Transylvanian Review

Vol 32, No. 3, 2024

Transylvanian Review
Centrul de Studii Transilvane| str. Mihail Kogalniceanu nr. 12-14, et.5, Cluj-Napoca
Email: transylvanianreview@gmail.com
Online Submission System: http://transylvanianreviewjournal.com/

Didactic and experimental study on the impact of augmented/virtual reality on students
Case studies: students with pervasive developmental disorders (PDD)

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ABSTRACT

Our research is part of the analysis of cognitive problems mainly in students with pervasive developmental disorder (PDD) and the introduction of virtual or augmented reality into their daily lives in order to remedy them. The emphasis will be on techniques or computer-modeled applications that can contribute to the improvement of the subject's communicative and emotional skills.

In order to provide answers to all our questions, we based ourselves on exploratory interviews and examinations based on the use of virtual or augmented reality (AR/VR) in the care of students with PDD. In other words, we considered it necessary to focus our study on the use of virtual environments (geolocalized) and avatars, which result in:

- The display of the environment in 3D as well as all the objects (avatars) constituting it;
- The discernment of the task performed or to be performed;
- The increase in the salience of certain objects;
- The delivery of instructions in interaction with the virtual or real environment with the aim of increasing the students's ability to process and use incoming information in order to better manage activities of daily living (ADL), repeat them as much as necessary, and subsequently control the situation.
- The exposure of various innovative specific techniques little known in the treatment of PDD.

Keywords: pervasive developmental disorder, virtual reality, augmented reality, communicative and emotional skills.

1. Introduction

The objective of our work is to apply virtual or augmented reality, being two multidisciplinary fields relying on a wide range of technologies, in the management of autism spectrum disorders in students with PDD, and to understand how the use of these technologies could contribute to the improvement of their communicative and emotional skills.

Our research will thus be conducted with the aim of providing answers to all our questions, or even affirming our basic hypothesis which assumes the favorable contribution of such use in the treatment of students with PDD. We will therefore, and throughout this work, try to emphasize the capacity of these new technologies to promote the skills of brain-damaged students during the exercise of their daily activities.

Our work, both empirical and theoretical, will allow us to answer our basic question: "How does the application of virtual or augmented reality to students with a pervasive developmental disorder contribute to the improvement of learning, communicative skills and recognition of the expression of emotions?"

In this research article, the expressions "New Technologies" will be used to designate any hardware and software that can help the students who are the subjects of our research.

This research is part of one of the research projects of our research laboratory at the Higher Institute of Specialized Education, and which will aim to develop new methods of prevention and rehabilitation in order to improve learning, communicative and emotional skills in students with PDD.

Our project has two components. The first component consists of studying the meaning of empathy on the psychiatric and neurological side and the technologies of virtual or augmented reality allowing it to be developed to promote understanding and appropriation of gestures. The second component consists of applying virtual or augmented reality in the field of PDD to promote communication, recognition of emotions and the development of techniques to help with the functional rehabilitation of cognitive and behavioral disorders in autistic students .

Our approach throughout this project will be in two fundamental stages, one that concerns the psychiatric and neuropsychological side of PDD students , the other that deals with the use of new technologies in the treatment of these students , namely, AR and VR. In addition, we will use these new techniques to produce 3D avatars, virtual environments, etc. capable of generating and stimulating emotions, or even helping the cognitive and behavioral reconstruction of subjects in situations close to those of everyday life.

1.1. Virtual reality

To begin with, it is very important to note that:

"Virtual reality = 75% virtual + 25% real"

"Augmented reality = 75% real + 25% virtual"

"Augmented reality is a virtual reality mixed with a real environment".

It is a "Scientific and technical field using computer science and behavioral interfaces to simulate within a virtual environment the behavior of 3D entities that interact in real time with each other and with one or more users" [1]. The emergence of this concept illustrates the dynamism of interdisciplinary dialogues between computer graphics, computer-aided design, simulation, remote operation and audiovisual [2].

Although the applications of this context have proven very useful in the field of psychology for the treatment of pervasive

developmental disorders [3], applications in the field of PDD remain very limited and the first exploratory study of emotions is presented in the article by [4]. These authors wanted to present the potential of these technologies in collaborative virtual environments (CVE) to work with patients with PDD. They examined whether the latter understand the basic emotions represented by the avatars. This analysis reveals an innovative approach and offers several ideas to guide future studies in the field of virtual or augmented reality.

Other studies have also analyzed the theme of the effectiveness of virtual or augmened reality applied to the treatment of people with pervasive developmental disorders. [5], and [6] focused on learning. [7] focused on learning imagination.

This system can be useful to increase emotions and recognition of emotional expressions [8], PDD by [9]. In addition, by using educational potentials of this technology, we can make the students with PDD interact with an avatar that is a 3D avatar (a man, an animal, ..) (figure.01). It is also interesting to create situations such as the passage of a boulevard or a fire to train in order to anticipate real-world events (Figure.02). The researchers add that EVC allows patients to train in a real conversation in a virtual world [10], cited by [5].

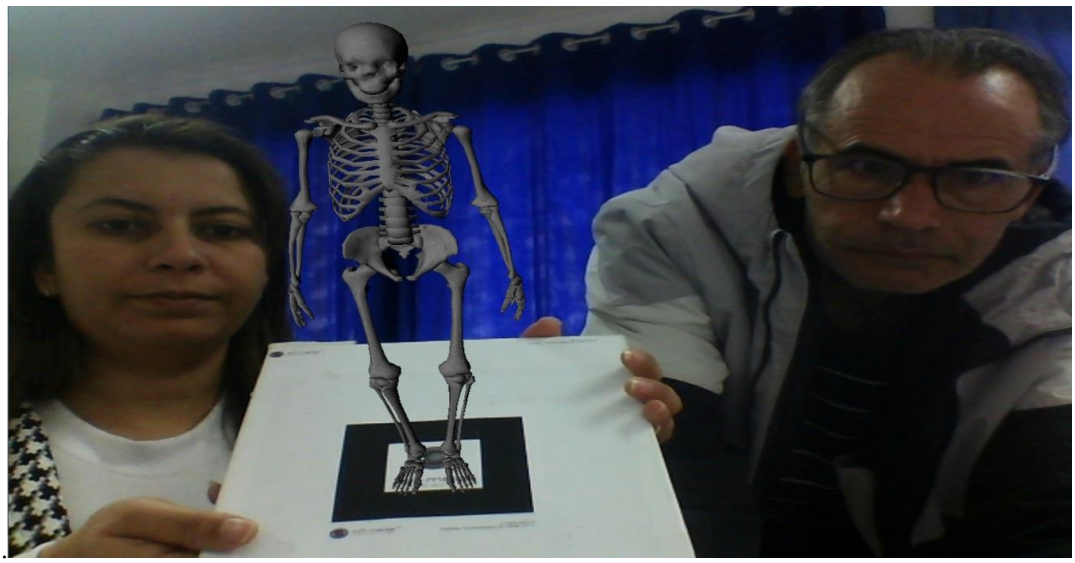
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Figure 01: Application of AR to improve communicative and emotional skills.

Figure 02: Creating situations such as crossing a boulevard or a fire to train to anticipate real-world events.

1.2. Augmented reality

Theoretically, augmented reality or virtual reality are geometries, which is why after an introduction to epipolar geometry and an explanation of the techniques used, we will follow the steps that lead to the development of a 3D model and then move on to practical studies for the creation of our application.

We are talking about epipolar geometry between photos taken with a video system (camera) from a different viewing angle. Therefore, the plane passing through a point that belongs to the environment and the image points is called epipolar. By tracing all these planes, we note that they intersect at a point in the images, the epipoles (e1 and e2).

Computer vision accounts for the relationships combining the scene and the photos through the use of sensors and mathematical models. This activity focuses on image processing, the interpretation of visual data and their use. Geometric visual data will allow to develop a link with visual servos, by considering:

- Projection in a photo of a point of the scene,
- Relationships between the different projections of the scene,
- Geometric reconstruction of the scene from the projections in several photos.

The applications are diverse. Their sectors are essentially:

- shape recognition,
- modeling of environments,
- dimensional control,
- augmented reality and assistance with image synthesis or representation,

1.2.1. La géométrie épipolaire

Epipolar geometry allows to develop a geometric link between 2 images of the same scene, it evokes the obligations linking the observations of the same scene observed by one or two cameras, noted C1 and C2 (figure.03). These obligations are directly associated with the relative positioning between the two cameras but are completely independent of the structure of the scene. It is important to remember that concerning the movement of a camera, epipolar geometry is only verified if the observed scene is rigid.

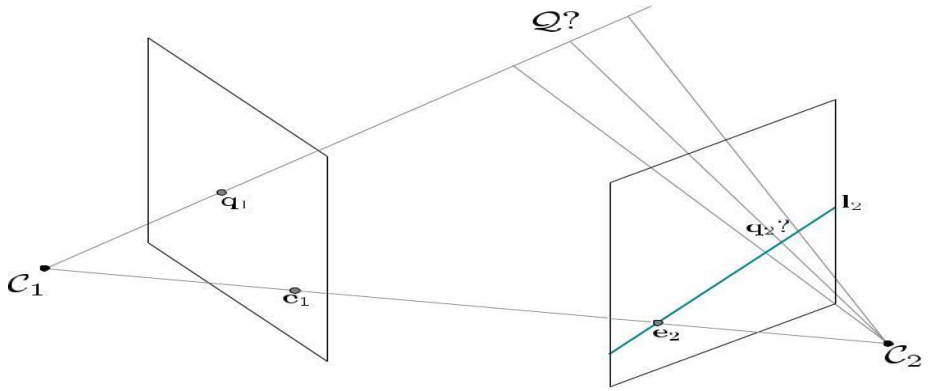

Figure 03: Epipolar geometry.

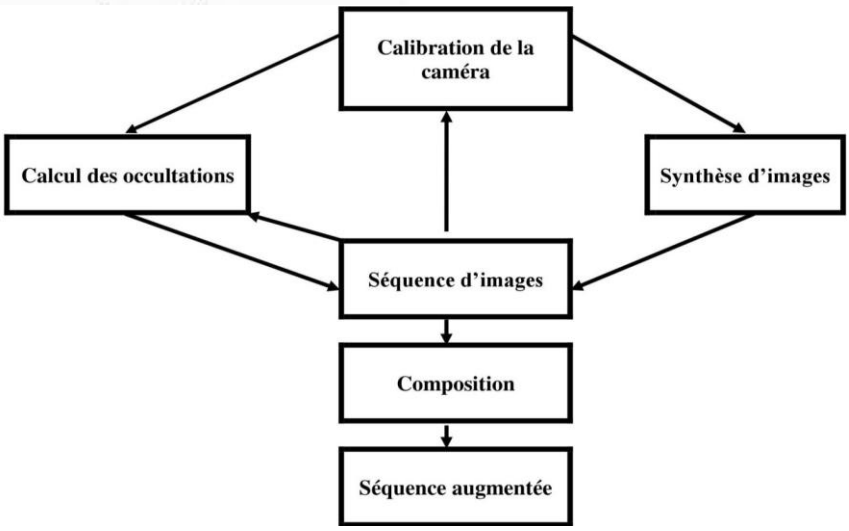

Figure 04: General architecture of an AR system.

1.2.2. General architecture of an AR system

Indeed, for an augmented reality system, three distinct phases are required before the composition (Figure.04): the image synthesis phase which aims to model the avatars to be embedded in the real scene and to illuminate them, the occultation calculation phase which aims to establish the real objects occulting one or more avatars in order to ensure the geometric coherence of the scene, and finally, the core of the system represented by the motion estimation or camera calibration phase which consists in determining the camera parameters. The latter are used simultaneously for the calculation of the avatars and the determination of the occultation masks.

Indeed, for an augmented reality system, three distinct phases are required before the composition (Figure.04): the image synthesis phase which aims to model the avatars to be embedded in the real scene and to illuminate them, the occultation calculation phase which aims to establish the real objects occulting one or more avatars in order to ensure the geometric coherence of the scene, and finally, the core of the system represented by the motion estimation or camera calibration phase which consists in determining the camera parameters. The latter are used simultaneously for the calculation of the avatars and the determination of the occultation masks [11].

2. Problem

Through this approach, we will therefore try to answer this problem:

"How does the use of AR or VR with students with a pervasive developmental disorder contribute to the improvement of their communication and emotional skills?"

In other words, the following questions arise:

What are the factors that contribute to the development of communication skills in students with a pervasive developmental disorder?

What are the elements that make it possible to simplify the improvement of the emotional and expressive capacities of students with a pervasive developmental disorder (PDD)? [12].

3. Methodology

In recent years, psychotherapists have seized the support offered by VR/AR. Scientists and clinicians have initiated research and applications to attest to the performance of these tools. This area of use of VR/AR causes a growing advantage because of the many benefits revealed by VR/AR. VR/AR applications allow on the one hand the exposure, under control, of the patient to simultaneous complicated, dynamic, interactive 3D stimuli, and on the other hand the evaluation and treatment of the patient's cognitive and behavioral results, in actions likely to be close to those of real life.

These techniques therefore offer the possibility of creating environments with a therapeutic aim. Phobias, autism, rehabilitation are sectors in which the use of VR/AR has so far been mostly planned.

In this article, we will consider the use of VR/AR with students with a pervasive developmental disorder.

3.1. Pervasive developmental disorder (PDD)

Signs of pervasive developmental disorders always appear before the age of three. It is a delay or change in the students's development.

Students who have a pervasive developmental disorder (PDD) may:

Have difficulty interacting with others;

Have difficulty speaking or playing;

Play with some toys in a repetitive way;

Be very agitated when their routine is changed.

As for the diagnosis, it is not yet easy to make, for the simple reason that the signs of pervasive developmental disorders (PDD) strangely resemble several intellectual disabilities or severe maturational delays. In addition, therapists, doctors and speech therapists are not yet sufficiently trained to administer screening in an unmistakable manner, in particular since the developmental tests routinely used during the visit to the pediatrician do not allow the detection of signs related to the profile of pervasive developmental disorders (PDD). We will therefore propose a tour of the various known consequences by explaining the more than feasible association of elements in the incidence of pervasive developmental disorders and the need for the scientific world to continue research, lists the concerns observed during the diagnosis and specifies the technical specifications that can distinguish pervasive developmental disorders (PDD) from each other.

What are the causes of pervasive developmental disorders?

How is the diagnosis made?

Pervasive developmental disorder always raises a lot of questions. This interest could be due, on the one hand, to the fact that the public is more informed about its existence, its extent and its impact and on the other hand, because of the consensus between researchers and clinicians on the influence of acting early with young students [13].

3.2. The use of VR/AR with PDDs

For many years, new information and communication technologies have been frequently used with students with PDD, whether we think of aids for daily living or training conditions targeting dedicated learning. Over time, computer systems have evolved and the two-dimensional environment broadcast by computers can reproduce real scenes of different themes in three dimensions with more realism.

Virtual or augmented reality would prove to be especially useful as intervention tools with students with PDD [14]. This new technology offers possibilities that are especially advantageous for this type of population. Its main advantage would lie in the idea that these applications offer wonders for the creation of safe environments [15].

The external environment or rather the real environment can from time to time be disconcerting for an autistic person because it is complex to grasp. Since this new technology allows for a space to be left for an environment that is either real or not but controlled, the person with a pervasive disorder can therefore exercise several skills without fear of the consequences that would be likely to occur with a real life situation [16]. Sensory hypersensitivities are identified in this type of population. Therefore, the person with a PDD may feel invaded by several stimuli from the real environment, while virtual or augmented reality manages to regulate the quantity [17]. Also, the environment created can simply be adjusted to each person according to their needs. We can then create well-defined

intervention programs for each students [18]. Given that individuals with a PDD have different specificities, in particular several can speak while others cannot, virtual or augmented reality offers a way to create a private environment according to the strengths and weaknesses of the students and based on their interests to make the quality of their participation in interventions more effective. In addition, with these applications, it is easy to gradually increase the level of complexity and modify the contexts to allow excellent propagation of learning. Individuals with PDD have complexities in mental representations and creativity. Therefore, for them, it is not easy to make it appear or imagine a scene that is realized. Mixed reality then makes it possible to overcome this complexity by creating 3D objects or an imaginary scene representing the real world for them. [19] however warn users of this type of intervention because of its artificial nature. According to them, virtual or augmented reality can be too safe and too attractive for the person with PDD. The latter can become dependent on this new universe because it is more accessible and would be likely to come to flee interactions with the real universe. Currently, this technology is only used in clinical settings with supervision, so the dangers of abuse and dependence would be quite controlled . In addition, it is advisable to pair AR or VR interventions with more "traditional" processes, such as social scenarios or role-playing games. In any case, the potential gains of applications made with people with PDD appear to be much greater than the potential risks. With intervention techniques, VR or AR appears to be a practical modality with students with pervasive developmental disorders because they demonstrate advantages and meet our needs. The first research identified analyzing the use of VR or AR with this type of population aimed to establish whether students with pervasive developmental disorders with minimal verbal ability could tolerate an immersive virtual universe and provide solutions for this population. The virtual environment broadcast in the head-mounted display (Figure.05) represented a boulevard with vehicles to teach students how to cross the boulevard safely (Figure.06).

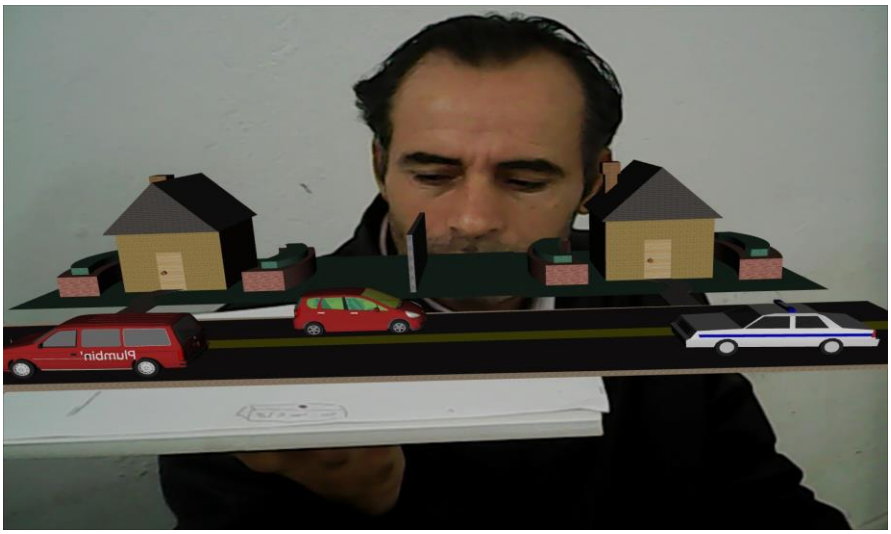

Figure 05: The virtual environment broadcast in the video headset.

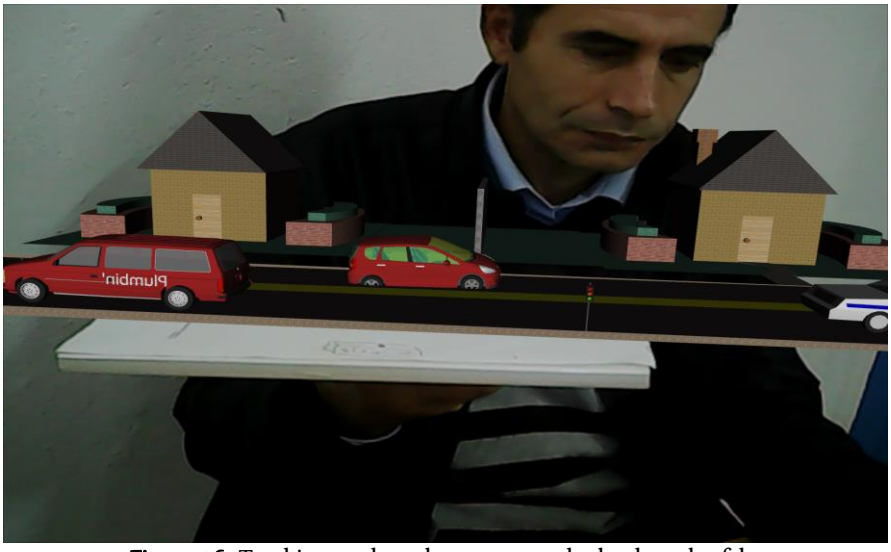

Figure 06: Teaching students how to cross the boulevard safely.

He researchers created scenes in such a way that the students with PDD was able to go to the stop sign and stop, or the students with PDD could locate the location (this is why our first articles are based on the localization of virtual reality), but did not move to the goal (figure.0&07). The latter did not seem to understand that these actions were reproduced in the virtual environment. Also, they noticed that he tried to remove the headset to observe the photo on the monitor. In all cases, the students with PDD were able to move around in the virtual environment and promote several features of it, such as the color of the vehicles. Since there were no pre-test provisions. However, this preliminary research suggests that students with pervasive developmental disorders would be interested in this recent innovation. It also appears that in this research, students were able to use the head-mounted display, although several students with PDD, due to their sensory specificities, would be likely to feel complexity, do not like having their vision disturbed or an additional object on their head [20].

For this, few studies have used the head-mounted display as an interface. However, wearing it is interesting given that it protects against environmental visual detractors and ultimately allows good mobilization of attention, even if the virtual environments are designed to capture the attention of students with PDD [21].

Indeed, VR or AR are scientific tools that capture the advantage of individuals with a pervasive developmental disorder.

[29] observed the behaviors of people with PDD according to the media that was exposed to them. In our opinion, the use of augmented reality alone will be able to provide good results because the immersion is more logical and the students can interact with the environment created even without the use of a headset that has been a foreign body for some students with PDD, in such a way that when the environment created is projected onto the projection screen, the students with a pervasive developmental disorder can move around freely without any worries.

Figure 07: The students with PDD is able to go to the stop sign and stop.

4. Experimental studies and discussion

Most research has used virtual or augmented reality as a means of intervention for students with pervasive developmental disorders, mainly on the social skills program. However, many of these studies did not specifically evaluate the effect of these applications on social skills, but in fact the way in which individuals with pervasive developmental disorders navigated within the virtual or real environment created. Like the research case of [6], who modeled a virtual café through which twelve individuals with pervasive developmental disorders had to complete several social actions, such as moving to find a chair to sit down, buying and going to the checkout to pay. Individuals were able to exploit the virtual environment created and their performance improved with each attempt.

In practice, navigation time within a virtual environment improved from exercise to exercise, regardless of the level of executive functioning (EF) of individuals with PDD. But, students with better planning skills are the people who took the least time to do most of the actions in the created environment. [22] also used this virtual café to teach social conventions to six individuals with a pervasive developmental disorder aged 14 to 16. Following two training trials in the created environment, patients had to watch videos that simulated the virtual environment of the café and a car, then choose a seat and have their choice explained. The results show that, for four people, the level of social acceptance of an action, namely choosing a seat to sit on, progressed as soon as they tried the created environment. Subsequently, all patients saw their level of reasoning improve. According to these researchers, virtual reality would be the ideal application to teach social skills to students with PDD. The results of this research seem promising in terms of improving social skills, but it has several limitations. Other teams of

scientists have been interested in the use of virtual or augmented reality as a means of intervention whose objective is to improve social skills. [23] created a 3D virtual learning environment allowing users to interact with each other in real time. This creation aimed to support young people with PDD to improve better social skills. Different virtual environments were created (restaurant castle, cars, mosque) (figure.10) in which students with PDD communicated with each other via avatars.

Figure 10: Different virtual environments to improve better social skills.

The pilot study included four students . The research goal was not to control the therapeutic effect of the application, but in fact to describe the behaviors of users in the virtual environment. This program was not designed with the objective of teaching users to improve social skills, but in fact served as a social context allowing interactions between students with PDD. The project allowed to examine in detail the behaviors of users and the way in which they interacted for their part. For example, the assessments prove that patients used verbalization as an essential mode of interaction. This tool is important because it allowed to objectively control a large number of behaviors with social value. In the previous analysis, no feedback was given to patients regarding their social method in the virtual environment created. The involvement of a clinician who offers feedback on transactions would however seem essential to encourage social skills. [24] conducted a trial with some students with PDD in which virtual reality social situations generated interaction between the patient and a clinician specialized in the field of PDD via avatars. The scenarios presented included diverse contexts, such as meeting people, making a social choice, and having a job interview. The clinician met the patient in person following the trial in order to exchange their impressions. The latter also offered feedback on the patient's behaviors, then a repeat of the scenario was done to offer the patient an opportunity to integrate the comments received. After the ten trials, the patients were better at recognizing emotions on faces, and they improved in terms of the hypothesis of the mind. In addition, they admitPDD to having good social skills in their real life:

They were able to maintain a discussion, assimilate the point of view of the other and develop relationships with others. It seems that virtual or augmenPDD reality is more effective when combined with feedback from an expert to promote social skills.

Virtual or augmented reality would also be an interesting tool for teaching safe behaviors to students with pervasive developmental disorders. Thus, [25] used an application made in 3D to teach

students with PDD to behave safely in the event of a fire (figure 11). The virtual environment created showed an animated character, who performed the different actions to be taken during a fire.

After the test, the PDD students had to carry out the same instructions under the encouragement of the caregiver. To move around in the virtual space. The results show that all of the students acquired ideal results at the end of the tests. It also appears that most of the participants generalized their learning in a real situation.

On our part, the realization of a phenomenon similar to the latter but with augmented reality can give enormous results since the students suffering from PDD moves in a real environment created without any worries.

Figure 08: Teaching students with PDD about safe fire procedures.

[31] were also interested in the use of virtual reality to teach safety skills in case of visualization of fire (figure 11) with some students with a pervasive developmental disorder.

Indeed, these students with PDD, using language as a tool of expression and being able to use a computer independently, participated in a training application. A classic learning method was offered to half of the patients, which included social scenarios such as images, videos and games; the other half of the group participated in a virtual reality learning program. Following the learning trials, both groups of patients were able to respond ideally to the fire alert in a real situation. On the other hand, some patients could react completely autonomously, while other patients needed specific requests (e.g.: show me). The difference between the two learning methods was in the training trial period, the latter being clearly short in virtual reality. So, whether through "classic" learning or through virtual reality, students with pervasive developmental disorder have developed better strategies, but virtual reality allows them to learn safe behaviors much faster. In order to teach students with PDD to cross the street safely, [26] used a virtual environment presented to the six patients with PDD representing a boulevard with vehicles traveling on it and the participant had to cross it without having an accident. The degree of complexity progressed as the patient progressed through the nine stages. At the end of the learning trials, all students improved in crossing the boulevard in the VE safely because they looked most of the time to the right and left before crossing the boulevard and had fewer accidents when crossing at traffic lights. Almost half of the latter had also generalized their learning by adopting safe behaviors to cross the boulevard in a real state. The application of virtual reality in this context seems to be a very effective way to teach students with PDD to use safety standards and apply them in their real life.

To date, only one study has tried to use virtual reality as a psychotherapeutic tool with students with PDD. [27] used virtual reality without the presence of avatars with two students with PDD in order to bring them into a hypnotic state in order to reduce anxiety and signs associated with PDD, such as hyperactivity, poor eye contact and auditory hypersensitivity. The assessments obtained do not show any change in anxiety and PDD signs according to the questionnaires completed by the families of the students with PDD. However, the students and parents appreciated this new learning, they reveal that their students seemed more relaxed after the tests. In general, virtual or augmented reality has been used with students with PDD as a means of intervention in terms of social skills, symbolic imagination and safe behaviors, as well as the level of psychotherapeutic intervention. We cannot currently finalize the performance of this intervention technique with students with PDD. On the other hand, it is obvious that this type of patient adapts quite well to this technique and is interested in it. According to [28], the virtual environment created would increase the desire of students with PDD to succeed in the intervention and their involvement in it. The results of the various research studies suggest that virtual reality interventions are very effective with this population, but practical studies are still few in number. The majority of research is intended to be exploratory and tries to observe the behavior of students with PDD in a modeled virtual environment. In addition, the caliber of the research samples is very small and there were sometimes large variations between students with PDD. Notably, some patients could use language as a tool of expression, while other participants could not. Apart from the research of [29], no other has compared virtual reality intervention to traditional methods. Despite this, it would have been nice to be able to compare these two methods in order to effectively understand the benefits of applying virtual or augmented reality in intervention.

5. Results: Techniques and assessment of PDD by VR/AR

According to [30], some therapists have sugges PDD that techniques using VR/AR can be very useful for students with pervasive developmental disorders.

These techniques could indeed provide assistance in planning, resolving difficulties, behavioral management and communication.

The advantages that VR/AR could bring to students with PDD have been highlight PDD [31]:

- Simplification of stimulus control and understanding
- Optimization of the user's motivation to perform actions using environmental factors and avatars.
- Personalization of the project PDD interface.
- Interaction with the environment or object promoting the development of social skills through real-time feedback.

The advantages provided by EVS and avatars have also been highlight PDD by [32]:

- Mastery of the environment is easier than situations encountered in everyday life.
- The interaction modalities being possible, the environment created or the avatar does not require face-to-face communication (users could notably get in touch through their avatars).
- The verbal or non-verbal parameterization of the exchange would be capable of being controlled and manipulated.
- The behaviors and solutions can be produced in an environment simulating reality, VR/AR offers a very great potential for the propagation of acquired knowledge, a more rigorous representation of a situation through projection.

Other experiments carried out by researchers have suggested that VR/AR could constitute the basis of simple learning modules to use, and which can promote learning in all environments of students with PDD.

The majority of research has focused on virtual reality for the purpose of intervention, but some, more recent, have used it as a means of assessment. Students with a pervasive developmental disorder frequently present attentional problems; however, virtual reality is a favorable modality because it offers a means of controlling the attentional aspect. In addition, instead of using two-dimensional photos, new scientists have preferred the use of three-dimensional images in virtual reality because the latter clearly resemble reality more. Research has looked at the use of virtual reality to measure perceptual functioning, emotion recognition, and memory skills in students with PDD. Scientists have used virtual reality to assess proprioceptive technical specifications in students with pervasive developmental disorder because of its technological strengths. [33] used immersive virtual reality to monitor reactivity and control in them. The patients felt like they were in a tunnel where a disturbance was created at the level of the visual system. Scientists justify the decision of virtual reality by the fact that it offers a way to easily use the particularities of the environment, namely the tunnel, in order to analyze its consequences on vision and position. In addition, it offers the possibility of reducing the consequences of confounding variables such as inattention. [34] also used virtual reality because of its highly detailed scientific characteristics. To control the eye movement of students with PDD in a conversation with others, they modeled a task where patients had to observe a virtual individual or object (avatar) (Figure.12). Virtual reality was selected as a verification modality because it offers the possibility of making facial expressions, with facial features that appear very real. The results show that patients with PDD have poor eye contact, which is consistent with the existing hypothesis on the subject.

[5]used virtual reality to measure basic emotion recognition in students with PDD.

They had to recognize emotions on faces, infer emotions from a situation and associate it with a specific emotion. The results show that most of the students assessed (30 out of 34) provided explanations at a rate of correct answers. This research is exploratory, but it would have been nice to look at the difference between neurotypical students and other PDDs regarding emotion recognition within a created virtual environment.

The researchers conclude that virtual reality is an innovative technique that deserves to be considered with this type of students.

One review compared the level of social judgment between students with PDD without intellectual disability and neurotypical students [35]. Several scenarios were revealed to the participants through virtual reality: in one, the individual interacts with them and sets socially acceptable tasks, while in the other, the tasks set are unacceptable.

Afterwards, the students with PDD had to answer a paper questionnaire about their interaction with the individual and to what extent they would like to become friends with the latter. The results show that neurotypical students recognize the individual as a potential friend in the first scenario than in the second, while there is no difference between the two scenarios for students with PDD. Because the latter also have problems interpreting the objectives of peers in everyday life, the researchers conclude that virtual reality would make it possible to simulate social situations that reflect their problems quite a bit.

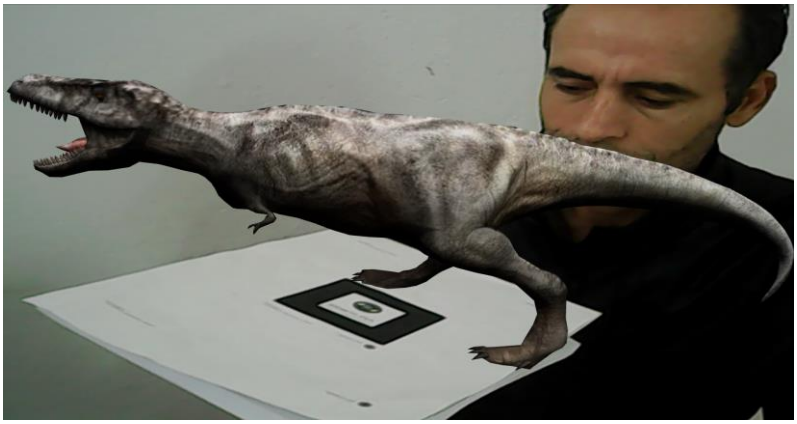

Figure 12: How to control the eye movement of students with PDD.

In order to explore the behaviors of students with pervasive developmental disorder within a virtual environment and their adherence to social conventions, [35] developed a virtual reality model where subjects had to complete a journey to go inside a café and place an order. Students with PDD had less adapted social behaviors, such as moving on the grass and flowers instead of using the sidewalks compared to non-PDD subjects. A certain number of the latter (5 out of 12 students) had behaviors unrelated to the tasks, such as moving around the café or on individuals. It therefore appears that more PDD students would benefit from this modality than others. On the other hand, the study made it possible to prove that students had difficulty adhering to social conventions in the virtual model. [36] used virtual reality to measure the memory of faces and objects in PDD students compared to non-PDD students . The work consisted of memorizing a series of faces and objects revealed virtually with a video headset (Figure.13). Afterwards, they were shown a series of faces and objects and they had to indicate yes or no.

The results show that students with a pervasive developmental disorder would be better than those without PDD at recognizing objects, while the latter would be better at remembering faces. This assessment therefore reflects what is established in scientific literature: PDDs would memorize faces less well.

Finally, virtual reality is used in the context of assessment or verification with students with a pervasive developmental disorder because of the scientific strengths that allow us to produce faces or situations that reflect the real world again. In addition, it would be able to promote the attention of PDD students .

The results of the research cited above are consistent with what we find in scientific analyses on the PDD side. Virtual reality actions have the authorization to prove in this population an unfortunate visual contact, a weakened social decision, a lack of adherence to social conventions and a complexity in memorizing faces. Virtual reality would then prove to be a relevant assessment and verification tool with students with PDD because it offers the possibility of objectively controlling the behaviors related to this diagnosis.

On our part, the realization of faces using augmented reality will be more effective since the students with PDD can dialogue with virtual objects in a real world.

Figure 13: Memory for faces and objects in students with PDD compared to students without PDD.
Études N°1 ayant utilisé la RV comme moyen d'évaluation auprès des personnes présentant un PDD

Authors	Skills assessed	Number of subjects	Interface used	results
Greffou 2012	Perceptual functioning	08 PDD	Immersion with head-mounted display	Reproduction of the effect with other instruments that return a two-dimensional image
Grynszpan2011	Eye contact	13 PDD	Virtual environment on a laptop	Poor eye contact
Parsons2005	Adherence to social conventions	12 PDD	Virtual environment on a laptop	Less appropriate social behaviors in PDDs
Rajendran2011	Executive functions	18 PDD	Virtual environment on a laptop	Rigidity Impulsivity and difficulties with prospective memory
Stipanicic et Nolin2012	Attention and impulsivity	12 PDD	Immersion with head-mounted display	Impulsivity in PDDs
Trepagnier2002	Memorization of faces and objects	05 PDD	Immersion with head-mounted display	-Memorization of objects -Memorization of faces

Table 01: VR as a means of assessment for people with PDD

Studies #2 using AR as a means of assessment with people with PDD.

Authors	Skills assessed	Number of subjects	Interface used	results
Adel fridhi et.al	Perceptual functioning	01 PDD	-Projection of a 3D model (Virtual environment). -Projection of a 3D model (Avatar)	Reproduction of the effect with other instruments that return a two-dimensional image
Adel fridhi et.al	Eye contact	01 PDD	Virtual environment on a laptop	Poor eye contact
			-Virtual environment with projection -Avatar with projection	Perfect eye contact
Adel fridhi et.al	social conventions	01 PDD	Virtual environment on a laptop	Less appropriate social behaviors in PDDs
			-Virtual environment with projection -Avatar with projection	Appropriate social behaviors in PDDs
Adel fridhi et.al	Attention and impulsivity	01 PDD	Immersion with head-mounted display	Impulsivity in PDDs
Adel fridhi et.al	Memorization of faces and objects	01 PDD	Immersion with head-mounted display	-Memorization of objects and faces

Table 02: RA as a means of assessment for people with PDD.

6. Conclusion

The clinical reasoning for the use of VR/AR in psychotherapy is now well established, even though all research is occasionally limited to feasibility studies or preparation trials. Because the VR systems (hardware and software) and the methods of the various operating groups are not standardized, there are few controlled trials that present compelling results on the clinical performance of the approach. The Research Laboratory on Disability and Social Unsuitability's (LDSU-ISES) research project was born out of this sentiment. Therefore, it is anticipated that virtual and augmented reality technologies will become more significant in the development of novel diagnostic, treatment, and support tools for students with PDDs (ASDs in particular), which has become a public concern.

References

[1] Taghian, A., Abo-Zahhad, M., Sayed, M. S., & Abd El-Malek, A. H. (2023). Virtual and augmented reality in biomedical engineering. Biomedical engineering online, 22(1), 76.

[2] Jiang, J., Zhang, J., Sun, J., Wu, D., & Xu, S. (2023). User's image perception improved strategy and application of augmented reality systems in smart medical care: A review. The International Journal of Medical Robotics and Computer Assisted Surgery, 19(3), e2497.

[3] Urlings, J., de Jong, G., Maal, T., & Henssen, D. (2023). Views on Augmented Reality, Virtual Reality, and 3D Printing in Modern Medicine and Education: A Qualitative Exploration of Expert Opinion. Journal of Digital Imaging, 36(4), 1930-1939.

[4] Lastrucci, A., Wandael, Y., Barra, A., Ricci, R., Maccioni, G., Pirrera, A., & Giansanti, D. (2024). Exploring Augmented Reality Integration in Diagnostic Imaging: Myth or Reality?. Diagnostics, 14(13), 1333.

[5] HARRATH, Z., & BOUAJILA, A. (2021). Impact of PROSIT on learning immunology in Tunisia. Transylvanian Review, 29(2).

[6] Harrath, Z., Bouajila, A., & Fridhi, A. (2023). Artificial Reality and Science Learning. Computer Science, 18(4), 697-705.

[7] De Jesus Encarnacion Ramirez, M., Chmutin, G., Nurmukhametov, R., Soto, G. R., Kannan, S., Piavchenko, G., ... & Montemurro, N. (2024). Integrating augmented reality in spine surgery: redefining precision with new technologies. Brain Sciences, 14(7), 645.

[8] Toshmurodovich, K. Z. (2024). ADVANCING MEDICAL EDUCATION THROUGH TECHNOLOGY INTEGRATION: A COMPREHENSIVE ANALYSIS OF VIRTUAL REALITY, AUGMENTED REALITY, AND ARTIFICIAL INTELLIGENCE INTEGRATION. ОБРАЗОВАНИЕ НАУКА И ИННОВАЦИОННЫЕ ИДЕИ В МИРЕ, 46(12), 153-158.

[9] Fridhi, A., & Bali, N. (2021). Science Education and Augmented Reality: Interaction of students with Avatars Modeled in Augmented Reality. International Journal of Environmental Science, 6.

[10] Fridhi, A., & Frihida, A. (2019). GIS 3D and science of augmented reality: modeling a 3D geospatial environment. Journal of Soft Computing in Civil Engineering, 3(4), 78-87.

[11] Fridhi, A., Faouzi, B., & Hamid, A. (2017). DATA ADJUSTMENT OF THE GEOGRAPHIC INFORMATION SYSTEM, GPS AND IMAGE TO CONSTRUCT A VIRTUAL REALITY. Geographia Technica, 12(1).

[12] Fridhi, A., Benzarti, F., & Amiri, H. (2019). Planimetric Error and geolocation of a Virtual Reality. Transylvanian Review, 24(05).

[13] Fridhi, A., Benzarti, F., Frihida, A., & Amiri, H. (2018). Application of virtual reality and augmented reality in psychiatry and neuropsychology, in particular in the case of autistic spectrum disorder (ASD). Neurophysiology, 50(3), 222-228.

[14] Fridhi, A., Bali, N., Rebai, N., & Kouki, R. (2020). Geospatial virtual/augmented environment: applications for students with

pervasive developmental disorders. Neurophysiology, 52(3), 239-246.
[15] Fridhi, A., & Bali, N. (2022). Augmented Reality in Sports Education and Training for Students with an Autism Spectrum Disorder. Neurophysiology, 54(1), 73-79.
[16] Fridhi, A., & Bali, N. (2021). Science Education and Augmented Reality: Interaction of students with Avatars Modeled in Augmented Reality. International Journal of Environmental Science, 6.
[17] Bali, N., Fridhi, A., & Hassen, Z. (2022). Coronavirus: introduction of the application of augmented reality to help students with disorders to overcome the phobia of contamination facing an indefinite end of the pandemic. Romanian Journal of Neurology, 21(2).
[18] Bali, N., & Fridhi, A. (2023). Impact of augmented reality on sports performance of disabled. Romanian Journal of Rheumatology/Revista Romana de Reumatologie, 32(1).
[19] Bali, N., & Fridhi, A. (2024). Learning of surface and volume formulas by augmented reality: experimental studies. International Journal of Mathematics & Computer Science, 19(3).
[20] Fridhi, A., Laribi, R., & Bali, N. N. (2023). 3D Modeling and Augmented Reality for Learning. Computational Engineering and Physical Modeling, 6(3), 52-61.
[21] Laribi, R., Fridhi, A., & Rebai, N. (2021). The impact of augmented reality in improving non-verbal communication in students and young adults with autism spectrum disorder (ASD). International Journal of Education and Learning Systems, 6.
[22] Bouajila, AHMED., Jebahi, ASMA., Fridhi, ADEL., & Bouraoui, RAHMA (2023). The Role of Educational Media in Motivation to Learn: Digital Media as a Model. The International Journal of Engineering and Science, 06(2023), N°06, 65-71
[23] Fridhi, A., Laribi, R., Rahim, K., Naila, B. The Use of Virtual Reality to Promote Communication and Recognition of Emotions in Students with Pervasive Developmental Disorders (PDDs). Global Journal of Intellectual & Developmental Disabilities, Volume 13, Issue 2, February, 2024.
[24] Fridhi, A,. Naila, B. Augmented Environment: Learning Through Augmented Reality for Students with Pervasive Developmental Disorders. Global Journal of Intellectual & Developmental Disabilities, Volume 13, Issue2, February, 2024,
[25] Laribi, R,. Fridhi, A., Rahim, K., Naila, B. Impact of Augmented Reality on Student Motivation in the Context of an Immunity Course. Global Journal of Intellectual & Developmental Disabilities, Volume 13, Issue2, February, 2024,
[26] LARIB, R., FRIDHI, A., & Naila, B. A. L. I. (2024). Augmented Reality: Interaction of students with Avatars. Transylvanian Review, 32(2).
[27] LARIB, R., FRIDHI, A., & Naila, B. A. L. I. (2024). Augmented Reality: Interaction of students with Avatars. Transylvanian Review, 32(2).
[28] Fridhi, A., Benzarti, F., Frihida, A., & Amiri, H. (2018). Application of virtual reality and augmented reality in psychiatry and neuropsychology, in particular in the case of autistic spectrum disorder (ASD). Neurophysiology, 50(3), 222-228.
[29] Alves, C., Reis, J. L., dos Santos, J. P. M., Gomes, L. M., & Machado, J. (2024). Future Perspectives in Healthcare: An Analysis of Augmented Reality and Spatial Computing in Hospital Environments. Procedia Computer Science, 238, 932-937.
[30] Daineko, Y., Ipalakova, M., Tsoy, D., Alipova, B., Kozhakhmetov, A., & Mustafina, A. (2024). Towards Metahospital: augmented and virtual reality in medicine. Procedia Computer Science, 231, 373-378.
[31] Machuca-Contreras, F., Lepez, C. O., & Canova-Barrios, C. (2024). Influence of virtual reality and augmented reality on mental health. Gamification and Augmented Reality, 2, 25-25.
[32] Escalada-Hernandez, P., Soto-Ruiz, N., Ballesteros-Egüés, T., Larrayoz-Jiménez, A., & Martín-Rodríguez, L. S. (2024). Usability and user expectations of a HoloLens-based augmented reality application for learning clinical technical skills. Virtual Reality, 28(2), 1-10.
[33] García-Robles, P., Cortés-Pérez, I., Nieto-Escámez, F. A., García-López, H., Obrero-Gaitán, E., & Osuna-Pérez, M. C. (2024). Immersive virtual reality and augmented reality in anatomy education: a systematic review and Meta-Analysis. Anatomical Sciences Education, 17(3), 514-528.
[34] Yadav, V. Use of Augmented Reality for Surgical Training: Studying the Effectiveness and Potential of Augmented Reality Tools in Training Surgeons. J Artif Intell Mach Learn & Data Sci 2024, 2(2), 927-932.
[35] Laribi, R., Fridhi, A., & Rebai, N. (2021). The impact of augmented reality in improving non-verbal communication in students and young adults with autism spectrum disorder (ASD). International Journal of Education and Learning Systems, 6.
[36] Parekh, P., Patel, S., Patel, N., & Shah, M. (2020). Systematic review and meta-analysis of augmented reality in medicine, retail, and games. Visual computing for industry, biomedicine, and art, 3, 1-20.