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An Educational Intervention for Theory of Mind Skills in Children Using a Virtual Reality Application: A Pilot Study

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Abstract

Aim/Purpose	This study explores the effectiveness of a virtual reality (VR) application designed to teach Theory of Mind (ToM) skills to children aged 5-6, addressing the gap in research on the use of VR for typically developing children.
Background	ToM is a critical skill for social interaction and understanding others' perspectives. Despite the potential of VR to simulate real-life scenarios for ToM development, prior research has primarily focused on clinical populations. This study aims to investigate its application in neurotypical children.

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Methodology	A pilot study was conducted with seven children from private educational institutions, divided into experimental and control conditions. ToM skills were assessed pre- and post-intervention using validated tests. The VR intervention involved interactive scenarios designed to enhance perspective-taking and understanding intentions.
Contribution	This paper demonstrates the feasibility and efficacy of using immersive VR technology to improve ToM skills in typically developing children, bridging the gap in the existing literature while also highlighting the novelty of applying VR beyond therapeutic contexts to educational settings.
Findings	Children in the experimental condition exhibited improvements in ToM assessments compared to the control group. These results highlight the potential of VR as an engaging and effective tool for teaching social cognitive skills. While the small sample size warrants cautious interpretation, the findings provide promising preliminary evidence supporting the effectiveness of VR-based interventions.
Recommendations for Practitioners	Educators and psychologists can incorporate VR-based interventions to foster ToM development in early childhood, leveraging its immersive nature to simulate complex social scenarios.
Recommendations for Researchers	Future research should replicate these findings with larger samples and explore the long-term impact of VR-based ToM training on real-life social interactions and relationships.
Impact on Society	Enhancing ToM skills in children could improve classroom dynamics, peer relationships, and overall social adaptation, contributing to healthier social environments in educational settings.
Future Research	Further studies should focus on evaluating the transfer of VR-acquired ToM skills to everyday social contexts and assessing their effectiveness across diverse populations and age groups.

Keywords	virtual reality, children, theory of mind

INTRODUCTION

Theory of Mind (ToM) is defined as the ability to attribute mental states to oneself and others and thus able to explain and predict human behavior (Hughes et al., 2007) based on the inference of desires, beliefs, and emotions (Wellman, 2016). This skill allows putting oneself in the other's point of view, understanding that others have mental states (thoughts, feelings, beliefs) that may be different from one's own and, therefore, that one's way of thinking and feeling is not the only one (Esteban et al., 2008). These mentalist skills refer to understanding other people's private world, also called the mental world (Serrano, 2012). As a result, they play a crucial role in fostering successful social interactions (Pineda-Alhucema, 2011) and facilitating strategies for one's own survival (Rubia Vila, 2018).

Studies reporting assessments and interventions on children based on ToM reflect the existence of a close relationship between this skill and successful social relationships, being one of the most important factors influencing the adaptation and rapport with peers in the classroom (Fink et al., 2015; Huyder et al., 2017; O'Toole et al., 2017; Smith, 2010). Good ToM skills consistently and significantly predict greater peer acceptance (Wellman, 2016), whereas weak ToM generates conflictual behaviors and, consequently, peer rejection and lack of friends. ToM seems to play an important role in children understanding peers' intentions, which in turn will allow them to generate context-appropriate behaviors and improve their social coexistence skills (Brock et al., 2019; Huyder et al., 2017). The prosocial use of these skills can be useful in creating new friendships and promoting lasting relationships, as they relate to popularity with peers and communication with friends.

Currently, there is a consensus within the scientific community that mentalist skills do not suddenly emerge at a certain age but that there are several evolutionary precursors that promote their development since birth (Aguilar et al., 2014; Melendez Jara, 2019; Sáiz et al., 2012). Some of these proto-mentalist abilities are related to the human early interest in social stimuli (Rochat, 2001; Schneider et al., 2005), to the perception of others as equals (Meltzoff, 2002; Meltzoff & Gopnik, 1993), or to knowing how to differentiate between objects and people (Poulin-Dubois & Shultz, 1988; Riviére, 2000; Sáiz et al., 2012). From the first months of life, infants show interest in social stimuli, imitate behaviors, and begin to recognize intentions and emotions (Moll & Tomasello, 2007; Moore & Corbit, 2019; Sommerville, 2010). Around ages 4–5, they start understanding false beliefs (Wimmer & Perner, 1983), a key milestone in ToM development that marks a crucial shift in their ability to predict and interpret peers' behaviors, enabling more complex social interactions (Araya et al., 2009; Astington & Gopnik, 1988; Gopnik & Astington, 1988; Perner et al., 1987; Wellman et al., 2001). More advanced skills emerge between ages 6 and 11, such as interpreting metaphors (Rubia Vila, 2018) or recognizing social faux pas (Happé, 1993).

Given its importance, ToM research has focused on interventions for populations with deficits in mental state attribution, particularly individuals with autism spectrum disorder (e.g., Baron-Cohen, 2008; Baron-Cohen et al., 1985; Begeer et al., 2011; Colle et al., 2007; Fisher & Happé, 2005; Happé, 1995). Interventions have focused on teaching children to identify the mental states of others, i.e., through the use of visual representations of mental states using typical comic books (Balint, 1993; Paynter & Peterson, 2013; Wellman et al., 2002) or through repeated exposure to scenarios that recreate or role-play these states. (Dhadwal et al., 2021; Inchausti & García-Póveda, 2017; Molina Cobos & Amador Castro, 2010; Villanueva-Bonilla et al., 2018).

LITERATURE REVIEW

Advancements in information and communication technologies (ICT) offer a range of alternatives for working with people with different needs, positioning themselves as facilitators for development and learning (Cáceres-Acosta, 2017). Virtual reality (VR) is a great ally since it favors the immersion of the user within an artificial environment but which, thanks to the different sensory stimuli and its software programming, is perceived as real (Vera et al., 2003). This section reviews existing studies on virtual reality applications aimed at teaching ToM skills. For example, Deusto-e-motion1.0, developed by Lázaro et al. (2020), was designed to enhance facial emotion recognition with a sample of 1236 children aged 8 to 11 years old with normative development. This software combines the serious game version with the VR version. More specifically, the virtual version features conflict-related situations in which the participant must select among six basic emotions. The results evidenced the validity of the program assessing the ToM components related to face recognition.

Similarly, VR-based interventions have been effective in populations with psychological or developmental challenges. For instance, Urgesi et al. (2021) used a VR-based rehabilitation system aimed at individuals with congenital cerebellar malformation to improve their predictive skills and the understanding of others' intentions in social scenarios. The results revealed that, in the post-training assessment, the experimental group showed greater confidence about contextual cues during the action prediction task than the control group. The authors concluded that training predictive skills in a social virtual reality scenario boosted implicit learning and the use of contextual cues during motion perception for predicting the actions of others. Vass et al. (2022) used a VR-based ToM intervention that combined cognitive and behavioral therapeutic techniques for patients with schizophrenia or schizoaffective disorder. The results demonstrated that patients who participated in the intervention showed significant improvements in all types of ToM tasks compared to the control group. These results proved to be sustainable three months after treatment. Similarly, Beaumont and Sofronoff

(2008) used the Junior Detective Training Program with a total sample of 49 children with Asperger's Syndrome. This program included a VR computer game with three levels aimed at teaching tools or skills for recognition, emotional regulation, and social interaction. The program also included training sessions for parents and teachers. The results showed improvements in social skills and functioning compared to the control groups (as reported by parents and teachers). In the same way, emotional regulation strategies improved in the posttest phase when compared to the pretest and the control group. However, there were no differences between experimental and control participants in terms of facial expression and body posture identification.

Although there are several studies using VR applications to work on ToM components in samples with some psychological difficulty, primarily schizophrenia (Vass et al., 2018) or disability (Montoya-Rodríguez et al., 2022), there are no studies to date that apply this technology to children without any impairment. In the systematic review conducted by Grossard et al. (2017), 31 articles were analyzed, showing that educational games using ICT may be used to train ToM skills such as emotion recognition or production or other general skills such as interaction, collaboration and adaptation to specific social contexts. While four of the articles featured in the review used VR-based procedures, all used individuals with autism spectrum disorders as their sample.

Therefore, despite growing interest in VR-based interventions for populations with psychological or developmental challenges and the consensus that VR technology interventions positively impact social skills in children and adolescents with developmental challenges (Yang et al., 2025), research on the use of VR for ToM development in neurotypical children remains scarce. In March 2025, we searched Scopus and Science databases with the keywords "virtual reality" AND "children" AND ("social skill" OR "Theory of mind") in the title and/or abstract fields, and no works on VR in typically developing school-aged children were found. This research gap represents a lost opportunity for typically developing children in school contexts since it limits access to innovative tools that could optimize the teaching of socio-emotional skills from an early age. Furthermore, the main benefits of implementing interventions in school settings lie in their practicality and direct relevance to real-world social interactions. While these approaches offer less experimental control, they have proven to be advantageous due to their adaptability and cost-efficiency (Yang et al., 2025). However, without sufficient evidence, its implementation in conventional education remains limited, wasting its potential as a complementary pedagogical resource in teaching social and cognitive skills.

At this point, if the use of teaching tools sufficiently like real-life situations, as in the case of VR, can facilitate transfer between the learning environment and real-life interactions, then it would be desirable to promote their usefulness for improving ToM skills in children. As mentioned in the preceding paragraphs, all this would have an impact on a better adaptation and relationship with peers in the classroom, generating behaviors appropriate to the context and improving social coexistence skills. For this reason, the present study had the objective of analyzing the effectiveness of a virtual reality application designed to teach ToM skills to children between 5 and 6 years of age. For this purpose, these skills were evaluated before and after implementing the intervention both in the participants who used the VR tool and in those who acted as controls. By investigating whether VR-based training enhances ToM development in young children, this research contributes to expanding the applicability of VR beyond clinical populations. It provides insights into its potential as a pedagogical tool in early childhood education.

METHOD

PARTICIPANTS

Seven children of 5 and 6 years of age (five girls and two boys) attending two private educational institutions participated in the study. The sample was chosen using a non-probability purposive sampling method with an experimental condition and a control condition. The small sample size was justified within the framework of a pilot study, whose purpose was to assess the feasibility and preliminary effectiveness of the designed intervention. The inclusion criteria for the study were the absence of a developmental disorder or learning difficulty diagnosis and the absence of attention problems or disruptive behaviors that would hinder the performance of the tasks. All participants were in level 5 of initial education. In every case, informed consent was obtained from the parents for their children's participation in the study.

The general cognitive functioning of all participants was assessed using the Wechsler Preschool and Primary Scale of Intelligence 4th edition (WPPSI-IV) (Wechsler, 2014) to confirm that they exhibited cognitive performance within the mean. As seen in Table 1, all participants showed IQ within the normal range. In addition, using the Baron-Cohen et al. (1994) mental state term recognition test, participants' understanding of terms referring to mentalist actions was evaluated to control for poorer performance on these terms compared to terms referring to body parts or what the body can do, as expected at these ages.

Table 1. Descriptive data of participants

Participant	EP1	EP2	EP3	EP4	CP1	CP2	CP3
Sex	Female	Female	Female	Male	Female	Female	Male
Age	6 years, 2 months	5 years, 8 months	5 years, 9 months	6 years, 1 month	6 years, 3 months	5 years, 6 months	5 years, 10 months
WPPSI-IV	85	92	103	97	119	112	110
Mental state term recognition test (Baron-Cohen et al., 1994)	10/20*	9/13	8/15	6/18	17/20	9/13	10/20

Note: Points obtained on mentalist terms/points obtained on bodily terms

Setting and Materials

The sessions took place at the educational facilities to which the participants belonged. Both rooms measured approximately 5 m x 4 m (16.4 ft x 13.1 ft) and included a table, several chairs, and school materials from the school. Different tests and evaluation instruments were used, and they are described below.

To assess the *general cognitive functioning* of all participants and to ensure the absence of cognitive difficulties, the Wechsler Preschool and Primary Scale of Intelligence IV (WPPSI-IV) (Wechsler, 2014) was used.

To evaluate the *recognition of mentalist terms*, the test designed by Baron-Cohen et al. (1994) was applied. This test involves reading two lists of words to the participant, asking him/her whether each of them refers to things that can be done with the body or things that refer to "what the mind can do". For this study, the number of words used was reduced from the 40 words that made up each of the lists in the original test to only 20 per list. This reduction was accomplished by randomly eliminating words. Therefore, any participant could obtain a maximum of 20 points in each list.

For the *ToM assessment*, adaptations of the test described by Wellman and Liu (2004) and Hadwin et al. (2015) test were applied. Both tests consist of vignettes, stories, and drawings, and the children are prompted to answer several questions. The application of the Wellman and Liu (2004) test requires 20 minutes and can be applied to children from 3 years of age. It is based on seven tasks that assess: (1) diverse desires or the ability to differentiate one's own desire from others' desire with respect to the same object; (2) diverse beliefs or the ability to discriminate different beliefs with respect to one's own belief about the same object, without knowing which is true and which is false; (3) access to knowledge or the ability to predict the knowledge that the others may have about an object; (4) false content belief or the ability to attribute to another person the false belief about the content of a container once the true content of this container, which does not correspond to that of the usual content, is known; (5) explicit false belief or the ability to recognize that another person may have a belief that is different from reality and is therefore false; (6) belief-emotion or the ability to predict an emotion from a false belief; and (7) real-apparent emotion or the ability to understand that a person may feel a particular emotion, but expresses a different emotion. The scores that may be obtained on each task range from 0 to 1, with a maximum test score of seven points.

The Hadwin et al. (2015) test consists of five tasks assessing different ToM levels. The time required for its application is 20 minutes, and it is intended to be used on children from 3 or 4 years of age. The five levels they evaluate are: (1) simple visual perspective taking, which involves understanding that different people can see different things depending on their location in space; (2) complex visual perspective taking, which requires understanding of not only what another person can see but also how they see it; (3) comprehending the "seeing leads to knowing" principle, which involves understanding that people only know things that they have had experience with (directly or indirectly); (4) predicting actions on the basis of another person's knowledge, in which the assessment tests the ability to understand that another person may have true beliefs due to prior experience and further predict that person's actions based on their belief; and (5) understanding false beliefs which, compared to the previous level, assesses the ability to understand the false beliefs that another person may have and predict that person's behavior based on it. The different questions present in the five levels have a score between 0 and 1, with a maximum test score of 16 points. Materials such as a box of cookies, a box of chocolate bars, dolls, picture cards, small stones, erasers, and a pig toy were required for these tasks.

The *virtual reality training protocol* was introduced by means of a software application for mobile devices developed for this research. This protocol consisted of ten scenarios adapted from Montoya-Rodríguez et al. (2024), which include everyday situations involving one or two characters. These scenarios were based on the 'seeing leads to knowing' principle of Hadwin et al. (2015), understanding that reasoning based on perceptual access is a precursor to more complex levels of ToM (Fabricius et al., 2021).

The scenarios from the Montoya-Rodríguez et al. (2024) protocol were presented sequentially until the participant met the performance criterion detailed later (see the Procedure section). All scenarios maintained the same structure. Figure 1 shows an example of the scenario. At the beginning (Part A, Figure 1), the participant could not see what the character was doing. After the corresponding questions, the second phase of the scenario was presented (Part B, Figure 1), in which the character turned around, or the stimulus that obstructed the participant's vision was removed, allowing the participant to observe what the character was doing.

The VR application was created using the Unity platform (Unity Technologies, 2024), with characters and environmental elements for the virtual scenarios sourced from the Unity Asset Store (Unity Technologies, 2023). Implementing it requires a cell phone VR viewer, a mobile phone, and a computer on which the experimenter could access the relevant questions in each case.

Part A of the scenario **Part B of the scenario**

Figure 1. Scenario example

Experimental Design

The performance of the participants in the ToM skills assessment tasks was considered the dependent variable. The independent variable was the intervention carried out using the virtual reality application, which, due to its characteristics, involves differential reinforcement in multiple and varied examples. The participants were randomly distributed in two experimental conditions: four participants in the intervention condition and three in the control condition. The arrangement of the variables and the procedure implementation resulted in a repeated-measures quasi-experimental design with pretest-posttest evaluations. A quasi-experimental design was chosen to conduct the intervention in a more ecological setting, such as a real educational environment, as opposed to a controlled environment, such as a university laboratory. Additionally, although subjects were randomly assigned to the experimental and control conditions, participants were not randomly selected.

Procedure

Ethical approval for this study was given by the Ethics Committee of the Universidad Católica del Uruguay and complied with Decree 158/19 of the Executive Branch of Government, which regulates research involving human subjects in Uruguay under legal procedures for the protection of the participants' identity. The sequence of the study phases is explained below.

Pretest

During this phase, ToM skills were assessed using the tests of Wellman and Liu (2004) and Hadwin et al. (2015). No aid was used, and no feedback was given after the participants' answers. This assessment was completed in two 20-minute sessions with each participant.

Training

Individualized training was applied to participants in the experimental condition during two sessions. Four scenarios were presented in the first session. The second session continued with the remaining four scenarios until the participants reached the established performance criterion: two consecutive scenarios with 100% correct answers. The content of the scenarios and the order in which they were applied were identical for all participants.

Each participant was informed of how the virtual reality glasses worked, and it was explained that in case of any discomfort of any kind, we could stop using the glasses without any problem. In addition, prolonged use of the glasses was avoided. For this, each session lasted 25 minutes with a short break in the middle. All participants started and finished the intervention without any expressed discomfort.

Three experimenters participated in each session. Each was given a written protocol, instructions, and information about the application. Before introducing the scenarios to the participants, they practiced the procedure and registration by role-playing. At the time of the training, one of them oversaw the interaction with the participant by applying the protocol and registering the execution. In contrast, the other two only registered the answers obtained as independent observers.

The participant sat in a swivel chair and was helped to put on the VR viewers, giving them time to become familiar with the displays. The first scenario was then presented. Using the scenario depicted in Figure 1 as an example, the procedure was conducted as follows. First, the character appears with his back turned so that the participant cannot see what he is cooking (part A of Figure 1). The presenter briefly describes the scenario to the participant ("In this scenario, you see a character cooking. He is in the kitchen and is cooking") and then asks them the following questions (the expected correct answers are indicated in brackets):

1. "Tell me what you see. Do you see the character? (Yes)"
2. "And do you see what he is cooking? (I don't)"
3. "So you do know what he is cooking? (I don't know). So, you do not see and you do not know what he is cooking."

Next, the character turns to show what he is cooking (part B of Figure 1), and the participant is asked:

4. "Now, can you see what he is cooking? (Yes, I can)"
5. "So now you know what he is cooking? (Yes, now I do). So now you do see and know that he is cooking bananas."

The structure of the questions remained constant throughout the protocol, adjusting only to refer to the action performed by the character in each scenario (playing in the bedroom, washing in the bathroom, shopping in the supermarket, etc.). Correct answers were followed by comments from the lead experimenter, such as "Very good, that's it," "That answer is correct," and the like. When the answer was incorrect, corrective feedback was provided. The lead examiner would say, "No, you don't see what he's doing, so you don't know what he is doing. Try again." and re-submitted the question explaining the answer. Once the performance criterion had been met, the post-evaluation was conducted the following day.

The participants in the control condition also left the classroom individually for the same number of sessions as the experimental participants by going to the room where the training was taking place. However, these participants performed school tasks such as drawing, painting, and cutting out silhouettes.

Posttest

After training, ToM skills were assessed in all participants using the same tests as those given in the pretest phase. This evaluation was carried out individually in a single 20-minute session. At the end of the session, the participants spent a few minutes performing playful activities.

Agreement Between Judges

Two independent observers simultaneously registered the participants' target answers in 75% of the sessions. The inter-judge agreement was calculated by dividing the total number of agreements by the total number of agreements plus disagreements and multiplying the result by 100 [A/(A+D)*100]. An agreement was previously defined as the observers' concurrence in registering the participant's answers to each question as either correct or incorrect. During training, a correct answer was defined as the correct answer to each question without providing any aid. The percentage of agreement reached 100% in all answers.

RESULTS

Table 2 summarizes the descriptive statistics of the experimental and control conditions on ToM skills, measured by the Hadwin et al. (2015) and Wellman and Liu (2004) tests before and after the virtual reality intervention. In the Hadwin et al. (2015) test, both groups presented a similar mean in the pretest phase (M = 7.25 for the experimental group and M = 8.33 for the control group), although with a slight advantage for the control group. However, after the intervention, the experimental group showed an increased performance (M = 11.5), while the control group remained stable (M = 8.33). In the Wellman and Liu (2004) test, the initial results were similar between both groups, with means of 3.5 and 4 in the pretest for the experimental and control groups, respectively. After the intervention, the experimental group showed considerable improvement (M = 5.75), whereas the control group showed no changes (M = 4.0). The variability in scores, reflected in the standard deviation, indicates that participants in the experimental group experienced more homogeneous improvements in the Wellman and Liu (2004) test. In contrast, in the Hadwin et al. (2015) test, the scores were more dispersed.

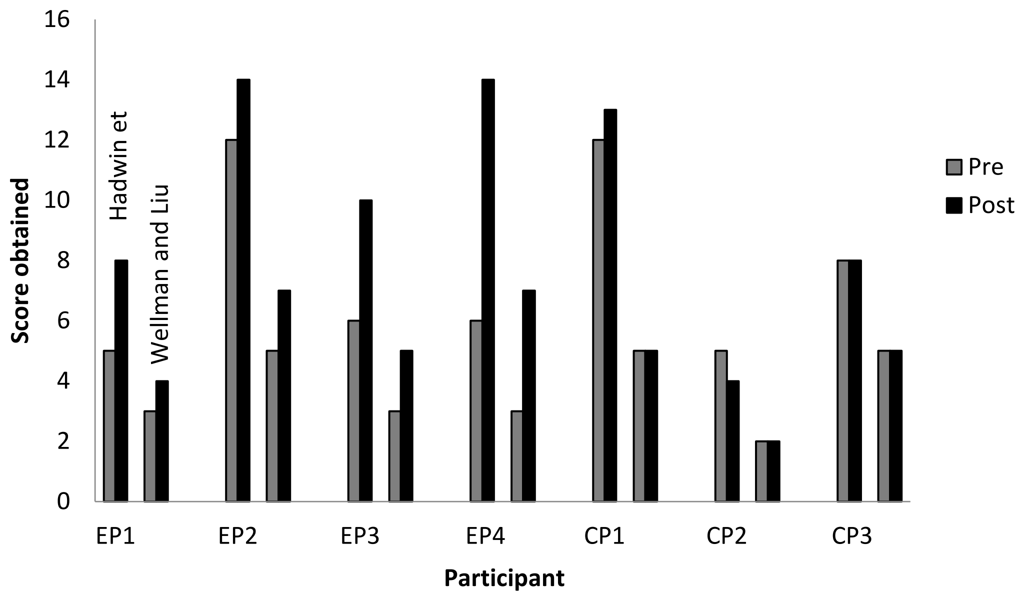
Table 2. Descriptive statistics

	Hadwin pretest		**Hadwin posttest**		**Wellman pretest**		**Wellman posttest**	
Condition	**Experi-mental**	**Control**	**Experi-mental**	**Control**	**Experi-mental**	**Control**	**Experi-mental**	**Control**
Valid	4	3	4	3	4	3	4	3
Mean	7.25	8.33	11.50	8.33	3.50	4	5.75	4
Standard deviation	3.20	3.51	3	4.50	1	1.73	1.50	1.73
Minimum	5	5	8	4	3	2	4	2
Maximum	12	12	14	13	5	5	7	5

Figure 2 shows the scores of each participant on the pretest and posttest assessments of ToM skills. All participants in the experimental condition achieved improved scores on both ToM measures following the intervention. In the Wellman and Liu (2004) test, three of the four participants (EP1, EP3, and EP4) started from the same score on the baseline measure (three points out of a possible 7), obtaining varying improvement on the posttest measure. In this test, two of the participants (EP2 and EP4) reached the maximum score after training, despite starting from different pretest baselines. These two participants also approached the maximum score in the posttest measure (14 points out of a possible 16) of Hadwin et al.'s (2015) test, even though starting from vastly different results in the pretest measure. Participants EP1, EP3, and EP4 initially scored below 50% on this test, reaching and exceeding this percentage on the posttest measure. As for the control condition participants, scores remained stable between assessments, except for CP1, which increased by one point, and CP2, which decreased by one point on the Hadwin et al. (2015) test.

Overall, the individual performance trends depicted in Figure 2 highlight a clear improvement in ToM skills among all experimental participants, whereas the control group showed little to no change between pretest and posttest measures. The data indicate variability in the magnitude of improvements within the experimental group, with some participants reaching ceiling effects while others showed more moderate gains.

Figure 3 shows the performance of the experimental participants during training. A general trend of progressive performance improvement is observed, although there are individual differences in the speed with which each participant reached the established mastery criterion (two consecutive scenarios with 100% correct responses). EP1 and EP4 reached the performance criterion with six scenarios, while EP2 needed seven scenarios and EP3 needed eight. It should be clarified that the sharp drop in EP1's performance in scenario 4 was due to the VR glasses being misaligned, which prevented them from clearly seeing the scenario.



Note: EP=experimental participant; CP=control participant

Figure 2. Scores achieved by participants in the Hadwin et al. (2015) and Wellman and Liu (2004) assessments

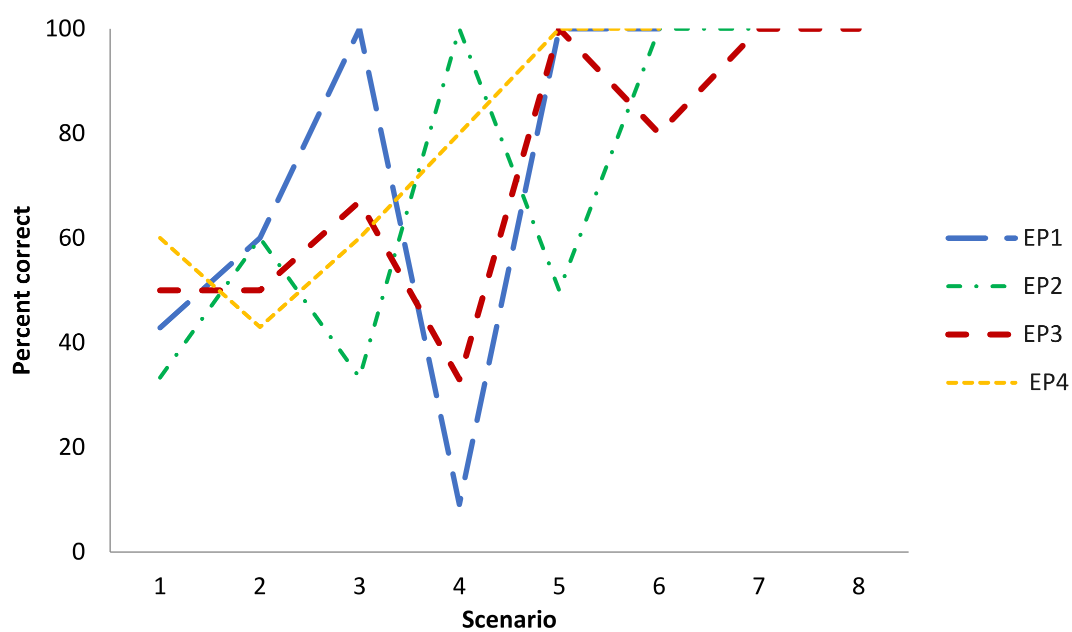


Figure 3. Percentage of correct responses obtained by the experimental participants during training

DISCUSSION

This study aimed to test the efficacy of a VR application in teaching ToM skills to typically developing children. The findings suggest its potential effectiveness. More specifically, all participants with whom the application has been used improved their posttest scores in the two tests used to measure ToM skills compared to participants assigned to the control condition.

A ToM skills training protocol developed in a relatively novel, motivating, and versatile format was used in this area. The use of virtual reality enables exposing participants to a variety of scenarios in an enjoyable, simple, and attractive manner (Wiederhold & Wiederhold, 2007), with the added advantage of being able to design and organize the presentation of the trials in a controlled manner and as may be appropriate for each case (Botella et al., 2009; Soto Triana & Gómez Villamizar, 2018). Although this study did not directly measure motivation, prior research suggests that virtual reality environments can enhance engagement and sustained attention in learning tasks (Radianti et al., 2020). On this topic, Sullivan and Winner (1993) indicate that the development of mentalist skills, specifically those aimed at understanding the emotional states of others, improves when participants are involved in activities that motivate them.

The protocol used was designed following the literature's indications about the basic linguistic components for teaching perspective-taking skills. In this sense, the teaching emphasized the insight that "seeing leads to knowing," which has been indicated as a prerequisite for the development of ToM skills (de Villiers, 2007; Fabricius et al., 2021). Several authors point out that without being specified by "if … then" conditional framing, we could not take the perspective as defined in many tasks (Quiroga-Baquero et al., 2022; Taylor et al., 2023). Therefore, as shown in Figure 1, the questions were aimed at the participant, pointing out what they were seeing to help establish the conditional relationship "if you see, then you know" or "if you don't, then you don't know". The double negatives were difficult for the children, but we emphasized that feedback because that was exactly what we wanted them to learn.

In addition to the preliminary efficacy observed – reflected in the improvement of ToM skill measures among all participants in the final evaluation – the speed with which participants reached the performance criteria established in the training was also noteworthy. After two work sessions, all participants answered 100% of the questions correctly in two consecutive scenarios, requiring only six scenarios (participants EP1 and EP4) or seven and eight scenarios for participants EP2 and EP3, respectively. It is, therefore, a training program that has proven to be both fast and effective. Previous studies that using VR to teach ToM-related skills do not report on in-process measures (Vass et al., 2022; Yang et al., 2025), as shown in Figure 3. Having in-process measures provides valuable information about learning dynamics. It allows for the analysis of the speed and effectiveness of the intervention, the examination of differences in learning rates, and the detection of setbacks that may occur due to technical or procedural factors during the experience with the technology, as occurred with EP1. Figure 3 shows that, although training allows for improvements in fostering ToM-related skills, some children may require more exposure to consolidate the skill set. This variability underscores the importance of individualized pacing in VR-based interventions, ensuring that each child receives the necessary number of learning attempts to maximize skill acquisition.

These results with VR technology are in addition to those previously reported by Vass et al. (2022) working with patients with schizophrenia or schizoaffective disorder and by Urgesi et al. (2021), who developed their study with a group of pediatric patients with cerebellar malformations. Similar to the present study, both used a pretest-posttest design with an experimental and a control group, which allows for obtaining evidence of the intervention's effectiveness. In all three cases – typically developing children in the present study, adults with schizophrenia (Vass et al., 2022), and children and adolescents with cerebellar malformations (Urgesi et al., 2021) – VR-based interventions improved performance on ToM tasks of experimental participants compared to controls. However, there is a central difference between the three studies related to the characteristics of the samples. Due to the variation in age ranges, each study employed different assessment tools to measure ToM skills, ensuring that the tasks were developmentally appropriate for each sample. Furthermore, this study pioneers the training of ToM skills through the application of immersive VR technology in typically developing children. As previously mentioned, despite the benefits of using VR for teaching social skills, no studies have been found that show this technology's efficacy in enhancing these skills in children without developmental impairments.

Although the results obtained are promising, they should be considered cautiously due to the small and homogeneous sample, which is composed exclusively of children from private educational institutions. This restricts the generalizability of the findings, as different educational and socio-cultural backgrounds may influence the effectiveness of VR-based interventions for ToM development. Future studies should replicate the procedure using more diverse and larger samples that enable more robust statistical comparisons. This would strengthen the validity of the conclusions and facilitate the establishment of clear causal relationships between the training and the outcomes obtained.

Additionally, the potential novelty effect associated with the use of virtual reality should be considered. Given that VR is an engaging and relatively uncommon tool for children, it is possible that some of the observed improvements in ToM skills were influenced by the excitement and increased attention elicited by the technology rather than by the intervention itself. Future research should incorporate longitudinal designs that assess the retention of ToM gains over time and compare VR interventions with alternative, equally engaging, but non-immersive training methods. This would help determine whether the observed improvements are attributable to VR's unique immersive features or if they could be replicated with other interactive methodologies.

Future research should also evaluate how acquiring new ToM skills impacts the participants' daily lives. In this regard, it would be useful to evaluate the possible impact of the new repertoire on the improvement of social interaction skills, coexistence, relationships with peers, etc. It is necessary to define the real scope of this type of training, which could either be sufficient for improving the participants' social skills (what is ultimately of interest) or would require additional elements to achieve these improvements. Regarding this aspect, it should be noted that at the beginning of the study, the recognition of mental terms was evaluated using the test designed by Baron-Cohen et al. (1994). It could be argued that greater knowledge or familiarity with these terms would improve the training of the skills to which these terms refer, either because they are incorporated into the verbal interactions during training or because they appear in the questions or instructions given during evaluation. In this respect, several studies have found significant correlations between language skills and the development of ToM (de Villiers & de Villiers, 2000, 2003; Happé, 1995; Jenkins & Astington, 1996; Peterson & Siegal, 1998). As such, control condition participant CP1, who achieves the highest score on the assessment of terms referring to what the mind can do, also scores the highest on the pretest measure of the Hadwin et al. (2015) test. However, the results do not reliably confirm this relation. Participants EP1 and CP3, who obtain the same score in the mentalist terms test, achieved different scores on the pretest measures of ToM. Furthermore, participant EP4, who obtains the lowest score on the mentalist terms assessment, is by far the one with the greatest increase in post-scores obtained on the ToM assessment tests. It would appear that performance on the Baron-Cohen et al. (1994) test does not help predict how individuals will respond to the initial ToM assessment. Greater or lesser knowledge of mental terms does not seem to influence performance on tests used to evaluate ToM. In any case, the influence of using these terms should be analyzed, considering research specifically aimed at testing this.

CONCLUSION

This study explored the effectiveness of a VR application in teaching ToM skills to typically developing children. A quasi-experimental design was used with an experimental and a control group, assessing ToM skills before and after the intervention. The results showed improvements in the performance of children who participated in the VR experience compared to the control group, suggesting that immersion in interactive scenarios can be an effective strategy for fostering perspective-taking and understanding the mental states of others.

Our findings represent progress in developing straightforward and efficient procedures for education and psychological intervention. Integrating VR technology in school settings could complement traditional methodologies, providing more dynamic and contextualized learning experiences. Specifically, VR could be used by teachers and educational professionals to enhance socialization and emotional regulation in young children, promoting more inclusive learning tailored to different needs.

Future studies should aim to replicate and improve on what is presented here as a preliminary approach. Achieving a more comprehensive evaluation of VR's benefits in ToM skills training will require future research incorporating larger and more diversified participant samples, along with long-term follow-up measures to assess the effective transfer of the skills acquired in the virtual environment to real-world situations.

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