entire population. If we focus on the responsibility aspect, it is associated to the beliefs, ethical codes, opinions, etc., of every individual, with all of this affecting a person and everything around him or her (García et al., 2022). Nevertheless, it is known that for the construction and re-construction of digital society to move forward, the participation of all the productive sectors is needed. In this sense, we must consider that digital resources form part of all (or almost all) the actions that shape the everyday life of individuals. Thus, if we focus on the area of education, we will observe that due to the SARS-CoV-2 virus (COVID-19), its presence has considerably increased (Kauz, 2022). Along this line, technologies such as virtual and augmented reality, and more recently mixed reality, have been gaining a foothold in the classroom methodologies at all levels of education (Barroso and Gallego, 2017; Lee et al., 2018; Leal, 2020; Villalustre, 2020; Magallanes et al., 2021; Ayuso et al., 2022).

Focusing our attention on mixed reality (from here on MR), it implies a step forward when referring to technological development within the area of immersion into reality. Born under the sum of virtual reality (from here on VR), and augmented reality (from here on AR), little by little we have observed its overlap in the area of teaching at all levels of education, as we have pointed out. MR allows the students to immerse themselves in total learning (Marín-Díaz et al., 2022a), named immersive learning (meaning one's introduction into an artificial world), inherited from VR (Barroso and Gallego, 2017; Marín-Díaz et al., 2022b), which allows delving into contents that could be excessively abstract for the comprehension of students (Marín-Díaz et al., 2022a,b).

On the other hand, it must be pointed out that both (VR and AR) technologies have a series of limitations, as pointed out by Aslana et al. (2019), given that the individual is limited when using them, as in the case of VR, it isolates the user from the environment in which he or she moves, and for AR, the perception of reality and immersion is not complete, given that we do not "incorporate" into the new scenario, but are merely observers.

MR arrived to schools thanks to reports such as Horizon (Johnson et al., 2016), which point to the degree of penetration that this and other technologies will have in the coming years, as well as the restless spirit of researchers and education practitioners. As already pointed out, MR is a step forward in the immersion of a subject in a completely virtual scenario, where his or her interaction with what it is observed can be total (Bockholt, 2017). From VR, MR has taken the virtual scenarios created with the 360° video technology utilized, and from AR, the possibility of visually projecting, with movement, that which we wish to try, see, "touch", etc., to ultimately experience it in first person.

Ultimately, MR combines three elements; immersion, simulation, and interaction. *A priori*, we understand that the first element brings with it the introduction of a completely unreal virtual scenario (here we talk about the part that incorporates VR), where what we see is not real, but a superimposed hologram, for example (here we talk about AR). Thus, we can talk about a simulation, given that what is provided is a well-simulated sequence in which we will be able to directly interact with objects, people, situations, etc., which can be observed within it (Marín-Díaz et al., 2022a,b).

On the other hand, we must consider that MR has great advantages, for example the visual richness that it provides to the contents, which will promote learning, thus turning into one of the key elements for its incorporation into teaching-learning methodologies (Zhang, 2021). Aside from this, it also allows the student to interact with objects, thus making the act of learning more invigorating (Dalingera et al., 2020; Zhang, 2021; Marín-Díaz et al., 2022a). Lastly, another added value is that the risk factor disappears. For example, when we interact with a laboratory with dangerous materials, the student is not at risk at all (Rossler et al., 2020).

An example of the education + MR association is found in the DICOM3D-VR application created by Sadeghi et al. (2021) which allows, through the application of models in three dimensions combined with MR, the evaluation of doctors in clinical pictures of a patient to be done in less than 1 min without losing image data, as we find with other three-dimensional models, so that the education of health professionals is improved. Still within the field of health and along the same line as Sadeghi et al. (2021), we find the study by Tennant et al. (2021) with children and adolescents under oncological treatment. Her study, whose aim was for patients to have a better understanding of the treatment process, and to provide them with education for health, showed that through the use of MR, their understanding of the medical process improved, at the same time that their states of anxiety were reduced.

Outside from the field of health, we find the work by Zhang (2021), who discussed advances on the use of MR with Early Childhood pre-service teachers. In this study, the author pointed out that its use will allow us to further explore the individual differences of the subjects (children), including how their environment affects the characteristics that define their personality, all of this through the use of avatars that simulate students, so that it imitates the complete ecology of an early childhood classroom.

As pointed out by Miller (2017), overlapping MR with education processes means introducing ourselves into an immersive experience through tangible and verbal interaction, which will promote the mobilization of skills needed by the subject to learn, both consciously and unconsciously, given that the information is presented in a realistic and authentic manner, and as a result, the retention in our memory is increased, with the memory firmly recorded (Marín-Díaz et al., 2022).

Given the above, the present study will try to determine, to the greatest extent possible, the views of teachers in the Social Sciences and Experimental Sciences fields, who work in Spanish Compulsory Secondary Education centers, on MR in their professional field, under the auspices of the R&D + I project *Design, implementation and evaluation of Mixed Reality materials for learning environments* (PID2019-108933GB-I00), financed by the Ministry of Science and Universities of Spain.

Materials and methods

For the present study, an *ex post* facto method was utilized, with a descriptive and correlational design, based on the classification by Jorrin et al. (2021). Beginning with this, the starting objectives were defined, which were based on the general objectives of the R&D + I Project within which the present study is framed, the Design, implementation and evaluation of Mixed Reality materials for learning environments (PID2019-108933GB-I00), financed by the Ministry of Science and Universities of Spain. The objective of the general project was the implementation and evaluation of MR materials in secondary education. Thus, the main starting objective of the present study was to determine the views on the use of MR, of teachers-in-training enrolled in the specialties of Social Sciences and Experimental Sciences Master's in Secondary Education Teaching at the University of Córdoba (Spain). The following working hypotheses were posited:

a) H1. There are differences according to gender on the use of MR in classrooms. More specifically, women value the attention to diversity in the use of MR in the Obligatory Secondary Education.
b) H2. The age of the teachers-in-training does not show differences on the use of MR in classrooms.
c) H3. There are significant differences according to the macro-area from which Obligatory Secondary Education pre-service teachers come from, with those from the Social Sciences valuing the attention to diversity in the use of MR.

Instrument

The collection of data was conducted through the implementation of a questionnaire through the Google Forms service.

The instrument was composed by 31 items, which were organized into two blocks: the first contained the socio-demographic data of the participants, in this case their gender, age, and macro-area. The second contained the other 28 items, which dealt with MR itself. The response scale was Likert-type, following the guidelines from Matas (2018) where one corresponded to complete disagreement, and five complete agreement.

For scientific rigor, a series of statistic tests were performed to determine its reliability and validity. To verify the reliability of the instrument, a Cronbach's alpha test was performed, which provided a value of 0.865, as well as McDonald' Omega, which provided a value of 0.827, both of which were considered by López-Roldán and Fachelli (2016) as being very high. Also, for further scientific rigor, the same tests were also performed after removing one item at a time, with the values found oscillating between 0.850 and 0.832, both of which were deemed acceptable (Ventura-León and Caycho-Rodríguez, 2017).

For validity, an exploratory factorial analysis (EFA) was performed, which was delimited to accept only the items with loads higher than 0.30 (Mavrou, 2015), this screening resulted in eight items of the 36 not being considered in the distribution of three factors that explained 43.0% of the variance (see **Table 1**). The extraction method utilized was unweighted least squares (ULS) and Kaiser normalization with oblimin rotation, with Kaiser-Meyer-Olkin (KMO) values obtained being 0.820 (acceptable), and a significant Bartlett's sphericity test [X^2 (378) = 2380.909 and $p < 0.001$]. Considering these parameters, the factorial structure was accepted (Ferrando and Anguiano-Carrasco, 2010).

All of these validity results, a not very large sample size, together with the extraction of various items, led us to replicate the test with the software Factor Analysis (v.11), to verify the structure through statistic tests that corroborate this structure (Freiberg et al., 2013). The three factor structure was re-affirmed through the use of the factor extraction method Robust Unweighted Least Squares (RULS) and a varimax promin rotation with Kaiser normalization procedure (Lorenzo-Seva and Ferrando, 2019), when using Pearson's correlations (KMO = 0.867; Bartlett's sphericity test: X^2 = 2373.6; gl; 630; sig < 0.01), and a recommended configuration of three factors, with the statistical values obtained (95% CI) being: CFI = 0.978; BIC = 1531.880; GFI = 0.957; AGFI = 0.941; RMSR = 0.0691; and an RMSEA = 0.045, below 0.05, considered acceptable (Escobedo et al., 2016).

Once the factors were defined, they were subjected to the reliability test, with high or very high values obtained (Rodríguez-Rodríguez and Reguant-Álvarez, 2020) (see **Table 2**).

Participants

The study population was composed by all the students enrolled in the Secondary Education Teacher's training Master's program taught at the University of XX during academic year 2021–2022, obtained through non-probabilistic, convenience sampling (Otzen and Manterola, 2017; Hernández and Carpio, 2019). From this population (N = 219), the sample extracted for the present study was composed by pre-service teachers in the macro-areas of Social Sciences and Experimental Sciences, of which 58.4% were women, and 41.6% men. Considering the macro-areas, 60.3% were found in Social Sciences, and 39.7% in Experimental Sciences.

With respect to the age of the participants, their mean age was 26.71 years old (SD = 5.378), (see **Figure 1**).

Analysis strategy

The analysis of the quantitative data will be first descriptive, through the use of central tendency and dispersion (mean and

TABLE 1 Exploratory factor analysis.

		Factors		
		1	2	3
1.	The use of MR will promotes the critical spirit of the students	0.732		
2.	The use of MR promotes the ability to dialogue and express oneself in public associated to the school subject in which it is utilized	0.708		
3.	The use of MR promotes values education	0.667		
4.	The use of MR will make it so that the didactic methodology utilized in the classroom will achieve more of the objectives of the subject in which it is used	0.650		
5.	The use of MR will make the didactic methodology utilized in the classroom promote the development of key competences	0.646		
6.	The use of MR will favor the personal initiative of the students	0.615		
7.	The use of MR promotes the oral expression associated to the school subject in which it is utilized	0.608		
8.	The use of MR will favor the student's ability to communicate what was learned	0.588		
9.	The use of MR promotes the reading comprehension of the texts associated to the school subject in which it is utilized	0.585		
10.	The use of MR will make the didactic methodology utilized in class more communicative	0.562		
11.	The use of MR will favor the creativity of the students	0.547		
12.	The use of MR will make the didactic methodology utilized in the classroom more active	0.535		
13.	The use of MR will make the didactic methodology utilized in class more participative	0.490		
14.	The use of MR can promote multicultural education	0.471		
15.	Learning how to use MR, on the part of the teachers, takes too much time		0.711	
16.	Learning how to use MR, on the part of the students, takes too much time		0.576	
17.	For using MR in the classroom, great technological support is needed (tablets, markers, screens. . .)		0.567	
18.	For using MR in the classroom, the teachers must have knowledge about informatics and/or programming		0.558	
19.	For using MR in the classroom, students must have knowledge about informatics and/or programming		0.479	
20.	RM can be used by subjects with hearing difficulties			0.872
21.	RM can be used by used by subjects with psychological disorders			0.824
22.	RM can be used by individuals with motor difficulties			0.747
23.	RM can be used by students with specific education needs			0.746
24.	RM can be used by gifted individuals			0.645
25.	The use of RM can promote cross-sectional learning of the contents			0.465
26.	The use of RM allows cooperative work between students			0.448
27.	The use of RM allows collaborative work between students			0.425
28.	The use of RM allows group work between students			0.413

standard deviations), and distribution (kurtosis). Secondly, an inferential analysis will be performed with the variables gender, macro-areas, and age, and thirdly, a relational analysis of these factors as well.

Results

Descriptive study

In first place, the descriptive study of the factors (see **Table 3**) shows that the factors followed a normal distribution, given that the kurtosis values were found between the +1 and −1 interval. On the other hand, the participants were more in agreement that the use of MR in the classroom methodology will favor personal initiative (M. = 4.06; SD = 0.736), and students will be more active (M. = 4.42; SD = 0.753) and more participative (M. = 4.27; SD = 0.770). Likewise, they were completely in agreement that for attention to diversity, the use of MR could be utilized by students who had specific learning needs (M. = 4.34; SD = 0.726), gifted (M. = 4.54; SD = 0.637), with hearing (M. = 4.23; SD = 0.720), and motor (M. = 4.01; SD = 0.815) difficulties, aside from allowing cooperative (M. = 4.29; SD = 0.721) and collaborative (M. = 4.26; SD = 0.706) work. Finally, they were in agreement that for the

TABLE 2 Reliability of the factors.

	Cronbach's alpha	McDonald's omega
Factor 1. Teaching methodology in the use of MR	0.852	0.844
Factor 2. Technology training on the use of MR	0.738	0.723
Factor 3. Attention to diversity on the use of MR	0.834	0.814

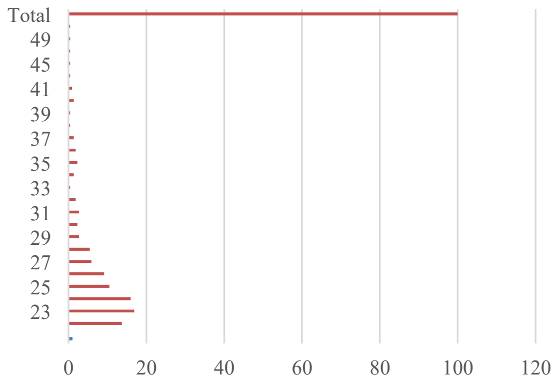

FIGURE 1
Distribution of the sample as a function of age.

use of MR in the classroom to be a reality, the teachers needed technology training or education (M. = 3.76; SD = 1.134), as well as technological support (M. = 3.81; SD = 1.053).

Inferential study

The inferential study performed refers to the differences in means. In this case, for the variables gender and macro-area, Student's *t*-test (n.s. = 0.05) was used for independent variables.

The results revealed that women are more in agreement with the assertions that give rise to factor 1 (teaching methodologies in the use of MR), than the men (assuming equal variances $t = -2.622$ and $p = 0.009$, Cohen's d = 0.485). And that pre-service teachers in the macro-areas of Social Sciences are more in agreement with the statements that referred to the teaching methodology in the use of MR (factor 1), than those from Experimental Sciences (assuming equal variances $t = 2.986$ and $p = 0.002$, Cohen's d = 0.484).

The comparison of the variable age was performed with an ANOVA analysis (n.s. = 0.05), resulting in an effect between the variable age and Factor 3 (Attention to diversity in the use of MR), F (2, 216) = 4.193 and $p = 0.016$, $Eta^2 = 0.037$ and $Epsilon^2 = 0.028$, where subjects aged between 21 and 30 years old were more in agreement than those aged 31 to 40 years old ($t = 2.328$ and $p = 0.021$, Cohen's d = 0.471). The rest of the differences were not significant.

Correlational study

Lastly, we present the relational study, by first executing a bivariate correlation to verify the existence of a relationship between the research factors, pointing out the existence of a low and notable relationship, and a high significance of 0.01 (**) and 0.05 (*), depending on the variables considered (see Table 4).

Factor 1 (Teaching methodology in the use of MR), is moderately or notably associated with factor 3 (Attention to diversity in the use of MR), R = 0.465 and $p < 0.001$. Meanwhile, factor 1 (Teaching methodology in the use of MR) is not well associated with factor 2 (Technology training on the use of MR) R = 0.150 and $p = 0.026$. There was no relation between factors 2 and 3.

With respect to these relationships, we tried to decipher the model that explains factor 1 as a function of the other variables, given that it has a relationship with the rest. For this, a stepwise multiple linear regression analysis was performed (see Table 5), where the dependent variable was the Teaching methodology in the use of MR (factor 1), and the independent or predictive variables were factor 2 (Technology training on the use of MR), and factor 3 (Attention to diversity in the use of MR), as well as the socio-demographic variables gender and macro-area (only had two categories), and the variables age, without categorization.

The result showed that only 23% was explained with the following equation: Factor 1 = 21.476 + 0.74 Factor 3 + 0.24 Factor 2, given the level of adjusted $R^2 = 0.227$ and a Durbin-Watson value of 1.9, with F (2, 216) = 33.058 and $p < 0.001$ (n.s. = 0.05), thus showing the interdependence of the residues, and that the explanatory variables have a joint and linear influence on factor 1.

Factor 1 is not explained by neither age, gender, nor macro-area, while factor 3 ($t = 7.729$ and $p < 0.001$), and factor 2 ($t = 2.277$ and $p = 0.024$) were kept, with both of them significant for the Teaching methodology in the use of MR (factor 1).

Therefore, we decided to study the predictive variables eliminated from the model as selection variables, through a stepwise multiple regression analysis. For gender, as shown in Table 6, the model still explains factor 1 with the same variables, but with different parameters for the men, while for the women, it does not take into account factor 2.

TABLE 3 Descriptive study.

						Asymmetry		Kurtosis	
	N	Min.	Max.	Media	D.T.	Statistic value	S.E.	Statistic value	S.E.
Factor 1	219	33	70	53.8	6.88	0.044	0.164	0.222	0.327
Factor 2	219	7	25	16.6	3.84	−0.095	0.164	−0.480	0.327
Factor 3	219	17	45	38.3	4.29	−0.733	0.164	1.003	0.327

TABLE 4 Correlational study.

		Factor 1	Factor 2	Factor 3
Factor 1	Pearson's correlation	1		
	Sig. (two-tailed)			
	N	219		
Factor 2	Pearson's correlation	0.150*	1	
	Sig. (two-tailed)	0.026		
	N	219	219	
Factor 3	Pearson's correlation	0.465**	0.032	1
	Sig. (two-tailed)	0.000	0.637	
	N	219	219	219

*High significance of 0.05.
**High significance of 0.01.

TABLE 5 Multiple linear regression for the Teaching methodology in the use of mixed reality (MR).

	Constant	Factor 3	Factor 2
B	21.476	0.739	0.243
S.E.	4.035	0.096	0.107
Beta		0.460	0.136
t	5.322	7.729	2.277
Sig.	0.000	0.000	0.024
Zero order		0.465	0.150
Partial R		0.465	0.153
Semi-partial R		0.460	0.136
Tolerance		0.999	0.999
VIF		1.001	1.001

TABLE 6 Multiple linear regression for the Teaching methodology in the use of mixed reality (MR) according to gender.

	Men			Women	
	Constant	Factor 3	Factor 2	Constant	Factor 3
B	25.809	0.514	0.444	21.721	0.855
S.E.	5.697	0.144	0.172	4.981	0.128
Beta		0.343	0.249		0.511
t	4.530	3.557	2.581	4.361	6.677
Sig.	0.000	0.001	0.012	0.000	0.000
Zero Order		0.386	0.309		0.511
Partial R		0.355	0.265		0.511
Semi-partial R		0.337	0.245		0.511
Tolerance		0.969	0.969		1.000
VIF		1.032	1.032		1.000

With respect to the result for the men, we find that only 19%, is explained with equation: Factor 1 = 25.8 + 0.51 Factor 3 + 0.44 Factor 2, given an adjusted $R^2 = 0.191$ and Durbin-Watson value of 2.1, with F (2, 88) = 11.628 and $p < 0.001$ (n.s. = 0.05), showing the interdependence of the residues and that the explanatory variables have a joint and linear influence on factor 1. Both factor s3 ($t = 3.557$ and $p = 0.001$) and factor 2 ($t = 2.581$ and $p = 0.012$), were significant for the Teaching methodology on the use of MR (factor 1).

While for the women, 26% is explained with equation: Factor 1 = 21.7 + 0.85 Factor 3, given an adjusted $R^2 = 0.256$ and Durbin-Watson value of 1.9, with F (1, 126) = 44.586 and $p < 0.001$ (n.s. = 0.05), showing the interdependence of the residues and that the explanatory variables have a joint and linear influence on factor 1. Factor 3 ($t = 6.677$ and $p < 0.001$) is significant for the Teaching methodology on the use of MR (factor 1).

Likewise, the predictive variables macro-areas, as selection variables, were analyzed through a stepwise multiple linear regression analysis. Table 7 shows that the model still explains factor 1 with the same variables but with different parameters for the pre-service teachers in social sciences, while for experimental sciences, only factor 3 is considered.

The result of Social Sciences is that only 25% is explained with the following equation: Factor 1 = 17.8 + 0.80 Factor 3 + 0.37 Factor 2, given an adjusted $R^2 = 0.245$ and Durbin-Watson value of 2.0, with F (2, 129) = 22.211 and $p < 0.001$ (n.s. = 0.05), showing the interdependence of the residues and that the explanatory variables have a joint and linear influence on factor 1. Both factor 3 ($t = 6.257$ and $p < 0.001$) and factor 2 ($t = 2.422$ and $p = 0.017$), were significant for the Teaching methodology on the use of MR (factor 1).

While for Experimental Sciences, 23% was explained with the following equation: Factor 1 = 27.1 + 0.66 Factor 3, given an adjusted $R^2 = 0.225$ and Durbin-Watson value of 1.8, with F (1, 85) = 25.970 and $p < 0.001$ (n.s. = 0.05), showing the interdependence of the residues and that the explanatory variables have a joint and linear influence on factor 1. Factor 3 ($t = 5.096$ and $p < 0.001$) is significant for the Teaching methodology on the use of MR (factor 1).

TABLE 7 Multiple linear regression for the Teaching methodology in the use of mixed reality (MR) for the macro-area.

	Social sciences			Experimental sciences	
	Constant	Factor 3	Factor 2	Constant	Factor 3
B	17.832	0.804	0.371	27.059	0.657
S.E.	5.625	0.129	0.153	4.961	0.129
Beta		0.475	0.184		0.484
t	3.170	6.257	2.422	5.454	5.096
Sig.	0.002	0.000	0.017	0.000	0.000
Zero order		0.472	0.174		0.484
Partial R		0.483	0.209		0.484
Semi-partial R		0.475	0.184		0.484
Tolerance		1.000	1.000		1.000
VIF		1.000	1.000		1.000

The variable age as a selection variable in the stepwise multiple regression analysis, did not show an explanatory model for the Teaching methodology on the use of MR (factor 1).

The non-multi-collinearity of all the models, observed through VIF and tolerance values, was adequate, according to Vilà et al. (2019), given that the values of the first parameter were equal or higher than 1, and the second were higher than 0.10.

Discussion and conclusion

We agree with Huang et al. (2016) in that the addition of digital resources to classrooms has provided teaching innovation with a new perspective, which implies the endowment of resources, as well as the training of teachers and students. However, so that a digital tool can be truly introduced into the methodology, or the manner in which teaching is performed, it is necessary for the teachers to express their beliefs, opinions, and experiences with them (Arancibia et al., 2020; Marín et al., 2022). As a result, studies on these views are necessary so we can move forward in the process of learning, to also promote the development of the digital competence of students, which is presently a key pillar in their incorporation to the society and the professional world.

In the specific case of our object of study, MR, we initially verified that pre-service secondary education teachers associate it with 3 factors, i.e., the teaching or classroom methodology, training, and attention to diversity, just as studies by Marín-Díaz et al. (2022c).

As for aspects associated to the teaching methodology, the participants pointed out that MR will promote the autonomy and initiative of secondary education students, and also indicated that the classroom and the learning process would be more active (Tang et al., 2018; Alfadil, 2021; Sousa et al., 2022), and therefore, more participative.

Just as the results obtained in a study by Meyer et al. (2019) it is underlined that knowledge, i.e., being trained on the use of MR, plays an important role in the development of learning processes, and it is the reason why there is a need to promote the training of teachers on its proper use, in agreement with that expressed by the participants in our study and those from Fuentes et al. (2019) and Aso et al. (2021).

Training on the use of this technology is another of the worries expressed by the study participants, who pointed that they as teachers, as well as students in this education stage, need training that will allow them to implement it in the classroom, and to promote meaningful learning in the education community (Palomo, 2020). More specifically, the pre-service secondary education teachers, just as in the studies by Bower et al. (2020), Vasilevski and Birt (2020), Zhang (2021) pointed out the need to have technological support for its successful implementation in classrooms.

As for aspects associated to attention to diversity, the participants pointed out that students who were gifted, as well as those who had hearing difficulties, could benefit from its use, so that we can conclude that their learning would be enriched (Huang et al., 2019; Magallanes et al., 2021).

When considering the hypotheses posited, we verified that for hypothesis 1 (*There are differences according to gender on the use of MR in the classrooms. More specifically, women value the attention to diversity in the use of MR in the Obligatory Secondary Education*), we can consider that gender is an element that determines the presence of MR in the classroom, in the sense that women leaned toward its use as a resource in their teaching. Thus, H1 can be accepted in factor 1 (Teaching methodology in the use of MR), and rejected in factors 2 and 3 (Technology training on the use of MR, and Attention to diversity on the use of MR), as opposed from the results obtained by Bursztyn et al. (2017) and Marín-Díaz et al. (2022c).

If we consider age to obtain an answer to H2 (*The age of pre-service teachers does not show differences on the use of MR in classrooms*), we observed that no differences were found, so that the hypothesis can be accepted in the three factors, as opposed to the results obtained by Marín-Díaz et al. (2022c) with a study population that was similar to that in the present study.

Lastly, for the third hypothesis (*There are significant differences according to the macro-area from which Obligatory Secondary Education pre-service teachers come from, with those from the Social Sciences valuing the attention to diversity in the use of MR*), the results indicate that it must be accepted with respect to factor 3, as well as in factor 2, which refers to technology training (Bower et al., 2020; Vasilevski and Birt, 2020; Zhang, 2021). It is significant that for the participants from the macro-area of Experimental Sciences, the third factor affected the first, and not the other way around.

Ultimately, and to conclude, we can indicate that pre-service secondary education teachers had a very positive view about the use of MR in the classroom, and its introduction as a resource in their teaching methodologies, although they need training for this, as well as and endowment of resources. Likewise, they believe that learning would be more active and collaborative between the students.

Limitations

Studies conducted in the field of education have an initial handicap, which is the size of the sample utilized, and on which the study will be conducted. In this case, we are aware that an $N = 219$ does not allow us to generalize the results to the entire population of pre-service secondary education teachers. However, starting with the results obtained, the instrument can be perfected to be able to obtain one that has 100% of the guarantees of reliability and validity, to be able to generalize it to the entire education community independently of the country it is applied.

Another limitation we found is that not all the education centers even possessed basic digital resources, so that MR, a very recent technology, will not be present in all the classrooms. Thus, the training of the teachers will also be a variable that will limit the study, given that if many of them do not have the training, they will not overlap its use with their classroom methodology.

Data availability statement

The data analyzed in this study cannot be made public due to a lack of authorization by the participants. Requests to access these datasets should be directed to VM-D, vmarin@uco.es.

Author contributions

VM-D: conceptualization, writing of the manuscript, review, editing, and supervision. VM-D and BS-R: methodology and analysis and review final document. Both authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Alfadil, M. (2021). Effectiveness of virtual reality game in foreign language vocabulary acquisition. *Comput. Educ.* 153:103893. doi: 10.1016/j.compedu.2020.103893

Arancibia, M. L., Cabero, J., and Marín, V. (2020). Creencias sobre la enseñanza y uso de la tecnología en docentes de educación superior. *Formación Univ.* 13, 89–100. 89-100 doi: 10.4067/S0718-50062020000300089

Aslana, D., Çetina, B. B., and Özbilgin, ÝG. (2019). An innovative technology: Augmented Reality based Information systems. *Procedia Comput. Syst.* 158, 407–414. doi: 10.1016/j.procs.2019.09.069

Aso, B., Navarrro-Neri, I., García-Ceballos, S., and Rivero, P. (2021). “Quality requirements for implementing augmented reality in heritage spaces: Teachers’ perspective. *Educ. Sci.* 11:405. doi: 10.3390/educsci11080405

Ayuso, D., Gutiérrez, P., and Castro, M. P. (2022). Experiencia formativa virtual en realidad aumentada con el alumnado de educación primaria de un centro de atención educativa preferente. *EDMETIC* 11:4. doi: 10.21071/edmetic.v11i2.13671

Barroso, J. M., and Gallego, O. M. (2017). Producción de recursos de aprendizaje apoyados en realidad aumentada por parte de estudiantes de magisterio. *EDMETIC* 6, 23–38. doi: 10.21071/edmetic.v6i1.5806

Bockholt, N. (2017). *Realidad virtual, realidad aumentada, realidad mixta. y¿ qué significa” inmersión" realmente.* Available online at: https://intef.es/Noticias/informe-horizon-2016-primaria-y-secundaria-tecnologias-1-a-5-anos/ (accessed July 6, 2022).

Bower, M., DeWitt, D., and Lai, J. W. M. (2020). Reasons associated with preservice teachers’ intention to use immersive virtual reality in education. *Br. J. Educ. Technol.* 51, 2215–2233. doi: 10.1111/bjet.13009

Bursztyn, N., Shelton, B., Walker, A., and Pederson, J. (2017). Increasing undergraduate interest to learn geoscience with GPS-based augmented reality field trips on students’ own smartphone. *GSA Today* 27, 4–11. doi: 10.1130/GSATG304A.1

Dalingera, T., Thomas, K. B., Stansberrya, S., and Xiua, Y. (2020). “A mixed reality simulation offers strategic practice for pre-service teachers. *Comput. Educ.* 144:103696. doi: 10.1016/j.compedu.2020.103696

Escobedo, M. T., Hernández, J. A., Estebané, V., and Martínez, G. (2016). “Modelos de ecuaciones estructurales: Características, fases, construcción, aplicación y resultados. *Cienc. Trab.* 18, 16–22. doi: 10.4067/S0718-24492016000100004

Ferrando, P. J., and Anguiano-Carrasco, C. (2010). El análisis factorial como técnica de investigación en psicología. *Papeles Psicól.* 31, 18–33.

Freiberg, A., Stover, J., De La Iglesia, G., and Fernández, M. (2013). Correlaciones policóricas y tetracóricas en estudios factoriales exploratorios y confirmatorios. *Cienc. Psicol.* 7, 151–164. doi: 10.22235/cp.v7i1.1057

Fuentes, A., López, J., and Pozo, S. (2019). Análisis de la competencia digital docente: factor clave en el desempeño de pedagogías activas con realidad aumentada. *REICE Rev. Iberoam. Sobre Calid. Eficacia y Cambio en Educ.* 17, 27–42. doi: 10.15366/reice2019.17.2.002

García, V. M., Barriga, M. G., Anchundia, A. D., and Guarnizo Delgado, J. B. (2022). TIC en educación en contextos de disrupción tecnológica. *RECIAMUC* 6, 20–28. doi: 10.26820/reciamuc/6.(2).mayo.2022.20-28

Hernández, C. E., and Carpio, N. (2019). Introducción a los tipos de muestreo. *Rev. ALERTA* 2, 75–79. doi: 10.5377/alerta.v2i1.7535

Huang, K. T., Ball, C., Francis, J., Ratan, R., Boumis, J., and Fordham, J. (2019). Augmented versus virtual reality in education: an expolratory study examinig science knowlede retention when using agumented reality/virtual reality mobile applicatins. *Cyberpsychol. Behav. Soc. Netw.* 2, 105–110. doi: 10.1089/cyber.2018.0150

Huang, T. C., Chen, C. C., and Chou, Y. W. (2016). Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment. *Comput. Educ.* 96, 72–82. doi: 10.1016/j.compedu.2016.02.008

Johnson, L., Adams, S., Cummins, M., Estrada, V., Freeman, A., and Hall, C. (2016). *NMC horizon report: 2016 higher education edition. Austin, Texas: The new media consortium*. Available online at: https://www.learntechlib.org/p/171478/ (accessed on July 6, 2022).

Jorrin, I. M., Fontana, M., and Rubia, B. (2021). *Investigar en educación.* Madrid. Síntesis.

Kauz, A. (2022). Desigualdades tecnológicas educativas expresadas durante el encierro por COVID19. *EDMETIC* 11:5. doi: 10.21071/edmetic.v11i2.13657

Leal, L. (2020). Producción de recursos didácticos para el aula de matemáticas de Secundaria con realidad aumentada. *Innov. Educ.* 30, 185–198. doi: 10.15304/ie.30.6905

Lee, I., Lin, L., Chen, C., and Chung, C. (2018). "How to create suitable augmented reality application to teach social skills for children with ASD," in *Nawaz mohamudally, state of the art virtual reality and augmented reality knowhow*, (London: IntechOpen), 119–138. doi: 10.5772/intechopen.76476

López-Roldán, P., and Fachelli, S. (2016). *Metodología de la investigación social cuantitativa.* Barcelona: UAB.

Lorenzo-Seva, U., and Ferrando, P. J. (2019). Robust promin: A method for diagonally weighted factor rotation. *LIBERABIT Rev. Peru. Psicol.* 25, 99–106. doi: 10.24265/liberabit.2019.v25n1.08

Magallanes, J. S., Rodríguez, Q. J., Carpio, ÁM., and López, M. R. (2021). Simulación y realidad virtual aplicada a la educación. *RECIAMUC* 5, 101–110. doi: 10.26820/reciamuc/5.(2).abril.2021.101-110

Marín-Díaz, V., Sampedro, B., and Figueroa, J. (2022). Augmented reality in the secondary education classroom: Teachers' visions. *Contemp. Educ. Technol.* 14:e348. doi: 10.30935/cedtech/11523

Marín, V., Sampedro, B. B., Aznar, I., and Trujillo, J. M. (2022). Perceptions on the use of mixed reality in mobile environments in secondary education. *Educ. Train.* 64, 1–22. doi: 10.1108/ET-06-2022-0248

Marín-Díaz, V., Sampedro, B. E., and Vega, E. (2022c). Creencias del profesorado de Educación Secundaria en torno al uso de la Realidad Mixta en el aula. *Rev. Electrón. Interuniv. Formación Profesorado. En prensa.*

Marín-Díaz, V., Sampedro-Requena, B. E., and Vega-Gea, E. (2022a). "Visiones del profesorado en torno a la realidad aumentada en la enseñanza secundaria. *Teknokultura. Rev. Cult. Digit. Movimientos Soc.* 19, 25–36. doi: 10.5209/TEKN.77853

Marín-Díaz, V., Sampedro, B. E., and Vega, E. (2022b). La realidad virtual y aumentada en el aula de secundaria. *Campus Virtuales* 11, 225–236. doi: 10.54988/cv.2022.1.1030

Matas, A. (2018). Diseño del formato de escalas tipo Likert: Un estado de la cuestión. *Rev. Electrón. Invest. Educ.* 20, 38–47. doi10.24320/redie.2018.20.1.1347

Mavrou, I. (2015). Análisis factorial exploratorio. Cuestiones conceptuales y metodológicas. *Rev. Nebrija Lingüíst. Aplicada a la Enseñanza de Lenguas* 19, 71–80. doi: 10.26378/rnlael019283

Meyer, O. A., Omdahl, M. K., and Makransky, G. (2019). Investigating the effect of pre-training when learning through immersive virtual reality and video: A media and methods experiment. *Comput. Educ.* 140:103603. doi: 10.1016/j.compedu.2019.103603

Miller, R. (2017). *How digital technologies are transforming aerospace and defense*. Available online at: https://www.ey.com/en_gl/aerospace-defense/how-digital-technologies-are-transforming-aerospace-and-defense (accessed on July 6, 2022).

Otzen, T., and Manterola, C. (2017). Técnicas de muestreo sobre una población a estudio. *Int. J. Morphol.* 35, 227–232. doi: 10.4067/S0717-95022017000100037

Palomo, C. (2020). Percepción y desplazamiento en el espacio híbrido con realidad mixta. *Academia XXII* 11, 187–214. doi: 10.22201/fa.2007252Xp.2020.21.76680

Restrepo, J. F., and Gómez, D. S. (2020). La conectividad digital como derecho fundamental en Colombia. *Law State Telecomm. Rev. Brasilia* 12, 113–136. doi: 10.26512/lstr.v12i1.31161

Rodríguez-Rodríguez, J., and Reguant-Álvarez, M. (2020). Calcular la fiabilidad de un cuestionario o escala mediante el SPSS: el coeficiente alfa de Cronbach. *REIRE Rev. Innov. Invest. Educ.* 13, 1–13. doi: 10.1344/reire2020.13.230048

Rossler, K. L., Sankaranarayanan, G., and Hurutado, M. H. (2020). Developing an immersive virtual reality medication administration scenario using the nominal group technique. *Nurse Educ. Today* 56:10391. doi: 10.1016/j.nepr.2021.103191

Sadeghi, A. M., Maat, A., Taverne, Y., Cornelissen, R., Dingemans, A., Bogers, A., et al. (2021). Virtual reality and artificial intelligence for 3-dimensional planning of lung segmentectomies. *Thorac. Lung Cancer Evol. Technol.* 7, 309–321. doi: 10.1016/j.xjtc.2021.03.016

Sousa, C. V., Hwang, J., Cabrera-Perez, R., Fernandez, A., Misawa, A., Newhook, K., et al. (2022). Active video games in fully immersive virtual reality elicit moderate-to-vigorous physical activity and improve cognitive performance in sedentary college students. *J. Sport Health Sci.* 11, 164–171. doi: 10.1016/j.jshs.2021.05.002

Tang, Y., Au, K., and Leung, Y. (2018). Comprehending products with mixed reality: Geometric relationships and creativity. *Int. J. Eng. Bus. Manag.* 10, 1–12. doi: 10.1177/1847979018809599

Tennant, M., Anderson, N., Youssef, G. J., McMillan, L., Thorson, R., Wheeler, G., et al. (2021). Effects of immersive virtual reality exposure in preparing pediatric oncology patients for radiation therapy. *Tech. Innov. Patient Support Radiation Oncol.* 19, 18–25. doi: 10.1016/j.tipsro.2021.06.001

Vasilevski, N., and Birt, J. (2020). Analysing construction student experiences of mobile mixed reality enhanced learning in virtual and augmented reality environment. *Res. Learn. Technol.* 28, 2329. doi: 10.25304/rlt.v28.2329

Ventura-León, J. L., and Caycho-Rodríguez, T. (2017). El coeficiente Omega: un método alternativo para la estimación de la confiabilidad. *Rev. Latinoam. Cienc. Soc. Niñez y Juventud* 15, 625–627.

Vilà, R., Torrado, M., and Reguant, M. (2019). Análisis de regresión lineal múltiple con SPSS: un ejemplo práctico. *REIRE Rev. Innov. Recerca Educ.* 12, 1–10. doi: 10.1344/reire2019.12.222704

Villalustre, L. (2020). Propuesta metodológica para la integración didáctica de la realidad aumentada en Educación Infantil. *EDMETIC* 9, 170–187. doi: 10.21071/edmetic.v9i1.11569

Zhang, K. (2021). Animation virtual reality scene modeling based on complex embedded system and FPGA. *Microprocess. Microsyst.* 80:103632. doi: 10.1016/j.micpro.2020.103632