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Virtual Reality in promoting Empathy and Knowledge towards people with ASD

Maria Luísa Martins de Barros

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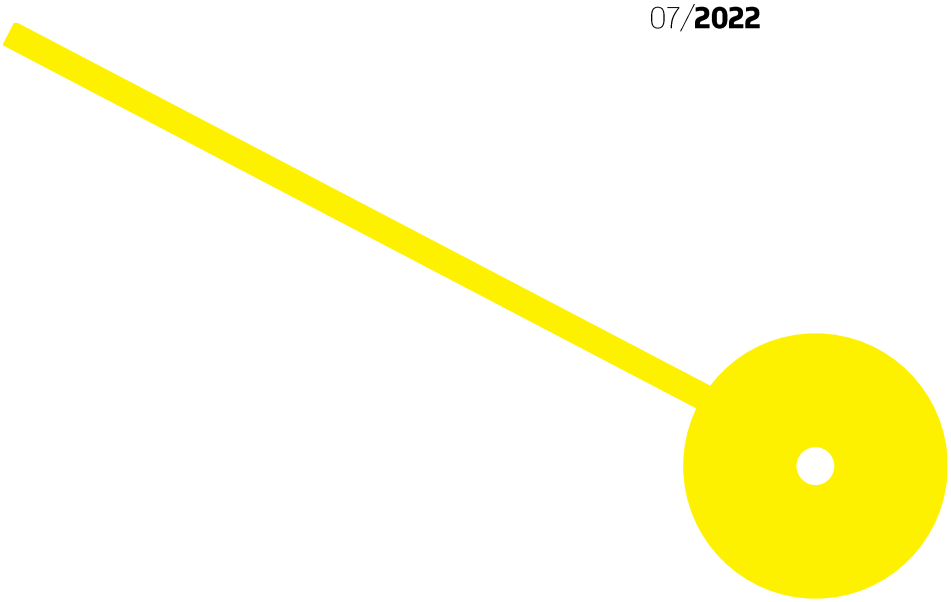

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Virtual Reality in promoting Empathy and Knowledge towards people with ASD

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Resumo

Aumentar a empatia e o conhecimento sobre as Perturbações do Espetro do Autismo (PEA) é crucial para potenciar uma melhor qualidade de vida para as pessoas com esta condição. A Realidade Virtual (RV) está a tornar-se cada vez mais uma ferramenta útil para aumentar a empatia e/ou conhecimento sobre as PEA. Esta dissertação pretende investigar o impacto de um programa de VR e a influência de género e contacto com pessoas com PEA no conhecimento e empatia com pessoas com PEA, bem como estudar a relação entre o nível de conhecimento e a empatia. Este estudo analisou os níveis de conhecimento e empatia em alunos do 7º ano de escolaridade (N=86) usando o *Empathy Quocient* e *Autism Stigma and Knowledge Questionnaire*. Os resultados mostram que o grupo experimental teve um aumento significativo dos níveis de conhecimento ($p < 0.001$) e níveis de empatia ($p < 0.001$), mas quando comparados ambos os grupos, apenas foi encontrada uma diferença significativa nos níveis de conhecimento ($p < 0,025$). De acordo com as nossas descobertas, a população jovem tem dificuldade em expressar empatia perante indivíduos com PEA, mas tem conhecimento adequado sobre as mesmas, e a RV é uma ferramenta poderosa para aumentar o conhecimento e a empatia perante pessoas com ASD. Existe uma ligação entre o conhecimento e o género, bem como o conhecimento e a empatia.

Palavras-chave: conhecimento sobre autismo; perturbações do espetro do autismo; empatia; realidade virtual

Abstract

Increasing empathy and knowledge about Autism Spectrum Disorders (ASD) is crucial to potentiate a better quality of life for people with the condition. Virtual reality (VR) is becoming a useful tool to increase empathy and/or knowledge about ASD. This dissertation intent to investigate the impact of a VR program and the influence of gender and contact with people with ASD on knowledge and empathy toward people with ASD, as well as studying the relationship between level of knowledge and empathy. This study examined the levels of knowledge and empathy in 7th grade students (N=86) using the Empathy Quocient and Autism Stigma and Knowledge Questionnaire. The results show that the experimental group had a significant increase in knowledge ($p < 0,001$) and empathy ($p < 0,001$) levels, but when comparing both groups, only a significant difference in knowledge levels was found ($p < 0,025$). According to our findings, the young population has difficulty expressing empathy for ASD but has adequate knowledge of it, and VR is a powerful tool for increasing knowledge and empathy toward people with ASD. There is a link between knowledge and gender, as well as knowledge and empathy.

Keywords: autism knowledge, autism spectrum disorders, empathy, virtual reality

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1. Introduction

Autism spectrum disorders (ASD) are a group of neurodevelopmental disorders characterized by difficulties in communication and social interaction, as well as restrictive and repetitive patterns of behavior, interests, and activities (American Psychiatric Association, 2013).

The most recent data in Portugal date back to 2007 and indicate an approximate ASD prevalence of 0.92‰ (Oliveira et al., 2007). However, and since has been an increase in global prevalence, it may be higher than previously stated (Gómez-Marí et al., 2021; Thompson et al., 2018).

In addition to the characteristics considered identifying the ASD, such as those mentioned above, it is important to highlight the limitation on empathy (Harmsen, 2019). This can be defined as the ability to share and understand the emotional and mental states of the other and respond adequately to the perceived (Harmsen, 2019; Rueda & Lara, 2020; Weisz & Cikara, 2021).

Since empathy is one of the primary connection facilitators with the other, the fact that the neurotypical population struggles to understand the characteristics and attitudes of people with ASD may be a relevant factor in the difficulties encountered in the inclusion of people with ASD in society (Dickter et al., 2020; Sasson & Morrison, 2019).

This is consistent with what some authors refer to as the "double empathy problem," which states that because relationships require bidirectional interaction, it is necessary to establish mutual understanding between individuals with and without ASD (Chen et al., 2021; Mitchell et al., 2021). Thus, the difficulties of social interaction associated with individuals with ASD are related to their neurobiological limitations and their ability to connect and understand their neurotypical peers (Chen et al., 2021; Sasson & Morrison, 2019).

This difficulty in empathizing with people with ASD may also be related to limitations in knowledge of ASD, since lower levels of knowledge can translate into greater stigma, and thus empathy, and have a direct effect on attitudes toward people with ASD, whereas higher levels of knowledge are associated with more positive attitudes toward people with ASD (Gemegah et al., 2020; John et al., 2018; Twi-Yeboah et al., 2021).

The lower levels of knowledge are often manifested through several myths associated with ASD, such as "All people with autism dislike being touched", "All autistic people are unable to notice rejection", "All people with autism have special talents" or even "All people autistic are dangerous", as analyzed by John et al. (2018). These negative perceptions of people with ASD have a significant impact on every person with the condition, not only children, but also adults and elders with this diagnosis (Hickey et al., 2018). In fact, it is known that the diagnosis rate is increasing in this age group due to the awareness and changes on the ASD criteria and, although there is a limited literature concerning ASD

and the elderly, some reports showed that the effect of the challenges faced by the elders with ASD is similar with the young population (Hickey et al., 2018; Murphy et al., 2016; Parchomiuk, 2021).

It is therefore critical to facilitate contact between these individuals and the neurotypical population because contact with clinical conditions, whether directly or indirectly, may benefit peer acceptance by increasing empathy towards people with the condition, but also because it provides an opportunity to acquire knowledge about the condition in a motivated and directed way (Shand et al., 2020; White et al., 2019).

There are various types of interventions in the literature that aim to increase knowledge and/or empathy towards ASD, such as informative videos with typical behaviors associated with the condition (Swaim & Morgan, 2001) ; analysis of informative vignettes (Campbell, 2006); peer mentorship (Gardiner & Iarocci, 2014); and online training programs (Gillespie-Lynch et al., 2015). In addition to these, one of the most used interventions for the empathy and knowledge promotion about clinical conditions is Virtual Reality (VR), which is a technology that allows users to easily experience what it is like to be in the position and condition of the other without having to just imagine (Louie et al., 2018; Martingano et al., 2021; Ventura et al., 2020).

There are several VR applications in the study of knowledge and empathy, being the most common and feasible the presentation of 360° videos in real scenarios using Head Mounted Display Devices (Martingano et al., 2021; Rueda & Lara, 2020). Thus, the person can move (especially the head) while exploring virtual space, and his field of vision changes in the same way that it would in real life, ensuring greater immersion and a sense of presence in the virtual environment (Louie et al., 2018; Martingano et al., 2021; Rueda & Lara, 2020). It is well known that the greater the immersion and presence, the greater the possibility of having effects on users' empathy, once the ability to see and understand the other may be beneficial for increasing empathy towards it (Barreda-Ángeles et al., 2020; Martingano et al., 2021; Simões-Silva et al., 2022).

In several countries there is already scientific production relating VR, empathy and/or knowledge about ASD (Gemegah et al., 2020; Shand et al., 2020; Twi-Yeboah et al., 2021; Yu et al., 2020), however no similar study has been conducted to date in Portugal.

Hence, considering the presence and inclusion of individuals with ASD in the Portuguese school community, it becomes relevant to explore the level of knowledge and empathy of young people towards ASD, before and after an intervention program using VR, allowing to notice the effectiveness of this type of intervention in the younger population.

As a result, we aim to investigate young people's levels of knowledge and empathy toward ASD, as well as the impact of a VR program in promoting knowledge and empathy toward people with ASD. Simultaneously, it is intended to investigate the impact of gender and previous contact with

people with ASD on knowledge and empathy towards them, as well as the relationship between level of knowledge and empathy for people with ASD.

2. Methodology

2.1. Study design

This study is a single-blind randomized control trial, in which each participant in the experimental and control groups will be evaluated before and after the intervention, with no knowledge of the type of intervention received (Hróbjartsson & Boutron, 2011; Miller & Stewart, 2011).

The Ethics Committee of the School of Health at the Polytechnic of Porto (CE0004C) approved the study, and all procedures followed the Helsinki Declaration (World Medical Association, 2013).

2.2. Participants

The study sample was collected through convenience sampling in collaboration with Primary and Secondary School of Campo. This educational institution is located in a suburban area of Porto, Portugal.

This study included male or female individuals who attend the 7th grade and it was considered as exclusion criteria the presence of auditory and visual difficulties that make it impossible to read and/or listen to the video, as well as some health condition that makes it impossible to use VR (history of epilepsy or psychiatric disorders). The initial recruitment and contact for participation in the study was carried out by the school principal, who directly contacted the teachers of the respective classes available to participate in the study.

To calculate the required sample size, the investigators used GPower, version 3.1 (Faul et al., 2009; Faul et al., 2007). It was selected a previous analysis for a t-test for paired samples (2-tailed), considering the objective and hypotheses under study, and the input parameters used were considered conservative values - effect size of 0.50, statistical power of 0.80 and a significance level (α) of 0.05 (Cohen, 2013). Hence, a minimum sample size of 34 individuals was obtained. However, anticipating that there may be limitations in obtaining data in the second moment (due to student non-attendance), it was decided to increase the value provided by the program by 30%, stablishing the minimum ideal sample value to 45 elements (Brueton et al., 2013). Therefore, considering the inclusion and exclusion criteria, as well as the recommended sample values mentioned above, 90 participants were selected. Nevertheless, with the dropouts on the second data collection, the final sample were established with 86 participants, within an age range of 12-14 years (mean: 12,186; SD: 0,448). After distribution in an allocation stratified by gender and previous contact with ASD within a 1:1 ratio by the control and

experimental groups, the participants were distributed as follow: 42 students on control group and 44 students on experimental group. Table 1 summarizes the characteristics of the final sample. Chi-square tests for gender, direct and indirect previous contact revealed no significant differences between groups.

Table 1: Demographic characteristics of participants

Demographic characteristics		Control group		Experimental group		Total		*p*-value
		n	%	n	%	n	%	
Gender	Male	23	54,76	18	40,91	41	47,67	0,280
	Female	19	45,24	26	59,09	45	52,33	
Direct previous contact	Yes	8	19,05	15	34,09	23	26,74	0,146
	No	34	80,95	29	65,91	63	73,26	
Indirect previous contact	Yes	23	54,76	25	56,82	48	55,81	1,000
	No	19	45,24	19	43,18	38	44,19	

2.3. Data acquiring instruments

2.3.1. Sociodemographic Questionnaire

Developed by the research team, it includes five questions necessary for sample characterization and randomized stratified allocation of participants. The questions cover gender, age, previous contact with the ASD population, whether direct ("Do you have direct contact with someone with autism?") or indirect ("Have you heard about autism spectrum disorders?"), as well as the presence of clinical conditions that may make participation in the study impossible.

2.3.2. Empathy Quocient – short form (EQ)

This standardized self-completion instrument consists of 22 questions designed to assess participants' empathy, with a 4-point scale (1 representing "Strongly Agree" and 4 representing "Strongly Disagree") used to answer each question. Each question is quoted with 0, 1 or 2 points, by the nature of the answer (0 being a non-empathic answer and the 2 being a very empathetic answer). For this reason, its maximum score can range from 0 to 44 points. Originally created by Wakabayashi et al. (2006) and with an internal consistency of 0,90, the scale has a validated version for the Portuguese population by Rodrigues et al. (2011) with an internal consistency of 0,85 and an application time of approximately 7 minutes. In the current study, this instrument has an internal consistency of 0,83.

2.3.3. Autism Stigma and Knowledge Questionnaire (ASK-Q)

This self-administered questionnaire aims to assess knowledge of ASD through 49 questions divided into four domains: diagnosis, etiology, treatment, and stigma. Each question has two possible responses ("I agree" and "I disagree"), which correspond to 0 or 1 point in the total score, which ranges from 0 to 48 points (item 1 has no assigned score and the stigma domain is not included in the total score of the questionnaire). The instrument also has partial scores for each domain, with maximum scores of 18 for diagnosis, 16 for etiology, 14 for treatment, and 7 for stigma. In terms of cutoffs, the authors highlight the following values: 10 in diagnosis, 10 in etiology, 9 in treatment, and 3 in stigma. The stigma domain has reverse punctuation, with lower scores indicating lower levels of stigma, however this domain was not used on this study.

2.3.3.1 Translation and adaptation of ASK-Q for the Portuguese population

To begin the adaptation process, the authors contacted the research team that developed the initial instrument. Following that, and with the team's approval, the ASK-Q was translated and adapted for the Portuguese population.

The main researcher, who is a native Portuguese speaker, translated a preliminary version of the instrument's 49 items into Portuguese. A panel of experienced and fluent English-speaking experts in the field translated it back into English, creating a revised version. The main researcher then proceeded on to the final translation, which already had semantic and syntactic changes for better understanding in Portuguese.

The original instrument has an internal consistency value of 0,88 and in the current study this value is 0,63.

2.4. Procedures

After approval by the Ethics Committee, the ASK-Q was adapted and the school's principal was contacted to begin the process of selecting the classes. The head teacher of each class contacted every legal represent of the students, to give information about the study and to receive their authorization so that the students could participate voluntarily in the study. The data collection occurred in April 2022. Both moments took place in the Basic and Secondary School of Campo.

The first data collection involved the administration of three questionnaires to collect the required information for assessing the impact of the VR program. Following the verification of the established inclusion and exclusion criteria, the investigators proceed with the randomized allocation of participants in the control and experimental groups, stratified by gender and previous contact with ASD, resulting in the distribution shown in Figure 1.

Following the allocation, and in accordance with Law 58/2019 of August 8th, a document was prepared with a list that contains all the data obtained in the collection, which will be encrypted using a password that will only be in the possession of the researcher responsible for this process. As a result, each participant will be assigned an ID (i.e. a random number) that corresponds to the data in the aforementioned document.

In the second moment, the intervention was conducted in both groups, with the control group using imagery to present the stimulus (textual description of the virtual environment video presented to the experimental group) and the experimental group using the environment in VR with the Oculus QUEST equipment. The virtual environment used in the study was created in 360° video format by the Psychosocial Rehabilitation Laboratory (LabRP) team. It includes a brief overview of autism spectrum disorders and their key characteristics, an immersive 3D moment that recreates the day-to-day and difficulties of a child with ASD in the school setting, and real testimonies from young people with ASD. The participants were then asked to complete two questionnaires designed to assess knowledge and empathy for ASD. All data will remain in this investigator's possession until the data deletion period, which is three years after the study's publication (Bailey et al., 2021; Peng, 2017).

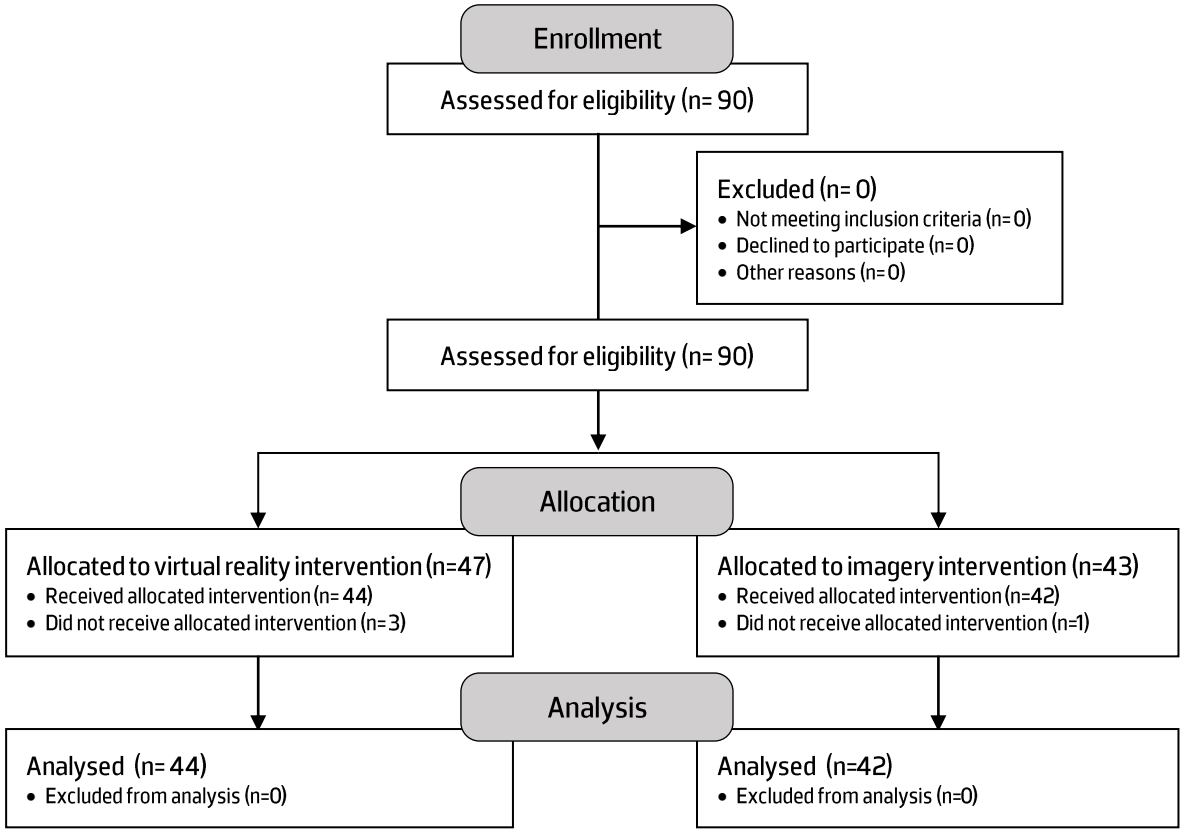

Figure 1: CONSORT diagram of study design

2.5. Data analysis

To conduct the statistical analysis of the collected data, an Excel document was used to create a database containing the information associated with the variables questioned in the initial data collection. All data were analyzed using the SPSS software version 28.0.0.0 (IBM Corp., 2021), with a significance level of 0.05 for all inferential statistical procedures .

In terms of sample description, descriptive statistics, measures of central tendency, and dispersion were used to analyze quantitative variables (age and evaluation instrument scores). Absolute and relative frequencies were also used to analyze qualitative variables (gender and previous contact with ASD).

The chi-square test was applied to the qualitative variables and the t-test for independent samples was applied to the quantitative variables to compare the sample groups resulting from the randomization of the participants by the control and experimental groups and ensure the absence of significant differences between them – and for the latter, the assumption of normality was verified by considering the central limit theorem (Cohen, 2013; Field, 2013).

Subsequently, in order to achieve the study objectives, a new variable corresponding to the difference between pre and post test scores for each instrument had to be computed. Then, for independent samples, a t-test was used to confirm the existence of significant differences in the score differences between the groups. T-tests for paired samples were used to compare results between the control and experimental groups' pre- and post-test scores. Since the normality of these variables was tested and assumed, chi-square tests were used to examine the effect of gender and previous contact on total scores, as well as a Pearson correlation to confirm the existence of a relationship between knowledge and empathy levels (Cohen, 2013).

3. Results

Table 2 displays the results of the scales used in the pre- and post-test. It should be noted that, due to the lack of cutoffs in the instruments used, the value of 22 points in the EQ (corresponds to half the value of the total EQ score) and the value of 29 points in the ASK-Q (corresponds to the sum of the reference values of the diagnostic, etiology and treatment domains) were used.

Table 2: Scale scores of the total sample (n=86)

	Pre-test				Post-test				*p*-value
	Range	Mean	SD	%	Range	Mean	SD	%	
EQ	4-41	20,907	7,254	46,51	11-42	23,581	5,918	67,44	<0,001*

ASK-Q	21-41	32,023	4,568	76,74	23-45	34,442	4,531	90,70	<0,001*
ASK_D	5-18	12,512	2,673	86,05	5-17	13,244	2,290	94,19	0,02*
ASK_E	4-15	10,558	2,419	68,61	6-15	11,640	2,086	82,56	<0,001*
ASK_T	5-13	9,186	1,857	69,77	6-14	9,547	1,767	67,44	0,16

Note: % corresponds to the total percentage of answers indicative of adequate level of knowledge or empathy; *$p < 0,05$

3.1. Level of Knowlegde and Empathy towards people with ASD

Pre-test results revealed that the average EQ score is lower than that defined as the cutoff (20.907±7.254), implying an insufficient level of empathy. This decreased empathy score is also visible in the percentage of responses above the defined cutoff (46.51%), as this is the only scale/domain where half of the correct answers are not obtained. Nonetheless, the highest score obtained is close to the scale's maximum threshold (41 out of 44 points).

Considering the knowledge levels, the total scores and the domains of the scale are above the defined cutoff, which translates adequate levels of knowledge (ASK-Q: 32.023±4,568; ASK_D: 12,512±2,673; ASK_E: 10,558±2,419; ASK_T: 9,186±1,857). The same is verified in the percentage of responses that translate adequate levels, with a minimum percentage of 68.61%. Regarding the range of responses, the total score approximated the maximum threshold of possible correct answers on the scale (41 out of 48 points), and this approximation was even more notable in the domains - in the domain of diagnosis, the maximum total score was reached and in the others only one point was missing.

3.2. Impact of a VR program on knowledge and empathy towards people with ASD

To verify the impact generated by the immersive VR program, it was verified whether there are significant differences between the score's differences obtained in the two evaluation moments for each group, whose results are described in Table 3.

Table 3: Score differences between pre- and post-test on both groups

	Control group		Experimental group		*p*-value	Confidence Interval
	Mean	SD	Mean	SD		
EQ	2,119	3,884	3,205	4,496	0,118	-0,720; 2,891
ASK-Q	1,357	5,031	3,432	4,633	0,025*	0,002; 4,147
ASK_D	0,214	2,968	1,228	2,560	0,047*	-0,174; 2,200

ASK_E	1,119	2,796	1,046	2,302	0,447	-1,170; 1,022
ASK_T	-0,071	2,352	0,773	2,341	0,050	-0,162; 1,851

*p < 0,05

It was verified that only significant differences in the score's differences are related to ASK-Q and the domain of diagnosis (Cohen's d : 4,381 and Cohen's d : 2,766, respectively). It is also worth noting that the experimental group has higher mean values on each of the scales than the control group in the EQ and ASK-Q, as well as in the diagnosis and treatment domains. In turn, the etiology domain score is higher in the control group.

However, given that the control group also had access to intervention (through imagery), it became essential to validate the existence of differences in scores between pre- and post-test in each group using t-test for paired samples, with results presented in table 4 for the control group and table 5 for the experimental group.

Table 4: Scale scores pre- and post-test on control group (n=42)

	Pre-test				**Post-test**				***p*-value**
	Range	Mean	SD	%	Range	Mean	SD	%	
EQ	4-41	21,857	7,413	50,00	12-42	23,976	5,953	69,05	<0,001*
ASK-Q	21-39	31,786	4,630	73,81	25-42	33,143	4,223	88,10	0,044*
ASK_D	5-18	12,333	2,860	83,33	5-16	12,548	2,308	90,48	0,321
ASK_E	5-15	10,310	2,363	64,29	8-15	11,429	2,038	80,95	0,007*
ASK_T	6-12	9,214	1,855	66,67	6-13	9,143	1,646	61,91	0,422

*p < 0,05

Analyzing the results of the control group, it is founded that there are significant differences between the two moments in the EQ score (Cohen's d : 3,884), ASK-Q (Cohen's d : 5,031) and in the etiology domain (Cohen's d : 2,795). In the other domains of knowledge, in which there were no significant differences between the pre and post-test, there were only improvements in the mean score and percentage of adequate responses of diagnosis - the treatment domain has not improved.

Table 5: Scale scores pre- and post-test on experimental group (n=44)

	Pre-test				**Post-test**				***p*-value**
	Range	Mean	SD	%	Range	Mean	SD	%	
EQ	6-33	20,000	7,064	43,18	11-39	23,205	5,928	65,91	<0,001*

ASK-Q	21-41	32,250	4,550	79,55	23-45	35,682	4,512	93,18	<0,001*
ASK_D	7-18	12,682	2,504	88,64	9-17	13,909	2,089	97,73	0,001*
ASK_E	4-15	10,795	2,474	72,73	6-15	11,841	2,134	84,10	0,002*
ASK_T	5-13	9,159	1,879	72,73	6-14	9,932	1,810	72,73	0,017*

*p < 0,05

Comparing the results in the two moments, every scale/domain present significant improvements in their scores (EQ: Cohen's d = 4.496; ASK-Q: Cohen's d = 4.633; ASK_D: Cohen's d = 2,560; ASK_E: Cohen's d = 2.302; ASK_T: Cohen's d = 2,341). In addition to the increase in the mean values and the percentage of adequate responses, it is important to highlight the visible improvement in the range of responses, with the increase of minimum and maximum score.

3.3. Influence of gender and previous contact with autism on the levels of knowledge and empathy towards people with ASD

The values obtained for the pre-test and post-test are shown in Table 6. Analyzing the influence of gender on the levels of knowledge and empathy, evaluated at the pre-test, it is notable that there is only an association between gender and knowledge in the domain of diagnosis (χ^2 (1, N = 86) = 4,174, p = 0,041). Considering the direct previous contact, it was only associated with knowledge about ASD (χ^2 (1, N = 86) = 4,433, p = 0,035) and no other significant association was found. Regarding the indirect previous contact, no associations were found between it and the levels of empathy and knowledge about the ASD.

Table 6: Demographic characteristics and the influence on knowledge and empathy on pre-test

		EQ		**ASK-Q**		**ASK_D**		**ASK_E**		**ASK_T**	
		%	*p*	%	*p*	%	*p*	%	*p*	%	*p*
Gender	Male	51,22	0,403	68,29	0,077	78,05	0,041*	63,41	0,322	65,85	0,451
	Female	42,22		84,44		93,33		73,33		73,33	
Direct previous contact	Yes	39,13	0,407	60,87	0,035*	73,91	0,076	60,87	0,350	60,87	0,299
	No	49,21		82,54		90,48		71,43		73,02	
Indirect previous contact	Yes	45,83	0,887	81,25	0,266	91,67	0,091	75,00	0,151	66,67	0,482
	No	47,37		71,05		78,95		60,53		73,68	

*p < 0,05

3.4. Influence of knowledge levels on empathy levels

At the post-test a moderate positive correlation was found between the levels of knowledge and empathy, r = 0.333, p = 0.027.

4. Discussion

This study aims to investigate young people's levels of knowledge and empathy toward ASD, as well as the impact of a VR program in promoting knowledge and empathy toward them. Simultaneously, it was intended to investigate the impact of gender and contact with people with ASD on knowledge and empathy towards them, as well as the relationship between level of knowledge and empathy.

4.1. Level of Knowlegde and Empathy towards people with ASD

Regarding young people's knowledge, 76.74% of the sample has an adequate knowledge about ASD, even though the average score obtained on the scale is only slightly higher than the cutoff defined as the reference value. This percentage and mean value of the scale can be explained by two factors: the participants' age and the dichotomous nature of ASK-Q.

In fact, the study sample consists of young people with a mean age of 12.186 ±0,448 years and attending the 7th year of schooling, and it is known that the awareness and knowledge about ASD tends to increase with age and schooling (Abualhommos et al., 2022; Alyami et al., 2022; Dillenburger et al., 2017).

In turn, dichotomic scales only have two response scenarios and no neutral option ("I don't know" or "no opinion" for example). Thus, literature suggests that those scales always give a 50 percent chance of getting the questions right or wrong, which may skew the results (Callegaro et al., 2015; Yu et al., 2020). Parallel to this, there is the possibility of an acquiescence response bias, which refers to participants' natural tendency to agree with the statements presented in the questionnaires (Bogner & Landrock, 2016; Callegaro et al., 2015; Maeda, 2015).

However, the percentage of correct responses in the knowledge domains was heterogeneous, and young people demonstrated greater knowledge of the condition's diagnosis to the detriment of etiology and treatment, which is consistent with the findings of similar studies (Abualhommos et al., 2022; Alyami et al., 2022; Jones et al., 2021; Kitchin & Karlin, 2021; Stronach et al., 2019). There are several possible explanations for what has been observed, including the fact that the heterogeneity of characteristics in people with ASD makes it difficult for the neurotypical population to acquire and generalize knowledge; additionally, in global awareness campaigns, the domains of etiology and

treatment tend to be devalued, which has a direct impact on the stigmatization of the ASD population (Harrison et al., 2017; John et al., 2018; Kitchin & Karlin, 2021).

In turn, young people show a reduced empathy, with only 46.51% of the sample having positive results in the EQ. This low score may be conditioned by certain characteristics of the instrument, which may lead to the answers being biased and not fully reflecting what the participants think or believe (Suárez Álvarez et al., 2018). These biases associated with Likert scale-based instruments refer to the tendency to: respond to the central or extreme options of the scale (Moderacy and extreme response bias) (Bogner & Landrock, 2016); respond in a more socially accepted way than the participant thinks is the most appropriate answer for himself (Suárez Álvarez et al., 2018); agree with the questions presented, whenever there is the scenario of agree/disagree in scale (acquiescience) (Maeda, 2015); as well as to choose more often the options presented on the left side of the scale (whether positive or negative) (left-side response option selection bias) (Maeda, 2015). In addition, the fact that the scale does not contain any neutral options as well as the existence of negatively expressed items ("I do not always have to"/ "I do not have to find") may hinder their understanding and also condition the choice of participants (Creswell, 2002; Kamoen et al., 2017; Kamoen et al., 2018; Swain et al., 2008).

4.2. Impact of a VR program on knowledge and empathy towards people with ASD

In terms of the effects of VR on knowledge levels, the study's findings show that the experimental group's general knowledge has significantly improved, which is consistent with the literature that shows VR is a useful tool in the promotion of ASD knowledge (Dickter et al., 2020; Gemegah et al., 2020; Yu et al., 2020). Nonetheless, both groups' levels knowledge increased significantly, indicating that the imagery intervention in the control group was equally important in increasing the sample's knowledge.

It was also possible to assume that VR played a significant role in improving knowledge associated with ASD diagnosis, as this improvement was not observed in the control group. Since this is a domain where the general public has a higher level of knowledge, these improvements were already anticipated (Abualhommos et al., 2022). Another reason to this improvement is associated with the emphasis placed on it in the video shown to the experimental group.

Concerning the etiology domain, its scores vary significantly between the pre- and post-test in both groups, but there were no significant differences in the score differences between the control and experimental groups – this means the impact of the VR program was insufficient to generate higher knowledge than imagery format, as previously seen in other similar studies (Abualhommos et al., 2022; Kitchin & Karlin, 2021). This may be justified by the fact that etiology is frequently associated with widespread myths about ASD, and a limited exposure may not be enough to mitigate the impact of

these myths (Alyami et al., 2022; John et al., 2018) and improve the knowledge in this domain (Jones et al., 2021; Wannenburg & van Niekerk, 2018).

Finally, it was identified that the treatment domain scores changed significantly in the experimental group but not in the control group or when comparing both groups. A plausible explanation for the lack of significant and visible results in the etiology and treatment domains is that video content may not adequately address them, and because of their lower initial levels more intensive or frequent intervention may be required to produce effects (Stronach et al., 2019; Wannenburg & van Niekerk, 2018).

There were no significant differences in empathy levels between the groups, though there were differences between the pre- and post-test in both groups. This means that the exposure method used did not produce significant changes, even with greater power at the experimental group. This could be because the impact of VR on empathy is not always visible, as discussed in other articles (Carey et al., 2017; Ventura et al., 2020). Furthermore, the role of the instrument used to assess empathy should be mentioned (EQ). This instrument assesses cognitive empathy, which is the ability to take the perspective of another and put oneself in the shoes of another, requiring awareness of one's own thoughts and feelings (Martingano et al., 2021; Rueda & Lara, 2020), and the domain of emotional empathy, which is concerned with the reflexive reaction that results in the mirroring of another person's emotion (Fisher, 2017; Rueda & Lara, 2020). According to the literature, VR has a greater impact on emotional empathy but not on cognitive empathy, so the improvement of empathy may not be visible in the instrument score if only one type of empathy has changed (Carey et al., 2017; Martingano et al., 2021).

In general, analyzing the results of the VR program, it was shown a positive evolution of the results in terms of empathy and knowledge between the pre- and post-test in both groups, which is consistent with previous findings in the literature (Underhill et al., 2019; White et al., 2019). However, the use of VR was not always important for changing the dimensions under study like it was expected - VR is known to produce better results than text-based interventions due to its interactivity, which increases motivation for learning and connectivity (Kamińska et al., 2019; Pilgrim & Pilgrim, 2016; Zhang et al., 2022).

4.3. Influence of gender and previous contact with autism on the levels of knowlegde and empathy toward people with ASD

Although there is a large body of literature supporting a link between gender and prior contact with adequate levels of empathy and knowledge (Alyami et al., 2022; Ballantyne et al., 2021; Gillespie-Lynch et al., 2019; Kitchin & Karlin, 2021), in this study was only possible to validate gender association

with the diagnostic domain of knowledge. Thus, females outperformed males in the sample, which is consistent with the literature (Kitchin & Karlin, 2021; Kuzminski et al., 2019). The lack of an association between gender and empathy, as well as other domains of knowledge is also present on other studies (Shand et al., 2020; White et al., 2019). Aside from that, gender influence may not be uniform across all populations and age groups, and published studies do not include populations as young as those in this study (Kitchin & Karlin, 2021).

Regarding the influence of previous contact on knowledge and empathy, our findings suggest that knowing someone with ASD is not a predictor of higher levels of knowledge. This association, as well as the lack of other associations between previous contact and the other variables can be explained by the fact that contact with the condition must be continuous over time, rather than sporadic, in order to impact and influence levels of knowledge and empathy (White et al., 2019). Furthermore, contact with someone with ASD only allows to acquire knowledge about that person's characteristics, which does not imply a generalized increase in knowledge or empathy (John et al., 2018).

4.4. Influence of knowledge levels on empathy levels

Our results show that there is a link between knowledge and empathy, knowing that the greater the knowledge, the higher the level of empathy. However, the relationship found between the variables is only moderate, which may be attributed to some methodological limitations, but also suggests that this relationship may not be linear, i.e., an increase in knowledge may not directly translate into an increase in empathy (Mac Cárthaigh & López, 2020; Stern & Barnes, 2019; White et al., 2019). Furthermore, there is no large bibliography relating the levels of knowledge and empathy, because knowledge is more often associated with stigma, which is visible in attitudes that translate the level of empathy (Clinton & Pollini, 2021; Dovidio et al., 2010; Vagheei et al., 2018).

4.5. Limitations

This study has some limitations. It is possible that our findings and their generalizability were influenced by the convenience sampling technique. Another limitation is the absence of a control group that did not receive any intervention and that there was no evaluation of the virtual environment's level of presence and immersion to determine whether students felt immersed in the environment, which is critical for maximizing the effects of VR.

Concerning the instruments used, it is worth noting that their extensive form may have resulted in an oversight in the filling by the participants, who, due to their age and maturity, may not

have been fully committed to the impact of their responses. Furthermore, the ASK-Q reveals only acceptable internal consistency values.

5. Conclusion

The young population has adequate levels of knowledge about autism, despite having difficulty expressing empathy towards people with ASD. The current study is one of the few that focuses on the impact of VR on knowledge and empathy toward people with ASD, providing important knowledge to enhance the general population's acceptance of this clinical condition. This study suggests that VR is a powerful tool for improving knowledge and empathy toward people with ASD, and that there is a link between gender and previous contact with ASD with some domains of knowledge, as well as knowledge and empathy levels.

It is suggested that future research enlarge the sample size and representativeness, collect more information about the type, frequency, and means of contact with people with ASD (personally, family, internet, television, ...), and assess subjective presence and immersion in the virtual environment.

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