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The Impact of Gender on the Use of Augmented Reality and Virtual Reality in Students with ASD

El impacto del género en el uso de la realidad aumentada y la realidad virtual en estudiantes con TEA

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ABSTRACT

Today's education is in the process of transformation as a consequence of the inclusion of educational technology in learning spaces. Among the most prominent technologies is augmented and virtual reality. These emerging technologies have reflected great educational potential in different contexts. The study's objective is focused on knowing the influence of gender in the application of augmented and virtual reality in students with ASD. They have been considered in various dimensions such as motivation, attention, communication, autonomy, and learning outcomes. A quantitative research methodology has been used through a descriptive and correlational non-experimental design to achieve this objective. 46 Spanish students with ASD participated in the study. The data were collected through a questionnaire. The results reveal differences in motivation, attention, and communication based on gender. However, in terms of autonomy and in learning outcomes, gender does not suppose any conditioner. The work culminates with various theoretical and practical implications.

Palabras clave
Realidad aumentada; Realidad virtual; Trastorno del espectro autista; Tecnología educativa; Género.

RESUMEN

La educación actual se encuentra en un proceso de transformación como consecuencia de la inclusión de la tecnología educativa en los espacios de aprendizaje. Entre las tecnologías más destacadas se encuentran la realidad aumentada y la virtual. Estas tecnologías emergentes han reflejado un gran potencial educativo en diferentes contextos. El objetivo del estudio se centra en conocer la influencia del género en la aplicación de realidad aumentada y virtual en estudiantes con TEA. Se han tenido en cuenta en varias dimensiones como la motivación, la atención, la comunicación, la autonomía y los resultados del aprendizaje. Para lograr este objetivo se ha utilizado una metodología de investigación cuantitativa a través de un diseño no experimental descriptivo y correlacional. En el estudio participaron 46 estudiantes españoles con TEA. Los datos fueron recopilados a través de un cuestionario. Los resultados revelan diferencias en motivación, atención y comunicación en función del género. Sin embargo, en la autonomía y en los resultados de aprendizaje, el género no supone ningún condicionante. El trabajo culmina con diversas implicaciones teóricas y prácticas.

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1. Introduction

The rapid advances in Information and Communication Technologies (ICT) are significantly challenging and changing traditional education and pedagogy (Alonso de Castro & García-Peñalvo, 2022). As modern digital devices allow for instant access to vast amounts of data anywhere and anytime, students' way of acquiring knowledge has changed (Chang et al., 2018). Therefore, their educational needs and requirements have also drastically shifted.

To address the 21st century educational requirements, increase the effectiveness of the educational process and assist teachers and educators in providing high quality education for students, technology-enhanced learning should be implemented. Additionally, it is crucial to put emphasis on learners' skills, knowledge, interests, and personalities as well as to constantly encourage and motivate students (Robinson et al., 2013). This is particularly important when students with autism spectrum disorder (ASD) are involved. ASD is recognized as a set of common developmental disorders and describes "a constellation of early-appearing social communication deficits and repetitive sensory–motor behaviors associated with a strong genetic component as well as other causes" (Lord et al., 2018, p. 1).

Students learn by imitating, interacting, observing, and sharing opinions with peers and teachers; hence, several pedagogical approaches, theories and methods focus on these key aspects. Furthermore, based on the instructional theory, when students practice their skills in environments like real ones and actively participate, it is highly likely that successful learning transfer can be achieved (Rupp et al., 2019). Immersive technologies can provide the necessary tools that enrich and enhance these vital aspects to promote and encourage proper behavior within educational settings as well as to instill a proper attitude and mindset for lifelong learning.

Immersive technologies aim at bridging the gap between the physical and virtual environments by replacing real sense perceptions with computer-generated ones (Slater & Sanchez-Vives, 2016) creating, thus, a sense of immersion (Suh & Prophet, 2018) and an "inclusive, extensive, surrounding, and vivid illusion of reality" (Slater & Wilbur, 1997, p. 1). In particular, immersive technologies support learning at anytime, anyplace and with anyone and consist of Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR). Based on the concept of "reality - virtuality continuum", AR is closer to the real environment while VR to the virtual one with MR being in the middle of these two ends (Milgram & Kishino, 1994). Given the technology used in each case, and particularly so in MR, the boundaries between what is perceived as real or virtual are not entirely clear and distinct (Schmalstieg et al., 2002).

With immersive technologies offering more engaging experiences, providing interactive digital content in real time, and enhancing the overall user experience (UX), several opportunities and merits can be yielded. Moreover, as they affect all five human senses by utilizing more informational channels, they allow students to attain a better perception of learning subjects, they offer contemporary teaching and learning forms and methods as well as learning opportunities and they enable instructional designer to develop environments that facilitate learning (Chang et al., 2016). Furthermore, they promote improved academic performance in various educational domains by enabling the use of new pedagogical methods and approaches within immersive environments (Beck, 2019). Due to the interactive and immersive experiences that they offer, immersive technologies allow for more intriguing, entertaining, motivating, satisfactory and creative learning experiences (Calvet et al., 2019).

Nonetheless, there are several ethical and moral dimensions that need to be taken into consideration when researching and applying immersive technologies in education (Lally et al., 2012). In addition, although more and more scholarly attention is being paid to immersive technologies, a lack of coherent understanding regarding their impact on students with ASD is evident (Suh & Prophet, 2018).

1.1. Augmented reality in education

AR is an interactive technology that utilizes technological applications of computer units in order to enhance users' perceived physical environment by incorporating virtual objects and digital data in the real word generating, thus, a mixed reality in which virtual and real objects co-exist (Lampropoulos et al., 2020). Due to its nature, its interactivity and close connection to the real world, AR can be widely applied in numerous learning

subjects and media (Garzón et al., 2019) and assist in developing new learning environments and experiences, promoting an active and interrelated learning process as well as providing quality education at anytime and anyplace (Goff et al., 2018).

Although there are still some barriers and limitations to using AR, the potentials, merits and benefits it yields outweigh them heavily and as a result, AR is being implemented in all educational levels and supports both students and teachers (López-Belmonte et al., 2019). Recent bibliometric, meta-analysis and systematic literature review studies (Avila-Garzon et al., 2021; Ozdemir et al., 2018) have highlighted the increasing popularity of both researching and applying AR within educational settings and presented the educational benefits and drawbacks of this technology (Mariscal et al., 2020).

When used in a student-centered manner, AR improves students' long-tern knowledge retention as it provides more realistic and interesting learning environments and supports problem-based learning (Fidan & Tuncel, 2019). When compared to traditional learning, AR further enhances students' cognitive development, saves time and money, and provides more interactive learning environments that increase students' engagement, motivation, academic performance and learning achievements and enhance their attitude towards education and their digital inclusion (Sahin & Yilmaz, 2020). Additionally, AR promotes ubiquitous, autonomous, collaborative and situated learning and supports educational activities for children with disabilities (Lin et al., 2016). Particularly, AR can be used as an effective educational tool to support children, adolescents and adults with ASD and help their cognitive and social development (Khowaja et al., 2020).

1.2. Virtual reality in education

VR refers to the computational creation of environments or realities that simulate an individual's physical presence in specific real or artificial environments which perceptually surround users and are presented in such a way that they can be considered real (Lampropoulos et al., 2021). Furthermore, as VR environments involve social and psychological processes, users can internalize and treat their virtual experiences as real (Blascovich & Bailenson, 2011). Therefore, presence, immersion, interaction, user involvement and immediacy can be regarded as the main characteristics of VR (Sherman & Craig, 2003).

As these characteristics greatly contribute towards more engaging and meaningful learning (Huang et al., 2010), the application of VR in education is gaining more ground (Radianti et al., 2020). Additionally, it can be used in numerous educational settings and fields as it creates unique environments in which both learners and teachers can interact even from a distance, something that otherwise would not be possible (Han, 2020). These immersive environments enable training and experiential learning in safe environments, increase involvement and motivation and widen the variety of learning styles supported (Hamilton et al., 2021).

VR enhances the overall learning process since it promotes autonomous decision-making, improves students' motivation, increases interactivity and active participation (Roussou, 2004) and enables the representation of abstract concepts in a tangible manner. Moreover, when used in a student-centered manner and in combination with project-based learning, VR has the potential to enhance students' critical thinking, psychomotor, affective and communication skills and enjoyment, assist their cognitive processing, reflective thinking, and knowledge transfer as well as to improve learning outcomes and academic performance (Araiza-Alba et al., 2021; Halabi, 2020; Jensen & Konradsen, 2018). Specifically, VR can be applied in educational settings to enhance the learning process for children, adolescents and adults with ASD and boost their development (Fernández-Herrero et al., 2018; Lorenzo et al., 2018; Mesa-Gresa et al., 2018).

1.3. Augmented and virtual reality in people with ASD

The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) considers ASD as a group of neurodevelopmental disorders from a multifactorial perspective (American Psychiatric Association, 2013). People who suffer from it have deficiencies in social and communication skills and repetitive and stereotyped behaviors (Lorah et al., 2019).

Likewise, the literature collects various deficiencies, difficulties, or peculiarities that people with ASD may present (Adams & Gaile, 2020; Muskett et al., 2019). These have been collected as a synthesis and are presented in Table 1.

Table 1. Characteristics of people with ASD

-Problems in executive functioning. -Alterations in sensory processing. -Difficulties in attention. -Appearance of depression. -Symptoms of aggressiveness. -Challenging behaviors. -Restricted interests. -Difficulties in emotional control.	-Appearance of anxiety. -Atypical response to sounds. Motor-type difficulties. -Autonomy. -Visual processing towards the faces of other people. -Deficiency when planning their actions or tasks. -Structure and use of language.

AR and VR technologies have been used with people with ASD for the purpose of conducting innovative and safe training experiences (Dixon et al., 2019). Based on these technologies, experts state that interaction with content (Köse & Güner-Yildiz, 2020) and with digital characters or interactive animations is encouraged to promote the development of social skills. This has repercussions on the communicative level, which is enhanced (Fridhi et al., 2018). Likewise, decision making, problem solving and autonomy (Miller et al., 2020) are also reinforced through activities designed under these realities (Baragash et al., 2020).

These technologies allow the generation of unique learning environments, which results in increasing learners' motivation and, consequently, their attention (De Luca et al., 2019). However, the high stimulation received can be counterproductive. This may cause anxiety to people with ASD, due to a high load of sensory stimulation. Therefore, it is important to regulate the type of activity designed under these technologies (McCleery et al., 2020). In this sense, the current development of AR and VR allows personalizing work environments and adjusting the requirements to the peculiarities of students with ASD (Malihi et al., 2020).

Therefore, the implementation of interventions through AR and VR involves the work and improvement of psychosocial and educational variables, as it has been revealed through scientific studies. All these improvements will bring about a better quality of life and inclusion in an increasingly technological society (Carmona-Serrano et al., 2020).

2. Justification and objectives

Expert literature on the state of the art reveals the potential of these next-generation technologies in learning spaces (López-Belmonte et al., 2020; Mak & Zhao, 2020). There is no doubt that educational interventions are being subjected to a process of methodological transformation to adapt the incidence of technology in society and within the educational spectrum (Moreno-Guerrero et al., 2021). All this to benefit the accomplishment of both educational and therapeutic in special populations objectives (McCleery et al., 2020).

Although AR and VR technologies have shown great expansion in the field of autism in recent years (Carmona-Serrano et al., 2020) they are still being developed. Therefore, the use of these emerging technologies is presented as a great challenge for professionals who interact with people with ASD (Ghanouni et al., 2019).

As far as gender is concerned, scientific studies reveal that women show less restricted and repetitive behaviors and attitudes than men. This statement leads to an alteration depending on the gender of the person in the brain networks, specifically in those concerning the social integration networks and the cortico-striatum (Van't Westeinde et al., 2019).

Likewise, the pandemic caused by Covid-19 has conditioned both teaching and learning spaces, the training development of students, as well as the use and effectiveness of teaching resources (García Peñalvo & Corell, 2020). In the same way, other essential and pertinent aspects such as the evaluation of learning have been harmed by this coronavirus (Corell-Almuzara et al., 2021). However, current education has been transformed and adapted to the new contingencies of a constantly changing society, derived from Covid-19 and the impact of technology (Daniel, 2020).

Based on the above-mentioned, the objective of this research is to get to know the influence of gender in the application of AR and VR when referring to students with ASD in aspects such as motivation, attention, communication, autonomy and learning outcomes. The following questions arise from this objective to specify the investigative process:

-RQ1: Does gender influence motivation after the application of AR and VR in people with ASD?
-RQ2: Does gender influence care after the application of AR and VR in people with ASD?
-RQ3: Does gender influence communication after the application of AR and VR in people with ASD?

-RQ4: Does gender influence autonomy after the application of AR and VR in people with ASD?
-RQ5: Does gender influence learning outcomes after the application of AR and VR in people with ASD?

3. Method

3.1. Research design and data analysis

This study has been based on a quantitative research methodology. Specifically, a descriptive and correlational non-experimental design has been used (Hernández et al., 2014).

Various statistics have been used for the data analysis. Mean (M), standard deviation (SD), such as elementary statistics and other more specific tests such as Pearson's coefficient of skewness and Fisher's pointing to determine the trend in the sampling distribution. In addition, statistics such as Pearson's Chi-square test ($\chi 2$) have been used to establish the association between the study variables. This has been complemented with the Cramer's V test (V) and the contingency coefficient (Cont) to know the degree of strength in the association.

The Statistical Package for the Social Sciences (SPSS) v.25 software was used to carry out the analysis. Statistically significant differences were established from $p < .05$.

3.2. Sample

A total of 46 Spanish students with ASD participated in this study, of which 34 (73.91%) were men and 12 (26.06%) were women, with a mean age of 10.63 years (SD = 4.58). The selection of the participants has been produced through an intentional sampling technique due to the collaboration of various associations that work with the ASD collective.

3.3. Instrument

Studies carried out in ASD populations are characterized by the application of questionnaires completed by the specialists who carry out the interventions. Therefore, it is these experts who, through observation, record the different items of the instrument (Carpenter et al., 2020).

In particular, in this research a questionnaire has been designed, taking as reference experts in this field of knowledge (Lorenzo et al., 2019), with the purpose of starting from reference tools already validated in scientific literature. Specifically, the instrument used consisted of 25 items with a Likert response scale of 4 ratings in increasing order. The questionnaire was structured in six dimensions (Sociodemographic = 6 items; Motivation = 3 items; Attention = 3 items; Communication = 3 items; Autonomy = 4 items; Learning outcomes = 6 items).

The questionnaire validation process was produced by the Delphi method (Cabero & Infante, 2014). Five experts in educational technology and attention to diversity participated in this process. These specialists analyzed the instrument and offered feedback to optimize the tool. The observations focused mainly on modifying the wording of certain items to improve understanding and avoid bias towards the results. Once the changes were made, the questionnaire went through another round of review by such experts to validate the modifications made and grant the relevance of the instrument for this research.

3.4. Procedure

The first action was to select the sample. For this purpose, several autism associations in Spain were chosen. Meetings were held to explain the objectives of the study and to have access to the sample. Once the participants had been selected, informed consent was obtained from each of them. This was followed by the innovative intervention through AR and VR through various resources (1-Quiver vision; 2-Around the world in 80 days beyond the story; 3 Jedi Challenges; 4-A gaping wolf; 5-Medusa has become angry again). To develop the interventions, a multidisciplinary team consisting of an occupational therapist, a psychologist, a speech therapist, and a special education teacher was formed. These specialists carried out a total of five sessions. These same professionals oversaw recording everything observed in the questionnaire to collect the information from each of the sessions carried out. Finally, the data was statistically analyzed to reach relevant conclusions for the scientific community.

4. Results

According to the descriptive statistics resulting from the applied analysis, it has been observed that the distribution of the sample is normal in most of the study variables. The evaluation achieved in each of the variables does not vary significantly between the measures achieved. The variable with the highest score is attention_3 and the one with the lowest score is motivation_3. The response distribution in all the variables is not dispersed, given that the standard deviation values are less than 1 in all the variables. The kurtosis varies, being platykurtic and leptokurtic (see Table 2).

Table 2. Descriptive results obtained by variables

Variables	Values			
	M	SD	Asymmetry	Kurtosis
Motivation_1	2.22	.671	-.280	-.627
Motivation _2	2.22	.518	.324	.250
Motivation _3	1.78	.671	.280	-.627
Attention _1	2.39	.656	.439	.356
Attention _2	2.87	.694	-.713	1.529
Attention _3	3.00	.798	-.588	.378
Communication _1	2.70	.926	-.446	-.400
Communication _2	2.17	.937	-.012	-1.237
Communication _3	2.74	.541	-.175	-.185
Autonomy _1	2.22	.671	-.280	-.627
Autonomy _2	2.30	.559	.023	-.462
Autonomy _3	2.04	.706	-.061	-.820
Autonomy _4	1.96	.638	.033	-.239
Learning_out_1	2.09	.417	.677	3.420
Learning_out_2	2.00	.603	.000	.157
Learning_out_3	2.39	.499	.477	-1.951
Learning_out _4	2.22	.671	.708	1.368
Learning_out _5	2.09	.596	-.013	.161
Learning_out_6	2.22	.518	.324	.250

Figure 1 shows that, in general, the variables related to attention are above the overall average. The rest of the variables are close to the overall mean. There are a couple of exceptions. The variable motivation_3 is well below. The variable communication_3 is above the overall mean. Attention_3 is the variable that shows the greatest distance from the overall mean. The evaluation of this variable is higher than the rest. Regarding the data as a whole, the totalized mean is above the idealized mean.

The correlational analysis between motivation and gender shows correlation only in the variable motivation_3. There is no correlation among the rest of the variables. The strength of correlation between gender and motivation_3 is medium. In this case, it can be indicated that men show a slightly higher tendency to motivation_3 than women (see Table 3).

The correlation analysis established between gender and attention shows mixed results. There is a correlation between gender and attention_1. No correlation is observed for the rest of the variables. The strength of correlation between gender and attention_1 is medium. In this case, it can be indicated that women tend to show slightly higher ratings than men in reference to attention_1 (see Table 4).

In the correlation analysis applied between gender and communication variables, different results are observed. There is a correlation between gender and communication_2 variable. There is no correlation among the rest of the variables. The strength of correlation is medium. In this case, men are more highly rated than women, with a significant difference between the two (see Table 5).

Figure 1. Distribution of mean scores

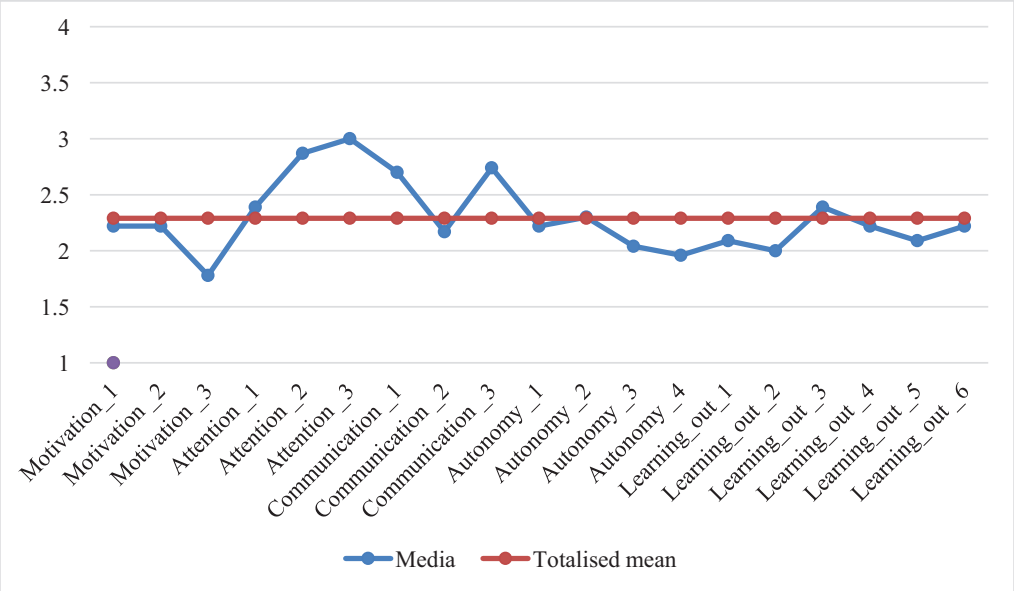

Table 3. Correlation between motivation and gender

	Likert scale n/%				Parameters			
Motivation	**1**	**2**	**3**	**4**	**M/SD**	**X²**	**Cont**	**V**
Motivation _1					2.22/.671	7.083	.365	.392
M	1(2.9)	12(35.3)	10(29.4)	11(34.4)	2.91/.900			
W	3(25)	5(41.7)	3(25)	1(8.3)	2.17/.937			
Motivation _2					2.22/.518	4.127	.287	.300
M	0(0)	12(35.3)	9(26.5)	13(38.2)	3.03/.870			
W	1(8.3)	6(50)	2(16.7)	3(25)	2.58/.996			
Motivation _3					1.78/.671	11.385*	.445	.497
M	5(14.7)	14(41.2)	2(5.9)	13(38.2)	2.68/1.14			
W	3(25)	1(8.3)	5(41.7)	3(25)	2.67/1.15			

Note: N=46; df=3 **. The correlation is significant at the level 0.01. *. The correlation is significant at the level 0.05.

Table 4. Correlation between attention and gender

	Likert scale n/%				Parameters			
Attention	**1**	**2**	**3**	**4**	**M/SD**	**X²**	**Cont**	**V**
Attention_1					2.39/.656	11.395*	.445	.497
M	5(14.7)	14(41.2)	2(5.9)	13(38.2)	2.94/.919			
W	3(25)	1(8.3)	5(41.7)	3(25)	3.00/.739			
Attention_2					2.84/.694	2.435	.224	.230
M	1(2.9)	12(35.3)	9(26.5)	12(35.3)	2.59/.743			
W	0(0)	3(25)	6(50)	3(25)	2.67/.985			
Attention_3					3.00/.798	5.162	.318	.335
M	3(8.8)	10(29.4)	10(55.9)	2(5.9)	2.56/.960			
W	1(8.3)	5(41.5)	3(25)	3(25)	2.50/1.08			

Note: N=46; df=3 **. The correlation is significant at the level 0.01. *. The correlation is significant at the level 0.05.

Table 5. Correlation between communication and gender

	Likert scale n/%				Parameters			
Communication	**1**	**2**	**3**	**4**	**M/SD**	**X^2**	**Cont**	**V**
Communication_1					2.70/.926	3.386	.262	.271
M	6(17.6)	8(23.5)	15(44.1)	5(14.7)	3.15/.821			
W	2(16.7)	5(41.7)	2(16.7)	3(25)	2.75/1.05			
Communication_2					2.17/.937	7.979*	.384	.416
M	2(5.9)	3(8.8)	17(50)	12(35.3)	2.74/1.02			
W	1(8.3)	5(41.7)	2(16.7)	4(33.3)	2.17/.937			
Communication_3					2.74/.541	5.432	.325	.344
M	5(14.7)	8(23.5)	12(35.3)	9(26.5)	3.18/.758			
W	4(33.3)	2(16.7)	6(50)	0(0)	2.83/.718			

Note: N=46; df=3 **. The correlation is significant at the level 0.01. *. The correlation is significant at the level 0.05.

The correlational analysis between gender and autonomy variables showed the same results. There is no correlation between gender and the autonomy variables (see Table 6).

Table 6. Correlation between autonomy and gender

	Likert scale n/%				Parameters			
Autonomy	**1**	**2**	**3**	**4**	**M/SD**	**X^2**	**Cont**	**V**
Autonomy_1					2.22/.671	2.027	.205	.210
M	0(0)	7(20.6)	14(41.2)	13(38.2)	2.85/1.01			
W	0(0)	4(33.3)	6(50)	2(16.7)	2.75/.965			
Autonomy_2					2.30/.559	.620	.115	.116
M	3(8.8)	11(32.4)	8(23.5)	12(35.3)	2.71/.836			
W	1(8.3)	4(33.3)	4(33.3)	3(25)	2.58/.669			
Autonomy_3					2.04/.706	1.702	.189	.192
M	2(5.9)	12(35.3)	14(41.2)	6(17.6)	2.47/.825			
W	0(0)	6(50)	5(41.7)	1(8.3)	2.17/.718			
Autonomy_4					1.96/.638	1.659	.187	.190
M	4(11.8)	13(38.2)	14(41.2)	3(8.8)	2.50/.788			
W	2(16.7)	6(50)	4(33.3)	0(0)	2.00/.739			

Note: N=46; df=3 **. The correlation is significant at the level 0.01. *. The correlation is significant at the level 0.05.

Finally, the correlational analysis between gender and learning outcomes shows the same results. There is no correlation between gender and learning outcomes (see Table 7).

Table 7. Correlation between learning outcomes and gender

	Likert scale n/%				Parameters			
Learning_out	**1**	**2**	**3**	**4**	**M/SD**	**X^2**	**Cont**	**V**
Learning_out _1					2.09/.417	3.625	.270	.281
M	3(8.8)	14(41.2)	14(41.2)	3(8.8)	2.88/.977			
W	3(25)	6(50)	3(25)	0(0)	2.92/1.08			
Learning_out _2					2.00/.603	4.733	.305	.321
M	0(0)	18(52.9)	2(5.9)	14(41.2)	2.74/.931			

Table 7. Correlation between learning outcomes and gender *(continued)*

W	1(8.3)	4(33.3)	2(16.7)	5(41.7)	2.42/.900			
Learning_out_3					2.39/.499	3.341	.260	.269
M	2(5.9)	14(41.2)	9(26.5)	9(26.5)	2.91/.866			
W	2(16.7)	4(33.3)	5(41.7)	1(8.3)	2.83/.718			
Learning_out _4					2.22/.671	2.418	.223	.229
M	0(0)	14(41.2)	9(26.5)	11(32.4)	2.68/.878			
W	0(0)	4(33.3)	6(50)	2(16.7)	2.92/.669			
Learning_out _5					2.09/.596	2.934	.245	.253
M	2(5.9)	14(41.2)	11(32.4)	7(20.6)	2.65/.981			
W	0(0)	3(25)	7(58.3)	2(16.7)	2.83/.718			
Learning_out _6					2.22/.518	2.695	.235	2.42
M	4(11.8)	12(35.3)	10(29.4)	8(23.5)	2.76/.855			
W	0(0)	4(33.3)	6(50)	2(16.7)	2.83/.577			

Note: N=46; df=3 **. The correlation is significant at the level 0.01. *. The correlation is significant at the level 0.05.

5. Discussion and conclusions

The rapid technological advances developed during the first quarter of the 21st century have resulted in extraordinary challenges for educational systems that have to offer a current response adapted to the demands of society (Alonso de Castro & García-Peñalvo, 2022). In this panorama, immersive technologies become extraordinary challenges to offer more attractive experiences, provide interactive digital content in real time and improve the general UX (Araiza-Alba et al., 2021). In addition, these technologies allow students to achieve a better perception of the learning subjects and provide teachers the opportunity to offer richer and more powerful experiences both in the forms and methods of learning that they adopt in class as well as in the design of more inclusive, entertaining, motivating, and creative learning environments that facilitate improvement in academic performance (Carmona-Serrano et al., 2020).

Currently, the educational use of immersive technologies is focused on three technologies: AR, VR and MR (López-Belmonte et al., 2019; Radianti et al., 2020). The UX flows from the closest to the real world (AR) to the furthest away (VR) through MR where the perception between the real and the virtual is not so clear to the user (Schmalstieg et al., 2002). The educational experiences of AR have allowed to contrast hypotheses that affirm that the use of AR in the learning processes improves the retention of knowledge in the long term due to the diversity of experiences that the student lives in these environments and supports learning in the resolution of problems (McCleery et al., 2020; Miller et al., 2020). In addition, these studies have corroborated that the use of this technology in the educational field increases commitment, motivation, academic performance and attitude towards education and its digital inclusion (Ozdemir et al., 2018; Sahin & Yilmaz, 2020). In recent years, and due to the cheaper equipment and the technology itself, VR has been making its way in both non-university and higher education educational centers thanks to its potential to offer a safe environment for interaction between students and teachers, even when at a distance (Han, 2020). In addition, VR has the potential to improve critical thinking, psychomotor skills, affectivity, and communication among students and, of course, to improve learning outcomes and academic performance (Araiza-Alba et al., 2021; Halabi, 2020; Jensen & Konradsen, 2018). Specifically, with ASD students, research has focused on the integration of educational technologies to favor the work of the various difficulties they face, such as motivation, autonomy, communication, attention and learning outcomes (Carmona-Serrano et al., 2020; Köse & Güner-Yildiz, 2020; Miller et al., 2020), variables that have been analyzed in this research.

In the specific case of this study, the results reveal that the distribution of the sample is normal, concentrating the answers given and not presenting any dispersion. This allows other statistical analyses of greater complexity and depth to be carried out. On the other hand, among the variables studied, special mention must be made of the one that refers to the need for the professional to guide the participant to be able to focus attention on the task. This variable is the best valued by the subjects studied in contrast to the variable linked to the completion of the task. Moreover, it was highlighted that the participant wants to continue performing the same

or similar activities. This assessment clearly indicates how these subjects need constant attention to complete the task or activity that is presented to them and that they do not feel any motivation to do it again on their own. In this sense, the dimension that obtains the best score with respect to the others is Attention, where two of the three items that compose it are in the highest positions above the totalized mean. Specifically, the variable referring to the need for the professional to lead the participant to be able to focus attention on the task is the one that obtains the best score on the entire scale. In addition, the item belonging to the Communication dimension related to interaction with the elements / materials generated in the task, also obtains one of the three best scores in the entire study above the totalized average. This data offers very significant and transcendental information for professionals and researchers on this subject on the most relevant and necessary aspects on which to focus attention when implementing projects with AR and VR involving students with ASD. In the same way, it is necessary for these researchers and professionals to indicate that a determining factor for a good execution of a task with these technologies is the students' motivation, a fact that has been revealed in this experience when the Motivation dimension was assessed, which has obtained the worst average and specifically, the item that refers to the participant's demotivation to wish to continue doing the same or similar activities. It is worth noting that the results presented above were based on a data set which had a totalized mean (2.30) which was above the idealized mean (2), reaching, thus, a very positive global assessment.

On the other hand, it is interesting to look at how the various variables of the questionnaire behave when they are correlated with the independent variable gender. Consequently, men show slightly higher attention than women when the participant wants to continue doing the same activity at the end of the task. In the same way, men present a better evaluation than women when the participants communicate with the professional to resolve doubts about the proposed task. However, women score better than men when it comes to keeping the focus of attention on the task they perform. Despite this, when the different items of the Autonomy and Learning Outcomes dimensions are correlated, the statistics do not offer any relevant data that can provide information on their ability to differentiate the behavior between men and women.

The development of various AR and VR activities with ASD students poses a series of challenges since, in the study carried out, these students tend to show average values in all the dimensions evaluated (motivation, attention, communication, autonomy and learning outcomes). Furthermore, it has been detected that these people show a greater need for the support of professionals to be able to focus attention on the AR and VR tasks. Along the same lines, the results obtained reveal that these students do not tend to continue using the pedagogical resource once the task they were developing has finished.

Another conclusion derived from this study is that gender is a variable to take into account when carrying out AR and VR tasks involving students with ASD, since it can affect the application of AR and VR as a pedagogical resource, and this might be a handicap for their use in the classroom. Within this same variable, men tend to stop carrying out the task they were developing and interact more with therapists than women. However, women are the ones who keep the most attention on the activity they are developing.

Among the limitations of the study, it can be noted that the sample examined is not balanced with respect to gender and this may lead to a bias in the statistics obtained. However, although the sample is important for the group studied, the results could be improved by designing a study involving a larger and more diverse sample size and controlling that there is an equitable participation between men and women.

As future lines of work, it would be important to observe the behavior of other variables such as age, educational level, level of involvement of the ASD students and the dependent variables that are raised in the questionnaire. This data would shed light on aspects as invaluable as the importance of using these technologies with younger or older students such as designing more precise tasks and activities where students maintain attention as well as motivation and are able to interact with professionals to dissipate doubts or express difficulties they are experiencing. Furthermore, it would be interesting to carry out this study in other countries to corroborate the results obtained in Spain.

At a theoretical level, this work contributes to the increase in the scientific literature on the application of AR and VR with ASD students in the educational context. In addition, the findings obtained allow researchers to offer a frame of reference for the design and development of activities using these technologies with ASD students to make better use of the sessions and time. Moreover, it can serve as a guide and support for future work by other scientists who wish to use the validated questionnaire to measure motivation, attention, communication, autonomy and learning outcomes in performing AR and VR tasks with ASD students.

From a practical point of view, the results of the study offer invaluable information on the relationship between gender and the performance of AR and VR tasks and activities. This data can allow us to focus and specify where the necessary reinforcement and support must be deployed so that students do not lose motivation, learn how to request help when necessary or how to remain focused and concentrated.

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