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VR-ASD Play: Therapeutic Games for Autism Spectrum Disorder

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by :

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Dedication

الحمد لله رب العالمين، الرحمن الرحيم، الذي بفضله تتم الصالحات.

أولاً وقبل كل شيء، أتوجه بأعمق مشاعر الامتنان والتقدير لمشرفي الأستاذ الدكتور محمد شوقي باباحنيني، الذي كان مرشداً ومعلماً استثنائياً خلال رحلتي البحثية. بفضل توجيهاته الحكيمة، وملاحظاته الثاقبة، وعلمه الواسع، وصبره الذي لا ينضب، تمكنت من إكمال هذا العمل. كان دعمه المتواصل ونصائحه القيمة بمثابة المنارة التي أضاءت طريقي في أصعب اللحظات.

ثانياً، أتوجه بأخلص عبارات الشكر والعرفان لوالدتي الحبيبة ووالدي العزيز، اللذين ضحيا بكل غالٍ ونفيس من أجلي، وكانا خير سند وعون طوال مسيرتي التعليمية. كما أخص بالشكر إخوتي وليد وزاكي، وأخواتي العزيزات أمينة وهاجر، على دعمهم المعنوي المستمر. ولا أنسى أن أذكر أبناءهم الأعزاء ليليا وجنة وعبد الجليل، الذين كانوا مصدر بهجة وسعادة في حياتي.

ثالثاً، أتقدم بجزيل الشكر لأعضاء لجنة المناقشة الأفاضل على قبولهم تقييم هذا العمل والمشاركة في مناقشته.

Abstract

Autism spectrum disorder (ASD) is a complex neurological condition affecting children's behavior, communication, and social interaction. Early intervention is essential for improving outcomes, yet access to adequate treatment remains limited in countries like Algeria. This thesis explores how virtual reality (VR) can offer new therapeutic tools through the development of a serious game tailored for children with autism.

The game provides interactive scenes designed to enhance emotional recognition, communication, and focus, while adapting to the child's level of severity. Developed using Unity and Meta XR, the project combines educational and therapeutic goals, with its effectiveness evaluated through user engagement and developmental indicators. The thesis includes a literature review, methodology, game design process, and experimental findings aimed at supporting future tools for autism therapy.

ملخص

اضطراب طيف التوحد هو حالة عصبية معقدة تؤثر على سلوك الأطفال وتواصلهم وتفاعلهم الاجتماعي. يُعد التدخل المبكر أمرًا ضروريًا لتحسين النتائج، إلا أن الوصول إلى العلاج المناسب لا يزال محدودًا في بلدان مثل الجزائر. تستكشف هذه المذكرة كيف يمكن لتقنيات الواقع الافتراضي أن تقدم أدوات علاجية جديدة من خلال تطوير لعبة هادفة مصممة خصيصًا للأطفال المصابين بالتوحد. توفر اللعبة مشاهد تفاعلية تهدف إلى تعزيز التعرف على المشاعر، والتواصل، والتركيز، مع القدرة على التكيف مع مستوى شدة التوحد لدى ، ويجمع بين الأهداف التعليمية Meta XR وتقنيات Unity الطفل. تم تطوير المشروع باستخدام محرك والعلاجية، حيث يتم تقييم فعاليته من خلال تفاعل المستخدم والمؤشرات التنموية. تتضمن المذكرة مراجعة أدبية، ومنهجية العمل، وعملية تصميم اللعبة، ونتائج التجربة التي تهدف إلى دعم تطوير أدوات علاجية مستقبلية للأطفال المصابين بالتوحد

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Introduction

As one of the most prevalent developmental diseases in young children in recent years, autism spectrum disorder (ASD) has caused anxiety among families, educators, and medical professionals around the world.

Autism is a multifaceted neurological condition that impacts behavior, social interaction, and communication.

According to research, one of the most important elements in lowering autism symptoms and enhancing children's developmental outcomes is early intervention. However, conventional approaches to autism treatment are frequently insufficient, particularly in poorer nations like Algeria where access to specialized resources is still restricted.

The development of novel educational and therapeutic tools to address the difficulties experienced by children with autism has become possible due to technological breakthroughs, particularly in the area of virtual reality (VR).

Children can engage with an immersive virtual world in a secure and regulated setting with VR technologies, which can enhance their social and cognitive development.

The purpose of this project is to create a serious game in a virtual reality setting that is especially targeted at young autistic children. Through interactive scenes that promote communication, emotional identification, focus, and social involvement, the game aims to lessen the symptoms of autism.

The game is made to adjust to the child's level of autism (mild, moderate, or severe), giving them a customized experience that suits their particular requirements.

To accomplish these goals, the research aims to respond to the following queries:

1. How can a serious game based on virtual reality contribute to early intervention in the treatment of autism in children?

2. What design patterns and techniques are most effective in enhancing the emotional and social development of children with autism?

An applied method has been used to treat these issues, using tools like Unity and Meta XR to create interactive gaming environments that target autism characteristics like emotional recognition, tone of voice comprehension, and enhanced motor coordination and focus.

Educational indicators, the game's simplicity of use, and its therapeutic effects will all be used to assess how effective this experience is.

There are four major chapters in this thesis. The study's theoretical framework is presented in Chapter One, which also includes a literature analysis and definitions of important terms pertaining to autism, serious games, and VR treatment applications.

The study's methodology is described in Chapter Two, which also examines the methods employed in game design and provides a summary of technical terms. The creation and design of the game's content are covered in Chapter 3.

The experiment's findings, data analysis, and suggestions that might aid in the future creation of therapeutic resources for autistic children are finally presented in Chapter 4.

Chapter 1

Autism Spectrum Disorder: Overview and Situation in Algeria

1 Definition and Characteristics of Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that affects how individuals perceive and interact with others, leading to persistent difficulties in communication and social interaction. It is also associated with restricted, repetitive patterns of behavior, interests, or activities.

The term "spectrum" reflects the wide range of symptoms, skills, and levels of impairment that individuals with ASD may experience. According to the DSM-5 classification, autism spectrum disorder encompasses several conditions that were previously diagnosed separately, including autistic disorder, Aspergers syndrome, childhood disintegrative disorder, and pervasive developmental disorder not otherwise specified [1].

Although the term Aspergers syndrome is no longer used in official diagnostic manuals, it is still commonly used by some individuals to describe milder forms of autism.

ASD typically appears during early childhood and can affect social, academic, and occupational functioning. Most children show signs of autism in the first year of life, such as lack of eye contact or limited social engagement. However, a small proportion of children may initially appear to develop typically before experiencing a period of regression between 18 and 24 months, after which symptoms become more apparent [2].

While there is no known cure for ASD, evidence shows that early and intensive behavioral intervention can significantly improve developmental outcomes in many children [3].

2 Symptoms of Autism Spectrum Disorder

Children with Autism Spectrum Disorder (ASD) may begin to show symptoms as early as infancy. These can include reduced eye contact, limited responsiveness to their name, or diminished interest in caregivers. In some cases, children may appear to develop typically during the first months or years of life, only to later regresslosing previously acquired language skills or becoming withdrawn or irritable [4].

Symptoms typically become noticeable by the age of two, although the presentation varies greatly from one child to another. The spectrum nature of the disorder means that children may range from low- to high-functioning, with differing patterns and severity of behavior.

While some children with ASD show signs of intellectual disability or delayed cognitive development, others may demonstrate normal or even high intelligence. However, even children with strong intellectual abilities may have difficulty with communication, applying their knowledge in real-life situations, or adapting to social environments.

Determining the severity of ASD can be challenging, as it depends on the combination of symptoms and how significantly they interfere with daily functioning. Clinicians generally assess severity based on the level of impairments in social communication and the presence of restricted or repetitive behaviors. [4].

3 Classification of Autism Spectrum Disorder

The classification of Autism Spectrum Disorder (ASD) has evolved significantly over time. The condition was first formally included in the *Diagnostic and Statistical Manual of Mental Disorders*, Third Edition (DSM-III), published by the American Psychiatric Association in 1980 [5]. Shortly thereafter, the World Health Organization recognized autism in its *International Classification of Diseases*, Tenth Edition (ICD-10) in 1992 [6].

In France, autism was initially categorized as a form of infantile psychosis in the *Classification Française des Troubles Mentaux de lEnfant et de lAdolescent* (CFTMEA) in 1993. However, in the revised edition of 2000, the CFTMEA moved closer to international standards by reclassifying autism as a developmental disorder [7].

What was previously understood as a group of pervasive developmental disorders (PDDs) often mistakenly viewed as psychiatric or behavioral in origin is now widely accepted as a set of neurodevelopmental conditions. These are influenced by complex genetic predispositions, in combination with neurological and environmental factors [8].

As a result, autism spectrum disorder is now viewed not as a mental illness, but as a lifelong developmental disability that requires continuous, specialized support from early childhood.

4 Autism Situation in Algeria

Little is known about autism in Algeria, and due to the limited number of specialized facilities, access to care for children with Autism Spectrum Disorder (ASD) remains difficult. Another major challenge is the shortage of professionals and caregivers trained in autism who can provide consistent support for autistic children in educational and social environments.

However, in recent years, there has been a growing awareness of the importance of inclusive education and the role of specialized autism centers. Some schools have started to implement dedicated classrooms for children with autism, supported by non-governmental organizations and compassionate individuals.[9]

To better understand the demographic distribution of autistic children in Algeria, Table 1.1 shows data collected during the 2018–2019 period. The statistics represent the percentage of diagnosed autistic children by age group, highlighting the predominance of younger age categories in the available records.

Age Group	**Percentage**
03 to 05 years	15.70%
06 to 10 years	62.81%
11 to 14 years	17.52%
15 to 18 years	3.98%

Table 1.1: Distribution of autistic children in Algeria (2018–2019)

As shown in the table, the majority of autistic children in Algeria are between the ages of 6 and 10. This reflects the critical need for early screening, intervention programs, and specialized educational environments targeted at younger children. The relatively low percentage in the 15–18 age group may indicate underdiagnosis or limited access to care for older children.

5 Education of Autistic Children in Algeria

According to official governmental sources, the rights of children and persons with disabilities, including the right to education, are protected under Algerian law. In its 2015 report to the United Nations, Algeria emphasized the importance of ensuring equitable opportunities for children with disabilities in accessing education [10].

The country has implemented procedures to educate children based on the type and severity of their disabilities. These include integration into mainstream public schools via inclusive classrooms, particularly for children with hearing or visual impairments, as established by an interministerial decree in 1998 [11]. Additionally, specialized institutions under the Ministry of National Solidarity serve children with more specific needs.

Several national laws underpin the inclusive education framework:

- Law 02-09 (2002), which promotes the protection and education of youth with disabilities [12].
- Law 08-04 (2008), which guarantees education for all Algerians and extends mandatory schooling by two years for students with disabilities [13].
- Presidential Decree 09-188 (2009), which ratified the UN Convention on the Rights of Persons with Disabilities, reinforcing inclusive education and lifelong learning principles [14].

However, autism is not explicitly referenced in these foundational texts, which mostly address sensory disabilities. Autism, by contrast, requires more individualized strategies, such as specially trained teachers, early diagnosis, and tailored learning plans. Many parents report difficulties due to a lack of early diagnostic services and limited access to autism-specific education programs.

In 2014, a regulation authorized the creation of special education classrooms for children with moderate intellectual, visual, or hearing impairments [15]. The first formal recognition of Autism Spectrum Disorder (ASD) in Algerian education policy came with Interministerial Circular No. 1 in 2019 [16]. This document introduced the role of *School Life Assistants* (SLAs), who support students in classrooms, daily activities, and communication with families. Their collaboration with school staff is essential to ensure successful integration of students with special needs, including those with moderate autism.

Although the 2019 circular marked an important milestone, it lacks detailed accommodations for autistic children, particularly in relation to standardized national exams. Thus, further legislative developments are required to provide comprehensive educational support tailored to the needs of autistic students.

6 Characteristics of Children with Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) typically manifests during early childhood and presents a wide range of developmental challenges. The condition varies greatly in expression and severity across individuals, which makes each case of autism unique [2].

Common features of ASD include difficulties in communication and social interaction. Children with autism may also exhibit repetitive behaviors, restricted and fixated interests, and heightened sensitivity to sensory stimuli such as sounds, textures, or smells [4].

One of the most notable characteristics of ASD is the variability in how symptoms appear and how severe they are. While some children may be non-verbal and show significant delays in development, others may possess average or above-average intelligence but still struggle with social communication.

Early diagnosis and intervention are critical. Although ASD has no known cure, timely support and therapy can substantially improve outcomes. Recognizing the early traits of autism is essential for understanding how this neurodevelopmental condition affects a child's development and for providing individualized care [3].

The *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), developed by the American Psychiatric Association, outlines three primary diagnostic characteristics of ASD [1]:

- **Delayed or absent speech and gestures**: Children with ASD may show delays in language development or may not develop spoken language at all.
- **Deficits in social communication**: This includes challenges in emotional reciprocity, difficulty initiating or maintaining social interactions, and a lack of spontaneous sharing or social interest.
- **Repetitive behaviors (stereotypy)**: These can include repetitive motor movements or speech, insistence on sameness, and fixated interests.

Although each childs profile is different, ASD symptoms typically emerge between the ages of one and three years. Early identification allows for timely evaluation and intervention, which are essential for long-term developmental support.

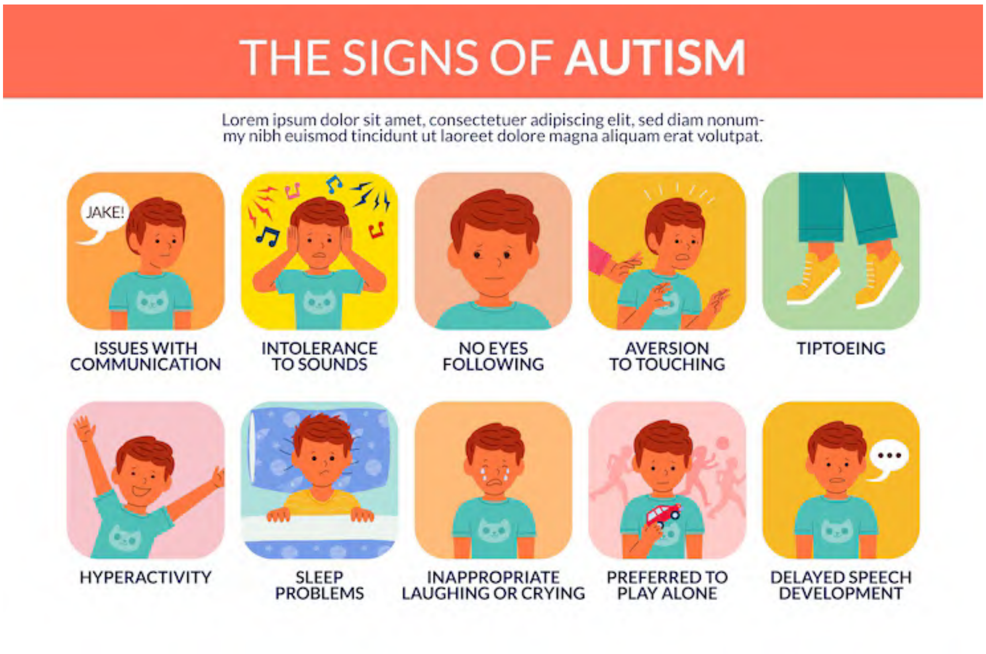

Figure 1.1: Characteristics of Children with Autism[17]

6.1 Early Signs and Clinical Indicators of Autism

Identifying autism at an early stage is essential for timely intervention and improved developmental outcomes. Research and clinical guidelines have identified a set of behavioral signs that may indicate the presence of Autism Spectrum Disorder (ASD) during infancy and early childhood. These early indicators vary across age groups and may appear gradually or suddenly, including developmental regression.

Table 1.2 summarizes the key clinical signs of ASD risk based on the child's age in months. This table can assist parents, educators, and healthcare professionals in recognizing potential red flags that require further evaluation by specialists.

Age (months)	**Clinical Presentation**
06–12	• Reduced or limited smiles or other joyful expressions directed at people • Limited or no eye contact • Limited reciprocal sharing of sounds, smiles, or facial expressions • Diminished, atypical, or no babbling or gesturing (e.g., pointing, reaching, waving 'bye bye') • Limited response to name when called
09–12	• Emerging repetitive behaviors (e.g., spinning or lining up objects) • Unusual play (e.g., intense visual or tactile exploration of toys)
12–18	• No single words • Absence of compensatory gestures (such as pointing) • Lack of pretend play • Limited joint attention (initiating, responding, sharing of interests)
15–24	• Diminished, atypical, or no spontaneous or meaningful two-word phrases
Any age	• Parental and other caregiver concerns about the possibility of ASD • Developmental regression (loss of skills): reduced frequency or loss of social behaviors (e.g., directing eye gaze to others) and communication (words and gestures) relative to earlier age

Table 1.2: Early warning signs in children at risk for ASD

As seen in Table 1.2, early symptoms of autism can be identified as early as 6 months of age. These include lack of eye contact, poor social reciprocity, and delayed communication behaviors. Recognizing these signs is crucial, as early diagnosis allows for early intervention, which significantly improves outcomes in social, emotional, and cognitive development.

7 Intervention and Treatment Strategies for Autism Spectrum Disorder

A variety of intervention and treatment strategies are available to support individuals with Autism Spectrum Disorder (ASD). These approaches generally fall into several categories: behavioral, developmental, educational, social-relational, pharmacological, psychological, and complementary or alternative methods [18].

7.1 Behavioral Approaches

Behavioral therapies are among the most widely researched and evidence-based treatments for ASD. These approaches focus on analyzing behaviors by observing what precedes and follows them. They are used extensively in schools, clinics, and therapeutic settings and are endorsed by medical professionals and educators alike.

One of the most prominent behavioral therapies is **Applied Behavior Analysis (ABA)**, which aims to improve specific behaviorssuch as social skills, communication, reading, and academicsas well as adaptive learning skills like fine motor dexterity, hygiene, and punctuality. ABA techniques promote desired behaviors while reducing harmful or disruptive ones, with progress tracked through structured measurement [19].

Two common instructional methods within ABA include:

- **Discrete Trial Training (DTT)**: This technique breaks down skills into small, teachable components. The trainer gives a clear instruction, prompts the correct behavior, and rewards the desired response. Incorrect responses are ignored or corrected without punishment.

- **Pivotal Response Training (PRT)**: Unlike DTT, PRT takes place in more naturalistic settings. It targets "pivotal" developmental areas such as motivation, response to multiple cues, self-management, and initiation of social interactions. Improving these skills can lead to broader developmental gains. For example, teaching a child how to initiate conversations can significantly expand social engagement [20].

7.2 Developmental Approaches

Developmental approaches aim to enhance specific skillssuch as language or motor abilitiesor broader interrelated developmental domains. These methods are often combined with behavioral strategies to provide a more holistic intervention [21].

One of the most common developmental therapies for individuals with Autism Spectrum Disorder (ASD) is **speech and language therapy**. This intervention helps individuals improve both their understanding and use of spoken language. While some people with ASD may develop verbal communication, others rely on alternative communication methods such as electronic devices, pictures, signs, or gestures [22].

Occupational therapy is another key developmental intervention. It aims to help individuals achieve maximum independence in daily life activities such as dressing, eating, bathing, and engaging in social interactions. Occupational therapy may also include:

- **Sensory integration therapy**, which helps individuals regulate responses to sensory input that might otherwise be overwhelming or restrictive.
- **Physical therapy**, which supports the development of gross and fine motor skillssuch as hand movements, posture, or body coordination.

An evidence-based developmental model known as the **Early Start Denver Model (ESDM)** integrates principles from Applied Behavior Analysis (ABA) with developmental techniques. It targets children between 12 and 48 months of age. In ESDM, therapists and parents use play-based and socially engaging routines to improve language, cognitive, and social skills in naturalistic settings [23].

7.3 Educational Approaches

Educational interventions for children with Autism Spectrum Disorder (ASD) are typically delivered within classroom settings. One of the most well-established educational models is the **Treatment and Education of Autistic and Related Communication-Handicapped Children (TEACCH)** program.

The TEACCH approach is grounded in the understanding that individuals with autism often benefit from visual learning strategies and structured environments. It provides educators with tools to organize the classroom in ways that enhance both academic performance and behavioral outcomes [24].

Key features of the TEACCH method include:

- Clearly displayed written or pictorial daily schedules.
- Well-defined physical boundaries around different activity or learning stations.
- Use of visual supports and physical demonstrations alongside verbal instructions.

These adaptations help create a predictable and structured learning environment that supports the unique needs of students with ASD, promoting both engagement and independence in learning activities.

7.4 General Developmental Assessment Tools

While autism-specific screening tools are essential, many developmental assessment instruments cover a broader range of developmental milestones. These tools help identify delays in cognitive, motor, social-emotional, and language development, and can serve as early indicators for potential developmental disorders, including Autism Spectrum Disorder (ASD).

Table 1.3 summarizes commonly used general developmental screening tools. These assessments vary in terms of target age, duration, and diagnostic performance, and are often used in both clinical and educational settings.

Screening Tool	Age Range	Completion Time	Test Performance	Test Sample	Comments
Ages and Stages Questionnaires (ASQ-3)	1 mo. – 5.5 yr	10–15 min	Se: 70–90% Sp: 76–91%	Diverse ethnic and socioeconomic groups	Assesses motor skills, language, social-emotional, and adaptive development
Child Development Inventory (CDI)	15 mo. – 6 yr	30–40 min	Se: 80–100% Sp: 94–96%	Mainly White, working-class families	300 items: Evaluates 8 developmental domains including cognition and language
Brief Early Childhood Screening Assessment (ECSA)	18–60 mo.	1–5 min	Se: 89% Sp: 85%	Primary care population	22 items: Screens emotional and behavioral development; Free tool
Nipissing District Developmental Screen	1 mo. – 6 yr	5 min	Se: 29–68% Sp: 58–88%	High-risk referrals	Covers 13 developmental domains; Common in Ontario; Free in region
Parents' Evaluation of Developmental Status (PEDS)	Birth – 8 yr	2–10 min	Se: 91–97% Sp: 73–86%	Diverse populations	Covers language, motor, behavioral, social-emotional and cognitive areas

Table 1.3: General developmental assessment tools

As shown in Table 1.3, tools such as ASQ-3 and PEDS are widely used for general developmental monitoring due to their quick administration and broad age coverage. Although these tools are not autism-specific, they can identify red flags that warrant further ASD-focused evaluation. Instruments like CDI provide more in-depth assessment but require longer completion time. Choosing the right tool depends on the clinical context, time availability, and the childs age.

7.5 Screening Tools for Early Detection of Autism

Early and accurate screening plays a crucial role in identifying children with Autism Spectrum Disorder (ASD), especially during critical developmental stages. Several standardized tools have been developed to help clinicians, therapists, and researchers assess early signs of ASD. These tools differ in terms of target age, duration, accuracy, and the domains of behavior they evaluate.

Table 1.4 provides a comparative summary of commonly used autism screening instruments, highlighting key aspects such as age range, time to complete, diagnostic performance (sensitivity, specificity, predictive values), and a brief description of each tool.

Screening Tool	**Age Range**	**Time**	**Test Performance**	**Sample**	**Description**
Modified Checklist for Autism in Toddlers, Revised with Follow-up (M-CHAT-R/F)	16–30 mo.	5–10 min	Se: 85% Sp: 91–99% PPV: 48% (ASD), 95% (DD)	Toddlers at 1824 month well visits	20-item checklist + follow-up interview. Evaluates early social communication. Free.
Infant Toddler Checklist (ITC)	8–24 mo.	5–10 min	Se: 93% Sp: 83% PPV: 71–79% NPV: 88–99%	924 mo. general population	24 items: Assesses gestures, eye contact, expressions, vocalizations. No cost.
Social Responsiveness Scale 2nd ed. Preschool (SRS-2-Preschool)	2.5–4.5 yr	15–20 min	Se: 75–78% Sp: 67–96%	442 children with and without ASD	65 items: Measures social awareness, communication, anxiety, and autistic traits.
Autism Spectrum Rating Scales (ASRS)	2–15 yr	5–20 min	Se: 92% Sp: 89% PPV: 91% NPV: 89%	2,560 children (normative sample)	70 items: Measures social and communication behavior, self-regulation. Short form available.
Screening Tool for Autism in Two-Year-Olds (STAT)	24–36 mo.	20 min	Se: 92–95% Sp: 73–85% PPV: 56% NPV: 97%	Children at risk or with older sibling with ASD	12 play-based tasks to evaluate communication and social interaction.
Rapid Interactive Screening Test for Autism in Toddlers (RIST-A)	18–36 mo.	10 min	Se: 100% Sp: 84% PPV: 88%	61 toddlers from early clinic settings	Differentiates ASD from other developmental delays (DD). Interactive and quick.

Table 1.4: Commonly used autism screening tools

As seen in Table 1.4, the Modified Checklist for Autism in Toddlers (M-CHAT-R/F) and the Infant Toddler Checklist (ITC) are widely used for early detection due to their short completion time and free availability. While tools like the SRS-2 and ASRS provide broader behavioral assessments, others like STAT and RIST-A offer structured interactive observations. Choosing the appropriate tool depends on the childs age, the setting (clinic, home, school), and the available time and resources.

7.6 Social-relational approaches

Social-relational treatments focus on improving social skills and building emotional bonds. Some social relational approaches involve parents or peer mentors.

- The Developmental, Individual Differences, Relationship-Based model (also called DIR or "Floor Time") encourages parents and therapists to follow the interests of the individual to expand opportunities for communication.
- The Relationship Development Intervention (RDI) model involves activities that increase motivation, interest, and abilities to participate in shared social interactions.
- Social Stories provide simple descriptions of what to expect in a social situation.
- Social skills groups allow people with ASD to practice social skills in a structured environment.[25]

Figure 1.2: Enhancing Social Skills in Autism Through ABA Therapy[26]

7.7 Pharmacological Approaches

Certain drugs assist persons with ASD function better by treating co-occurring symptoms, or those that occur alongside the disorder. Medication may be used to treat excessive energy, difficulty concentrating, or self harming behaviors like biting one's hand or pounding one's skull.

In addition to medical conditions such as seizures, sleep problems, or stomach or other gastrointestinal problems, medication can also assist in controlling co-occurring psychological conditions such as sadness or anxiety.

When it comes to medicine, it is crucial to collaborate with a physician who has experience treating individuals with ASD. This holds for both over the counter and prescription drugs. To ensure that there are no adverse drug side effects, patients, families, and physicians must collaborate to track responses and progress to ensure that the benefits do not outweigh the benefits [25]

7.8 Psychological approaches

People with ASD can manage their anxiety, depression, and other mental health conditions with the help of psychological techniques. One psychiatric strategy that emphasizes understanding the relationships between ideas, emotions, and behaviors is cognitive behavioral therapy (CBT). Together, the patient and the therapist set goals during cognitive behavioral therapy (CBT), after which the patient's perspective on a circumstance is altered to alter their response [25]

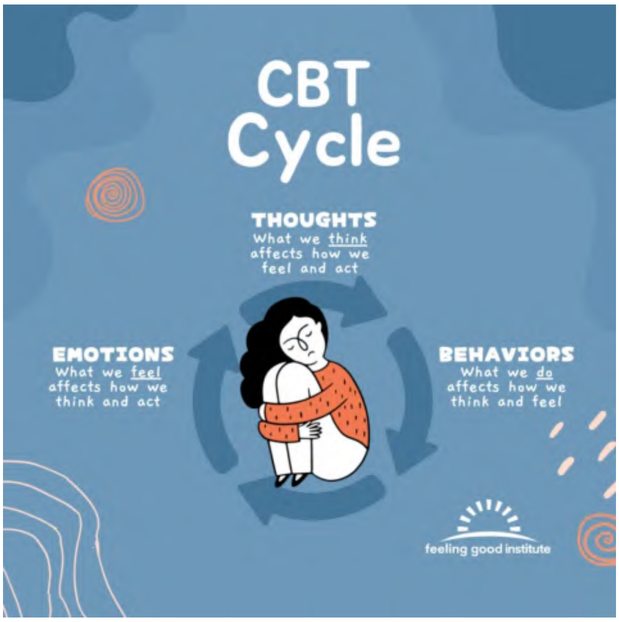

Figure 1.3: Cognitive Behavioral Therapy techniques[27]

7.9 Complementary and alternative treatments

Treatments that do not fall under any of the other categories. These therapies are referred to as alternative and complementary therapies.

More conventional methods are frequently supplemented with complementary and alternative therapies. Special diets, herbal supplements, chiropractic adjustments, animal therapy, art therapy, mindfulness and relaxation techniques are just a few examples. Before starting any complementary or alternative treatment, patients and their families should always see their physician [28]

8 Conclusion

The current status of autism spectrum disorder (ASD) care and policy in Algeria has been emphasized in this chapter. There are still significant gaps in early identification, educator training, and consistent intervention techniques, despite recent initiatives like the introduction of School Life Assistants (SLAs) and regulatory frameworks like Law 02-09 showing progress.

Important conclusions include the need for integrated behavioral and educational therapies, delayed identification of ASD, and restricted use of efficient screening instruments. Multimodal solutions that combine developmental models, ABA, and TEACCH-based educational approaches have been shown to improve outcomes.

Algeria must create laws specifically addressing ASD, increase professional training, introduce standardized testing, and invest in specialized learning environments if it hope to advance. To create a more effective and inclusive care system, greater focus must be placed on family support, technology-based interventions, and rural access.

Chapter 2

Virtual Reality Interventions for Autism Spectrum Disorder

0.1 Virtual Reality (VR)

Virtual Reality (VR) is a computer-generated simulation that uses visual and auditory stimuli to create immersive experiences, offering users the sensation of being present in an artificial environment. These virtual experiences can closely replicate real-world scenarios or introduce entirely fictional settings [29].

One of the key advantages of VR is its accessibility; it is not limited by geographical constraints, making it ideal for simulating naturalistic or therapeutic environments. VR has been especially useful in fields such as education, medicine, and therapy for neurodevelopmental disorders, including Autism Spectrum Disorder.

Two common VR systems include:

- **Head-Mounted Displays (HMDs)**: HMDs are wearable devices that contain built-in screens or projectors to visually isolate users from the external world. This isolation enhances immersion and allows for direct interaction and multisensory feedback. Popular consumer-grade HMDs include the Meta Quest and HTC Vive.
- **CAVE (Cave Automatic Virtual Environment)**: This system consists of multiple wall-sized screens or projections arranged around the user. Unlike HMDs, CAVE environments do not require a headset. Instead, they use motion-tracking sensors and stereoscopic 2D projections to simulate a 3D experience in a shared space.

Each of these systems provides varying degrees of immersion and interactivity, making them suitable for different research and therapeutic applications.

0.2 Virtual Reality Intervention to Improve Social Skills in ASD

Virtual Reality (VR) interventions grounded in occupational therapy have demonstrated promising results in enhancing social skills among individuals with Autism Spectrum Disorder (ASD). ASD is a neurodevelopmental disorder characterized by deficits in verbal and nonverbal communication, social interaction difficulties, and repetitive or restricted patterns of behavior.

Research indicates that VR environments can simulate real-world social situations in a safe and controlled manner, which helps individuals with ASD practice and develop social communication skills [30]. In particular, VR-based occupational therapy has been shown to improve peer interaction and overall engagement in social contexts.

For example, a study by Yang et al. (2018) involved children with ASD participating in a series of VR-based therapy sessions. The results revealed significant improvements in verbal and nonverbal communication, as well as increased initiation of peer interactions after the intervention [31]. Similarly, another investigation conducted by Lorenzo et al. (2016) showed that VR interventions led to enhanced social participation and reduced social anxiety in children with ASD [32].

These findings support the growing consensus that immersive VR, when designed with therapeutic goals, can serve as an effective tool for fostering social development in children with autism.

0.3 Theoretical Framework for Virtual Reality Therapy in Autism

An essential component of the theoretical foundation for virtual reality (VR) therapy in autism is the concept of social skills development. Children with Autism Spectrum Disorder (ASD) often face challenges in interpreting and responding to social cues, such as facial expressions, tone of voice, or body language. These difficulties can lead to heightened anxiety and reduced participation in social situations [33].

VR therapy offers a safe, controlled, and immersive environment where individuals can practice key social behaviorssuch as initiating conversations, recognizing facial expressions, and maintaining eye contactwithout the pressure or unpredictability of real-world interactions [34]. This structured and repetitive practice can help reinforce appropriate responses and build confidence in handling real-life social contexts.

This approach closely aligns with **Social Learning Theory**, which posits that individuals learn social behaviors through observation, imitation, and practice in relevant contexts [35]. VR provides the perfect medium for observational learning by allowing users to engage in and witness simulations of social interaction in a dynamic and feedback-rich setting.

Through repeated exposure to virtual social scenarios, individuals with autism can gradually improve their social competence and reduce anxiety levels, supporting long-term developmental goals.

0.4 Benefits of Virtual Reality Therapy for Children with Autism

Multiple studies have shown that Virtual Reality (VR) therapy offers significant benefits for children with Autism Spectrum Disorder (ASD). One of the primary advantages is the ability to fully customize the VR environment based on the individual needs and challenges of each child [36]. This personalization allows for targeted interventions that align with specific symptoms, preferences, and developmental levels.

Another major benefit is the high level of engagement observed in children with ASD during VR sessions. The interactive and game-like nature of VR makes therapeutic activities more enjoyable and motivating, which can enhance participation and lead to improved outcomes over time [37].

Moreover, VR provides a safe and controlled setting in which children can develop essential social and communication skills without the unpredictability or pressure of real-life environments. This helps reduce anxiety and facilitates gradual improvement in behaviors that are difficult to practice in traditional settings [38].

Overall, VR therapy presents a promising and flexible tool for supporting skill acquisition and emotional regulation in children with ASD, potentially improving their quality of life and social integration.

1 Challenges and Limitations of Virtual Reality Therapy

Virtual Reality (VR) therapy has demonstrated potential in reducing anxiety and enhancing social skills in children with Autism Spectrum Disorder (ASD). However, several challenges and limitations need to be considered for its broader application.

One significant limitation is the high cost associated with VR implementation. This includes expenses related to equipment acquisition, custom software development, updates, and ongoing maintenance [39]. These financial barriers can restrict access, particularly in low-resource settings such as public institutions or developing countries.

Additionally, there is a lack of trained professionals capable of designing and delivering VR-based therapy effectively. Proper training in both technical and therapeutic aspects is essential to ensure successful outcomes.

Another concern is the risk of **sensory overload** or disorientation for some children with ASD. The immersive nature of VR may overwhelm children with heightened sensory sensitivity, potentially reducing the therapy's effectiveness or causing discomfort [38].

Finally, accessibility issuesincluding physical disabilities, attention limitations, or discomfort with head-mounted displayscan limit the usability of VR systems across the full autism spectrum.

Addressing these challenges through targeted research, cost-reduction strategies, and adaptive design principles will be critical for optimizing the long-term effectiveness and reach of VR-based interventions for ASD.

2 Study Design and Participants

A special education school accepted the study, and participants voluntarily enrolled with informed consent from their guardians. Children aged 7 to 12 who had been clinically diagnosed with mild to moderate Autism Spectrum Disorder (ASD), and who required educational support, were eligible to participate.

Assessment tools such as the Childhood Autism Rating Scale (CARS) and the Autism Behavior Checklist (ABC) were used for evaluation before, during, and after the intervention [40, 41].

A total of 26 children were randomly divided into two groups: one group received an interactive virtual reality game-based intervention, while the other group used traditional picture books. The primary goals of the study included improving physical coordination, attention span, and eye contact.

The research process was structured into four main stages: pre-assessment, game development, intervention implementation, and post-assessment testing. Each family participated voluntarily and retained the right to withdraw from the study at any stage [42].

2.1 Participant Demographics and Study Context

To evaluate the effectiveness of the proposed VR prototype for children with Autism Spectrum Disorder (ASD), a preliminary pilot study was conducted. Understanding the characteristics of the participant group is essential for interpreting the results and determining the relevance and generalizability of the findings.

Table 2.1 summarizes the basic demographic and diagnostic information of the children involved in the study. The participants were selected based on specific inclusion criteria such as age range, ASD diagnosis level, and availability of prior assessments.

Characteristic	**Value**
Age range	7–12 years
Number of participants	26
Diagnosis level	Mild to moderate ASD
Assessment tools	CARS, ABC
Study duration	[Insert duration]

Table 2.1: Participant basic characteristics

As shown in Table 2.1, the study included 26 children aged between 7 and 12 years, all diagnosed with mild to moderate levels of ASD. Diagnostic evaluations were conducted using standardized tools, namely the Childhood Autism Rating Scale (CARS) and the Autism Behavior Checklist (ABC). The participant profile provides a focused sample appropriate for early-stage evaluation of the intervention. The final study duration should be reported once confirmed.

A. Picture book group

No	Gender	Age	Years of education	Interactive responses	Verbal communication	Emotional response	Somatic gaming experience	Other issues	Baseline test score		
									① 60	② 60	③ 62
1	F	10	3	Often	Nothing		NO	Stereotyped behavior	32	35	40
2	M	9	2.5	Often	Often	Unstable	YES		34	28	45
3	M	7	1	Often	Nothing	Stable	NO		30	31	38
4	M	8	3	Seldom	Often	Stable	YES	Finger-wrestling Hand-squeezing Basic play experience	31	33	42
5	M	11	3	Often	Often	Stable	NO	Switching light	34	30	41
6	M	7	1.5	Often	Often	Stable	NO		36	32	40
7	M	8	2.5	Seldom	Often	Stable	YES	Spinning	31	28	36
8	M	6	1.5	Often	Seldom	Stable	NO		35	32	38
9	M	9	3	Seldom	Often	Unstable	NO	Play games	32	30	40
10	M	8	2	Often	Seldom	Stable	NO		30	31	37
11	M	9	2.5	Often	Often	Stable	NO	Repetitive language	28	34	39
12	M	7	2	Often	Nothing	Stable	NO	Play games	31	35	40
13	M	8	2.5	Seldom	Often	Stable	YES	Repetitive language	33	31	42

B. Game group

No	Gender	Age	Years of education	Interactive responses	Verbal communication	Emotional response	Somatic gaming experience	Other issues	Baseline test score		
									① 60	② 60	③ 62
1	F	11	3.5	Seldom	Often	Stable	YES	Open and close doors	36	30	41
2	M		2	Often	Often	Stable	NO		31	32	40
3	M	9	2.5	Nothing	Seldom	Stable	YES	Refuse contact with others	32	29	36
4	M	7	1.5	Often	Often	Stable	NO		34	32	37
5	M	10	2.5	Often	Often	Stable	NO	Repetitive language	30	31	39
6	M	9	2.5	Often	Often	Stable	NO		35	34	40
7	M	8	2	Often	Nothing	Unstable	YES	Stereotyped behavior	32	36	42
8	M	7	1.5	Nothing	Often	Unstable	YES	Run in circle	30	31	40
9	M	8	2	Often	Often	Stable	NO	Play games	28	35	45
10	M	9	2.5	Nothing	Seldom	Unstable	YES		35	35	38
11	M	8	2	Often	Often	Stable	NO	Repetitive language	32	33	42
12	M	8	2	Nothing	Often	Unstable	NO		30	31	45
13	M	7	1.5	Nothing	Nothing	Stable	NO	Wink, nod	35	32	47

Figure 2.1: Participant basic characteristics status[30]

2.2 Types of VR Used in Therapy

There are three main categories of VR systems used in therapy:

- Non-immersive VR: Involves standard screen-based interaction (e.g., desktop applications).
- Semi-immersive VR: Utilizes large screen projections or limited interaction tools.

- Fully-immersive VR: Engages the user completely using HMDs like the Meta Quest 2, providing full sensory immersion and 6DOF (six degrees of freedom) tracking.

Fully immersive systems are particularly effective for children with ASD because they can isolate distractions and fully engage the user in therapeutic tasks

3 Why VR is Effective for Autism Therapy

Virtual Reality (VR) has emerged as a powerful tool in the therapy of children with Autism Spectrum Disorder (ASD) due to its ability to simulate controlled, repeatable, and personalized environments. Its effectiveness is supported by several key features:

- **Safe Environment:** VR enables children to explore social or sensory situations without real-life consequences or risks.
- **Repetition without Boredom:** Tasks and simulations can be repeated multiple times with varying feedback and reward systems, which maintains engagement and supports mastery.[43]
- **Personalization:** VR experiences can be adapted in real-time to suit the individual needs, abilities, and developmental level of each child.[12]
- **Multi-sensory Feedback:** Visual, auditory, and kinesthetic elements are integrated to create an immersive experience that reinforces learning through multiple channels.

These benefits are supported by empirical evidence showing significant improvements in emotional recognition and executive functioning in adolescents with ASD following VR-based social cognition training .

3.1 Therapeutic Mechanisms Behind VR

- Reinforced Learning: VR provides instant feedback through visual and audio cues, helping children connect actions with outcomes.
- Simulation of Real Life Social Cues: Facial expressions, tone of voice, and body language can be modeled in VR to support the learning of non-verbal communication [44].
- Neuro plasticity Support: Repeated interaction with therapeutic VR scenes may support the brain's ability to rewire itself and improve specific cognitive functions [36].

Feature	Traditional Therapy	VR-based Therapy
Environment	Real-world or clinical	Fully controlled virtual setting
Flexibility	Limited	Highly customizable
Repetition	May induce fatigue	Encourages engagement through gamification
Feedback Mechanism	Human therapist	Real-time visual and audio reinforcement
Sensory Management	May trigger overload	Designed to minimize sensory stress

Table 2.2: Comparison between Traditional and VR-based Therapies

3.2 Comparison with Traditional Therapies

VR treatment is more scalable and economical than traditional one-on-one therapy since it can replicate various scenarios and provide consistent experiences without the need for continual human supervision [44].

3.3 Theoretical Framework: Social Learning in VR

Bandura's Theory of Social Learning (1977) emphasizes learning through observation, imitation, and modeling. VR supports this by:

- Simulating characters that demonstrate correct social behaviors.
- Allow children to observe and then practice social responses in a safe loop.
- Providing repeated exposure to social cues, such as eye contact and facial expressions, which are often difficult for children with ASD.

These features are also supported by the "Systematic Desensitization" principle, gradually exposing children to stimuli they fear, helping reduce anxiety [44].

3.4 Documented Benefits of VR for ASD Children

- Improved eye contact and joint attention
- Better emotional recognition and empathy
- Increased verbal communication and language use
- Enhanced executive function and task switching
- Development of social problem-solving skills

These improvements demonstrate that immersive VR is more than a learning tool, it is an emotional and cognitive bridge for children with ASD [44].

3.5 Challenges and Limitations

Despite its benefits, VR therapy has notable limitations:

- Cost: Initial hardware and software costs may be high.
- Sensory Overload: Some children may find HMD's overwhelming or uncomfortable[45].
- Accessibility: The availability of trained professionals and the support infrastructure may be limited.
- Technical Barriers: Bugs, motion sickness, and calibration issues can affect usability[7].

These concerns are summarized in the research , suggesting the need for careful user-centered design and gradual exposure to VR environments .

3.6 Notable Studies and Research Examples

- Demonstrated significant improvements in social communication among children with ASD using VR occupational therapy interventions.
- Found increased social interaction and reduced anxiety in VR-based therapy versus conventional group therapy.
- Pioneered VR interventions for ASD, focusing on social story scenarios with controlled sensory inputs

The use of virtual reality in the treatment of autism spectrum disorder holds revolutionary promise. It enables therapists to create meaningful, controlled, and repeatable therapies tailored to the unique needs of every child [42].

VR-based therapy has the potential to develop from a supplementary tool to a fundamental element of autism intervention techniques as VR technology becomes more widely available and reasonably priced, and development tools such as Unity and Meta XR SDK become more potent [45].

4 Conclusion

Virtual reality (VR) has shown great promise as a cutting-edge therapy tool for kids with autism spectrum disorder (ASD). Due to its immersive and interactive environment, children can practice social, emotional, and cognitive abilities in secure, adaptable, and captivating settings.

In contrast to conventional therapy, virtual reality (VR) enables tailored feedback, repetition without boredom, and the simulation of real-world situations that may be difficult to replicate in therapeutic settings.

Evidence from previous research supports gains in social interaction, communication, executive functioning, emotional awareness, and other areas.

When used carefully and with expert assistance, VR's advantages outweigh its drawbacks, including cost, accessibility, and potential sensory overload.

As technology advances, virtual reality can be incorporated into standard therapeutic procedures for ASD, redefining the future of neurodevelopmental treatment.

More study, interdisciplinary cooperation, and inclusive design are essential to fully realize VR's potential for children on the autistic spectrum.

Chapter 3

Development Environment for VR Serious Games

1 Introduction

This chapter highlights the essential elements of the therapeutic game project's development environment, from the technical specifications of the hardware used to the choice of a suitable VR headset to the software and tools that allowed us to create rich and meaningful interactive experiences.

Every element was chosen with attention to guarantee excellent performance and stability during development, as well as to give the intended kids a seamless and practical user experience. The emphasis was on integrating interactive features like hand tracking and in-world navigation, and making programming easier with adaptable and customization tools like Unity and the Meta XR SDK. In this situation

The chapter thoroughly explains the design methodology, software, and hardware used, setting the groundwork for creating a serious game that successfully satisfies its therapeutic and educational objectives.

1.1 PC Specifications

The workstation was equipped with high-end hardware to ensure smooth VR development and high-quality game performance. The specifications are as follows:

- Case: NZXT CA-H710 B
- Power Supply: GIGABYTE GP-P680B 650W
- Processor: Intel Core i9-10900 (LGA1200)
- Cooling System: Kraken X63 RGB CPU cooler

- Memory: 32GB DDR4 RAM (3333 MHz)
- Storage: 1TB HDD and 512GB SSD
- Motherboard: GIGABYTE Z590 AORUS AX
- Graphics Card: Gigabyte GeForce RTX 3080 Gaming OC 10GB

In order to guarantee that the system could manage the high processing demands of VR applications, this robust configuration was selected. The system's exceptional graphical performance, made possible by the RTX 3080 GPU, was essential for rendering intricate 3D worlds and sustaining high frame rates in virtual reality.

This robust setup enables us to incorporate intricate scenes into the virtual reality setting, where character interactions and educational activities necessitated rapid processing and high-quality images. For instance, in order to provide consumers with a seamless, engaging experience, generating dynamic visual elements such as emotions or facial expressions requires quick processing from both the CPU and GPU.

1.2 Meta Quest 2

Meta Quest 2 (formerly known as Oculus Quest 2) is a standalone virtual reality (VR) headset developed by Meta Platforms. Released in October 2020, it is designed to provide an immersive VR experience without the need for a PC or external sensors. The device features:

- A high-resolution display (1832 x 1920 pixels per eye)
- A refresh rate of up to 120Hz
- Inside-out tracking using built-in cameras
- Wireless operation with onboard processing
- 6 degrees of freedom (6DoF) motion tracking
- Hand tracking and controller support

Meta Quest 2 is used extensively in training simulations, teaching, gaming, and treatment. It is an effective tool for creating VR applications, such as serious games that focus on social or cognitive development, like autism therapy for kids, because of its compatibility with Unity and the Meta XR SDK.

The Meta Quest 2 was selected due to its strong features, particularly the hand tracking feature that lets kids engage with the virtual world in a natural way. For kids with autism, this is especially helpful since it allows them to engage with characters and activities more naturally and intuitively, which enhances their social skills and motor abilities.[46]


Figure 3.1: Meta Quest headsets[47]

1.2.1 Why Choose Meta Quest 2

The Meta Quest 2 was selected for the VR headset because of its remarkable features and capabilities, which make it perfect for VR game production. The Meta Quest 2 offers several benefits:

- Resolution: With a resolution of 3664 x 1920 pixels, the Quest 2 gives customers sharp, detailed images.
- Field of View (FOV): The headset's broad 90-degree view enhances users' immersion and engagement in the virtual world.
- Wireless Freedom: The Quest 2 can operate without a computer since it supports independent virtual reality. To enable more intricate VR experiences, it can be linked to the PC via the Oculus Link.

Additionally, Meta Quest 2 was chosen due to its price and performance balance, making it the perfect option for creating a virtual reality game targeted at kids. It was the ideal choice for the project because of its mobility, simplicity of setup, and broad market availability [46].

1.2.2 Technical Integration with Unity and Meta XR SDK

- Meta XR SDK: The Meta Quest 2 was integrated with Unity using the Meta XR All-in-One SDK. The tools required to build key VR features like hand tracking, room-scale VR, and fluid interaction mechanics were made available via this SDK.
- Compatibility with Unity: The main game engine utilized for development was Unity. Because of the Meta Quest 2's complete compatibility with Unity and the Meta XR SDK's smooth interaction with the game engine, immersive VR features like real-time movement and gesture tracking could be implemented.

In addition to enabling thorough creation and testing in virtual reality, the combination of a powerful PC and the Meta Quest 2 headgear ensured that the game could provide players with a fluid and engaging experience [46].

2 Development Setup

Unity, a strong and popular game engine that provides outstanding support for virtual reality (VR) production, was used to create the serious game.

2.1 Unity

Unity is a cross-platform game engine developed by Unity Technologies that is extensively used to create interactive 2D and 3D applications, such as training aids, simulations, video games, and virtual reality (VR) experiences. Windows, Android, iOS, WebGL, and VR devices like the Meta Quest 2 are just a few of the platforms that Unity supports.

Unity was selected because of its adaptability and strong VR support, both essential for creating an interactive game that promotes learning and healing. We were able to establish smooth interactions in the virtual environment where kids may freely explore and learn, enhancing their social and cognitive skills, thanks to its compatibility with Meta Quest 2 and integration with the Meta XR SDK.

Unity is popular among developers due to its:

- User-friendly interface
- Large and active developer community
- Extensive Asset Store for free and paid game assets
- Support for C# scripting
- Built-in tools for physics, animation, and UI
- Integration with XR SDKs, making it suitable for VR/AR development

Its flexibility, powerful features, and VR support make Unity one of the best choices for developing serious games and educational applications [48].

2.1.1 Why Unity?

Unity was selected as the main development engine for several reasons:

- VR Support: Meta Quest 2 and other VR systems are well integrated with Unity, which provides native support for VR development.

Figure 3.2: Unity logo[49]

- Big Community: Unity boasts a sizable and vibrant developer community, which facilitates the discovery of best practices, solutions, and tutorials. Educational Resources: The learning and growth process was accelerated by the abundance of official and community-generated educational resources.
- Cross platform compatibility: Unity facilitates the game's deployment across several platforms, particularly mobile and virtual reality devices [48].

2.1.2 Unity Version

The version used for development was Unity 2022.3.17f1 (LTS), which is a Long-Term Support (LTS) release that ensures stability and compatibility with professional tools and plugins [48].

2.2 Plugins and SDKs

To enable full VR functionality and integration with Meta Quest 2, the following tools were used:

- The All in One SDK for Meta XR: all of the components required to function with the Quest 2 headset are included in this official SDK from Meta, including input handling, hand tracking, headset tracking, and interaction systems.
- XR Interaction Toolkit: Unity's XR Toolkit was used to handle VR interactions such as grabbing, teleportation, and ray based UI selection.
- Other Unity Packages:
  - TextMeshPro for advanced UI text rendering.
  - Unity UI Toolkit for building menus and in VR interfaces.

In order to ensure seamless development and user interaction within the VR environment, these technologies were crucial.

The Meta XR SDK was crucial for the game to incorporate cutting edge VR capabilities like hand tracking and room-scale VR. Because of this, we were able to create a more engaging experience for kids, allowing them to interact with the virtual world through gestures and natural movements. Additionally, the SDK made creating interactions easier, increasing the game's therapeutic effect [48].

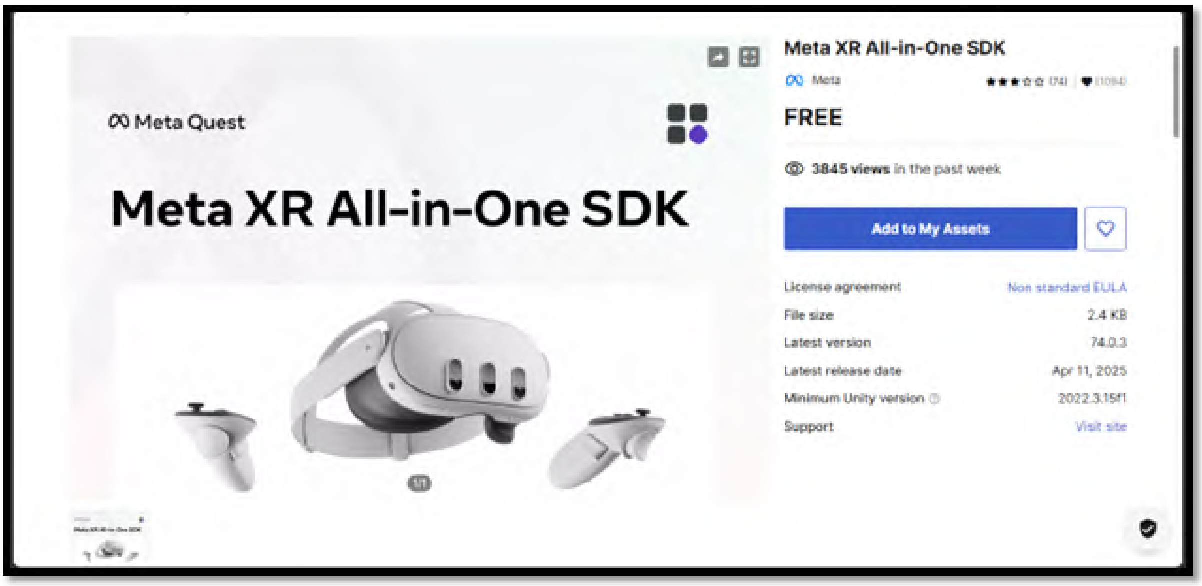

Figure 3.3: Meta XR All-in-One SDK Package[50]

2.3 Programming Language

The game logic was written in C#, Unity's primary scripting language. C# was used to:

- Handle user inputs (e.g., grabbing objects, selecting answers).
- Control game mechanics (e.g., triggering events, animations, and sounds).
- Implement educational logic (e.g., matching emotions with expressions).
- Manage UI navigation and interactions inside the VR space.

To facilitate the management and growth of the code base, scripts were organized in a modular fashion.

In addition to controlling game elements, C# was utilized to develop interactive systems that lead kids through instructional exercises. These systems provide a safe, virtual environment for kids with autism to practice social skills, including identifying emotions and reacting accordingly. By organizing the scripts in a modular fashion, we ensured that new features could be readily added or modified in response to user input and testing [51].

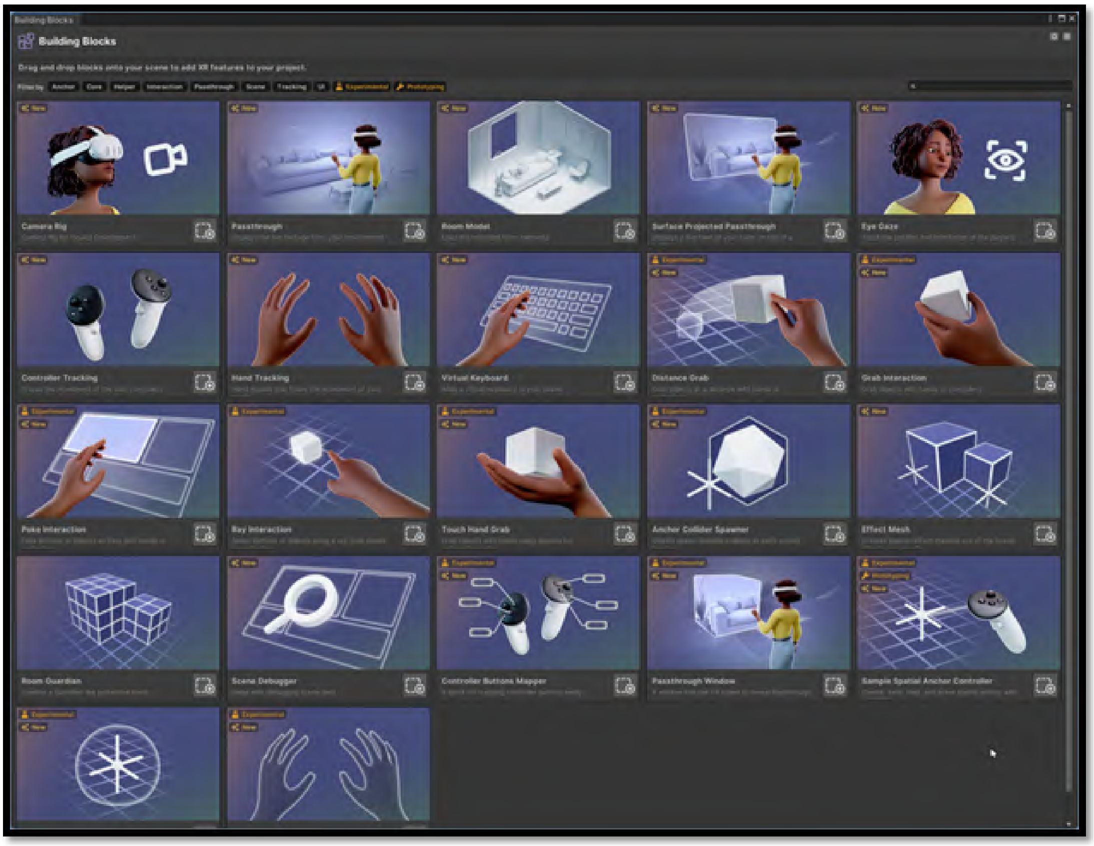

Figure 3.4: Building Blocks[50]

2.4 Tools Used

2.4.1 3D Models and Assets

The game's graphic components mainly were taken from the Unity Asset Store rather than individually created using programs like Blender, 3ds Max, or Maya. Because the project focused on game logic and interaction in a therapeutic virtual reality environment rather than 3D modeling, this method allowed for speedier prototyping and development.

Among the resources utilized were:

- Characters (NPC's and magical helpers)
- Environmental elements (fantasy settings, doors, sky boxes)
- Props and interactive objects used in mini-games

These assets were optimized and compatible with VR, making them ideal for quick integration into Unity with minimal adjustments.

2.4.2 Code Editor: Visual Studio

Visual Studio was the main Integrated Development Environment (IDE) for creating and maintaining C# scripts. Features like these were made possible by their interaction with

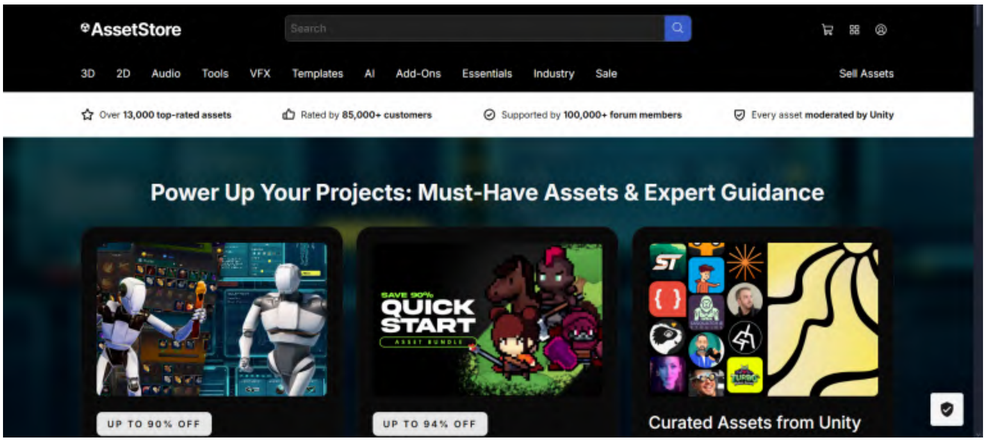

Figure 3.5: asset store site[52]

Unity:

- Code completion and Eisenstein, which sped up script development
- Debugging tools to trace errors and test functionality
- Version control integration (if needed)

Visual Studio was used to program all of the game logic, user interactions, and VR mechanics in C#, making it a crucial component of the development process [52].

Figure 3.6: Visual Studio[53]

2.5 Supporting Tools

2.5.1 XR Simulator

Since there was no VR gear available at home during the early stages of development, Unity's XR Simulator was used for the majority of testing and interface design. By simulating VR device input, this simulator enables developers to:

- Test interactions such as grabbing, UI selection, teleportation, and collision triggers.

- Preview player movement and object behavior in a virtual space without needing physical hardware.
- Save time and iterate quickly without needing to connect a real headset during early development.

Before implementing the project on the Meta Quest 2 headset in a lab setting, a large portion of the game logic could be developed and improved using XR Simulator.

During the early phases of development, the XR Simulator was an essential tool that enabled us to replicate VR interactions such as teleportation, UI selection, and object grabbing without the need for physical hardware. Prior to testing on the Meta Quest 2, this assisted us in improving the interaction and game logic systems. We were able to swiftly iterate on game play concepts and accelerate development thanks to the simulator [48].

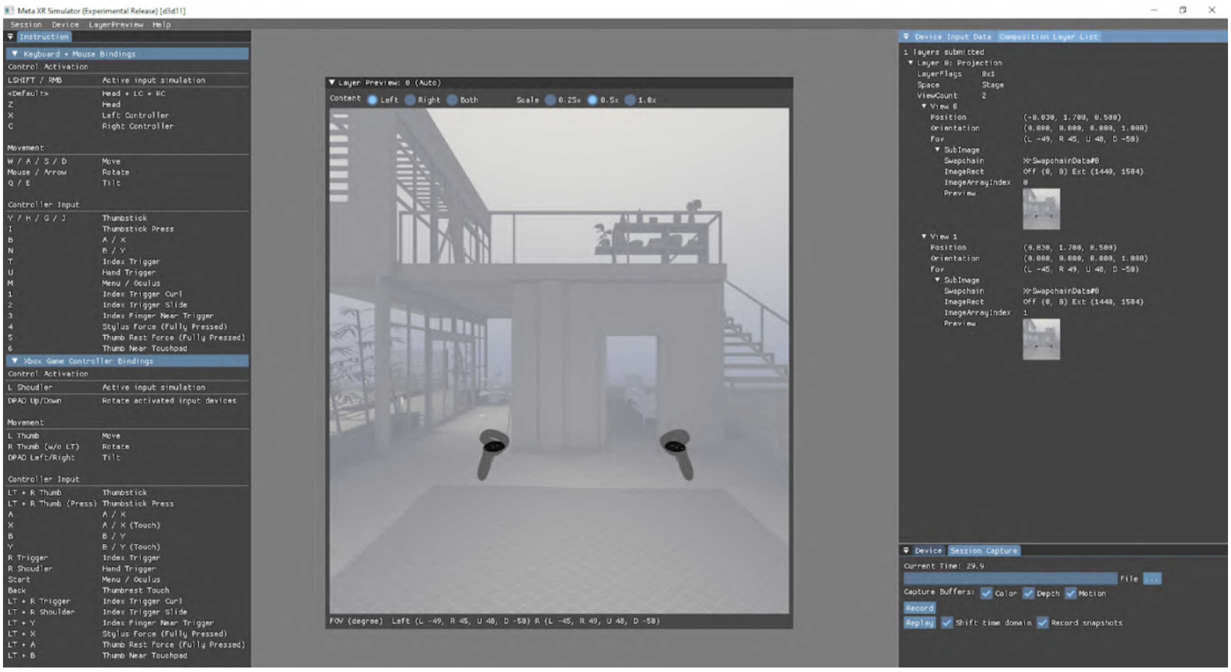

Figure 3.7: XR Simulator Shape[52]

2.6 Version Control

No specialized version control system such as GitHub or Git Lab was utilized during this project. Unity project files were regularly manually backed up to prevent data loss and monitor development progress at various stages [48].

2.7 Target Platform Configuration

The Meta Quest 2 headset, the last platform for the serious game's distribution, needed particular Unity configuration steps to guarantee compatibility and peak VR performance.

2.7.1 Build Platform Setup

Unity was configured to target Android as the build platform, which is necessary for Meta Quest 2 development. The following steps were taken:

- Android Build Support was installed via Unity Hub.
- XR Plugin Management was enabled, and Meta XR Plugin was added to support Oculus devices.
- The OpenXR backend was selected to ensure broad compatibility and support for hand tracking and advanced VR features.

2.7.2 Project Settings

Several Unity project settings were adjusted to optimize performance and compatibility with Quest 2:

- Multi threaded rendering and GPU skinning were enabled.
- The minimum API level was set to Android 10 (API Level 29), as required by Meta Quest.
- The target device was explicitly set to Meta Quest in the XR settings.

2.7.3 Input and Interaction Configuration

The game relied on the XR Interaction Toolkit for interaction handling. Special attention was paid to configuring:

- Hand/controller input
- Gaze or ray based UI selection
- Teleportation and movement boundaries

These settings ensured that the game could be fully navigated and interacted with using the Meta Quest 2's native controls [48].

3 Design and Development Methodology

3.1 Design Philosophy

The VR serious game was developed using a user-centered and therapeutic design approach. The main objective was to provide children with autism spectrum disorder (ASD) with a peaceful, stimulating, and non threatening environment. To prevent sensory overload, the visual design strongly emphasizes gentle hues, dimly lit spaces, and amiable people.

The following guidelines guided the development of each scene:

- Focus on a single therapeutic goal per scene
- Predictable interactions to reduce anxiety
- Positive reinforcement through animations and sound effects
- Free exploration without punishment or failure states

These choices are aligned with best practices in autism-focused digital intervention design [54, 45].

3.2 Scene Design Pipeline

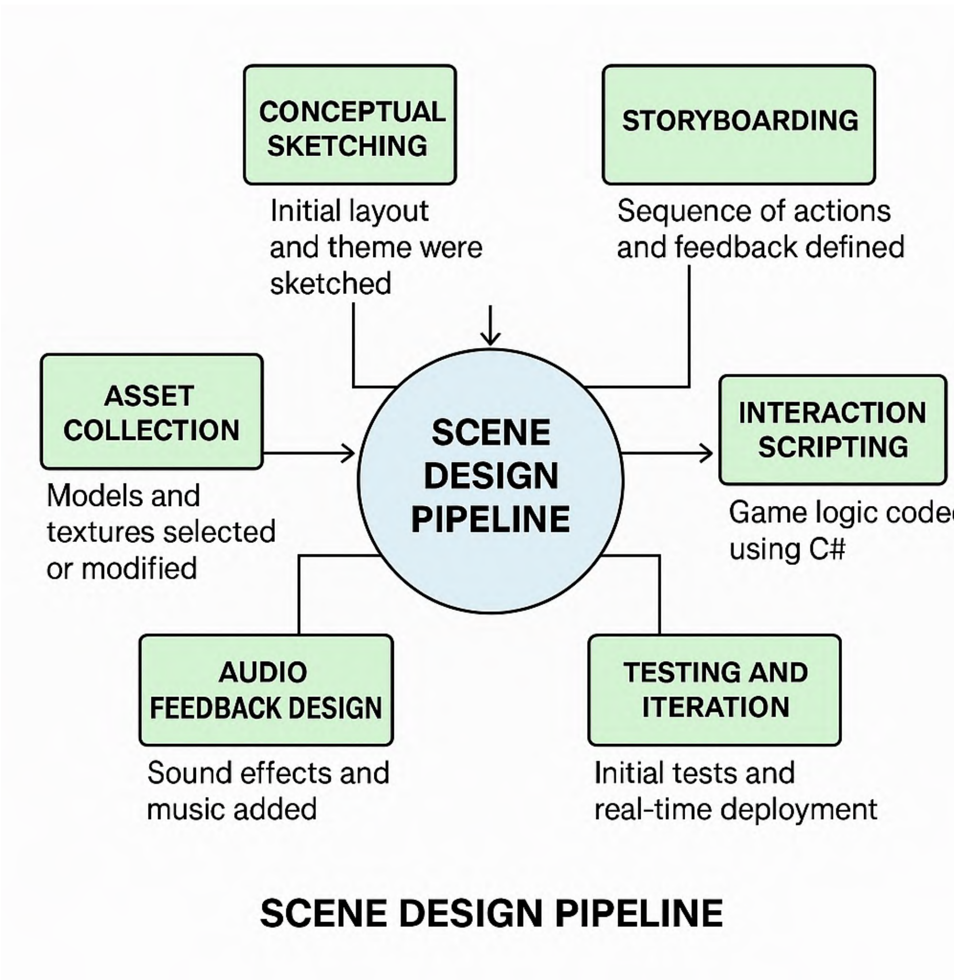

Figure 3.8: Scene Design Pipeline

3.3 User Experience Considerations for Children with ASD

The application's UX was designed to be intuitive, consistent, and encouraging. Special attention was paid to reduce cognitive load and enhance confidence:

- Navigation was simplified using large buttons, clear icons, and spatial cues.
- All interactions were met with visual and/or audio feedback.
- Mistakes were not penalized; instead, gentle cues guided the child.
- Visual clutter and rapid animations were minimized to avoid overstimulation.
- No reading was required; voice overs or non-verbal cues were used instead.

These design choices adhere to suggestions, which stress the value of visual clarity, predictability, and few instructions in autism oriented user experience.[55].

3.4 Testing and Iteration Process

Testing was carried out in multiple stages to ensure usability and therapeutic value:

- Initial Testing: Conducted in Unity using the XR Simulator to simulate VR interactions like object grabbing and UI selection.
- Hardware Testing: Scenes were deployed to Meta Quest 2 for real environment testing. Frame rates, hand tracking, and scene transitions were assessed.
- User Feedback: Informal testing with neuro typical users and ASD-focused expert consultation was used to identify overstimulating elements, which were removed or softened.

This testing loop ensured that each scene met performance and sensory criteria suitable for children with autism.[55].

3.5 Development Challenges

Several challenges were encountered during the development process:

- Hand Tracking Variability: Hand detection occasionally failed under low light conditions or rapid movement.
- Speech Recognition Limitations: Offline recognition options in Unity were limited; simple keywords were prioritized.

- Sensory Overload Risks: Early versions had bright lights and rapid movements that were later toned down.
- No Version Control System: Backups were done manually, making collaboration and tracking changes more difficult.

These challenges are common in VR projects for sensitive users and were addressed through iterative testing and user feedback [45].

3.6 Future Development Possibilities

The current version of the game is a foundation for further therapeutic innovation. Planned features include:

- AI-Driven NPC's: Characters that adapt to the child's behavior and language use.
- Progress Tracking: A dashboard for therapists or parents to monitor child progress.
- Expanded Voice Recognition: Integration with cloud-based API's for flexible speech analysis.
- Multiplayer Support: Shared interaction with peers or therapists to practice social skills collaboratively.
- Cultural Localization: Translation and adaptation for different languages and social norms.

These improvements aim to enhance personalization and increase the long-term therapeutic value of the system [45].

4 Conclusion

This chapter covered the entire development environment and technologies needed to produce a virtual reality serious game that supports kids with autism spectrum disorder (ASD). Every choice was made to create a seamless, immersive, and therapeutically successful experience, from choosing a powerful PC and the Meta Quest 2 headset to utilizing Unity and a collection of specialized SDKs and plugins.

Thanks to the technical infrastructure, careful design processes, and iterative testing, we were able to create interactive scenes that prioritize user comfort, accessibility, and clarity. This supportive setting provided the groundwork for creating a game that serves therapeutic objectives meaningfully and practically.

In the upcoming chapter, we will examine how the game's situations, content, and interaction dynamics are designed to convert these technical underpinnings into useful therapeutic interventions.

Chapter 4

VR Serious Game for Children with Autism Spectrum Disorder

Part I

Game Design & Scenes Content

1 Introduction

The application is a serious virtual reality (VR) therapeutic tool explicitly designed to support children with Autism Spectrum Disorder (ASD) in developing essential life skills. The VR experience runs on standalone Meta Quest 2 headsets, making it accessible for both clinical and home use, with minimal setup requirements.
At its core, the program features eight carefully structured scenes that progress from a calming introductory space to various skill-building activities.
Therapeutic games incorporate evidence-based techniques, such as applied behavior analysis (ABA) principles, through engaging virtual scenarios.
For instance, one activity uses gradual exposure to help children practice maintaining eye contact with friendly virtual characters, while another employs colorful, interactive objects to improve joint attention skills.
The visual design adopts a muted color palette with minimal sensory triggers, and all interactions use gentle haptic feedback to prevent overstimulation. A unique feature includes real time performance analytics that help therapists track subtle improvements in reaction times and task completion rates across sessions.
The system also allows caregivers to customize difficulty levels and session lengths according to each child's tolerance and developmental stage. What sets this solution apart is its balanced approach, maintaining scientific rigor in therapy goals while delivering them through playful, immersive experiences that children genuinely enjoy. Early testing has shown particular effectiveness in helping non verbal participants communicate choices through gaze tracking and simple gesture controls.
The architecture also supports future expansion with additional modules for advanced social skills training.

Scene Name	Main Objective	Skills Targeted	ASD Level
Welcome Scene	Create a calm and safe introduction to the VR experience	Emotional readiness, trust building	All levels
Doors Scene	Provide navigation and support decision-making	Executive functioning, spatial orientation, confidence	All levels
Focus Cups Game	Improve focus, aiming, and motor control	Visual attention, hand-eye coordination, fine motor skills	Mild to moderate ASD
Magical Storytelling Playground	Stimulate imagination through free object manipulation	Imagination, storytelling, spatial awareness, creativity	Mild ASD
Shape Matching Puzzle	Match 3D shapes to their outlines	Visual discrimination, spatial reasoning, problem solving	Mild to moderate ASD
Eye Contact Challenge	Encourage eye contact and reduce anxiety	Social engagement, eye contact, confidence	All levels
Magic Word Columns	Develop language skills and motivate verbal experimentation	Language skills, pronunciation, verbal interaction	All levels
The Friendly Forest	Improve comfort with touch, build connection with animals	Sensory integration, social interaction, cause-effect understanding	Mild to moderate ASD

Table 4.1: Therapeutic Game Scenes Overview

2 Game Name and Logo

2.1 Game Name:

Reno is a short and memorable name derived from the phrase:

- **Regulation of Emotion and Negative Outcomes**: capturing the game's therapeutic essence of helping children, especially those with Autism Spectrum Disorder (ASD), to better manage their emotions and reduce negative behavioral responses.

2.2 Meaning:

The name Reno emphasizes emotional growth and well-being:

- Teaching children how to understand and regulate their emotions through engaging activities.
- Preventing or reducing negative emotional outcomes by offering guided and playful scenarios that promote healthy expression.

2.3 Logo Design:

The logo reflects the gentle and joyful spirit of the game:

- **Style**: A soft, chubby fantasy creature with a friendly smile and VR goggles, symbolizing fun and technological interaction. It is surrounded by sparkles and soft clouds, evoking a dreamy atmosphere.
- **Typography**: The word "Reno" is written in a rounded, inflated bubble style with rainbow pastel gradients and subtle highlights, making it both playful and emotionally soothing.
- **Colors**: Soft rainbow tones with a smooth blend of orange, green, blue, and purple. The gentle pastel palette ensures visual calmness while remaining vibrant and appealing to young players.
- **Message**: The logo visually conveys safety, emotional warmth, and inner joy. It encourages children to feel welcomed and motivated to explore their emotional world with confidence.

Figure 4.1: Game Logo

3 Welcome Scene

The **Welcome Scene** serves as the primary entry point for the child into the virtual reality environment. From a development and design perspective, its goal is to create a calm and emotionally safe introduction, particularly for children on the autism spectrum.

3.1 Environment Setup

- **Lighting:** Soft, indirect lighting is implemented using Unity's Baked GI system to avoid harsh contrasts and maintain a soothing ambiance.
- **Color Scheme:** A warm and desaturated color palette is applied via the Sky box and material settings to reduce overstimulation.
- **Ambient Sound:** A looping ambient audio track is played through an `Audio Source` component attached to a central empty GameObject, triggered on scene load.

3.2 Interactive NPC (Non-Player Character)

- **Purpose:** The NPC acts as a magical guide (e.g., a fairy or friendly creature) to build emotional connection and provide reassurance.
- **Control:** The character is non controllable and animated using a predefined `Animator Controller` with pre authored animation clips.
- **Expressive Gestures:** Hand and head gestures are embedded within the animation timeline to enhance non-verbal communication.

3.3 User Interface Start Button

- **Element:** A 3D Start button is placed directly in the users field of view (FoV), floating at an accessible height.
- **Interaction:** The button uses Unitys XR Interaction Toolkit:
  - Configured as an `XR Grab Intractable` or `XR Ray Intractable` with collider based triggers.
  - On activation, it calls `SceneManager.LoadScene()` to transition to the next scene, optionally with a fade-out or transition animation.

3.4 User Interaction Design

- **No Time Pressure:** There are no countdowns or timers; the user initiates the scene transition entirely at their own pace.
- **Manual Scene Transition:** The next scene is loaded only upon user input to avoid any sense of being rushed.

3.5 Therapeutic Design Considerations

- Establishes initial trust and emotional readiness for the VR experience.
- Reduces the risk of sensory overload through careful control of light, sound, and visual stimuli.
- Smoothly introduces the child to the idea of exploration and interaction in a safe, judgment-free virtual space.

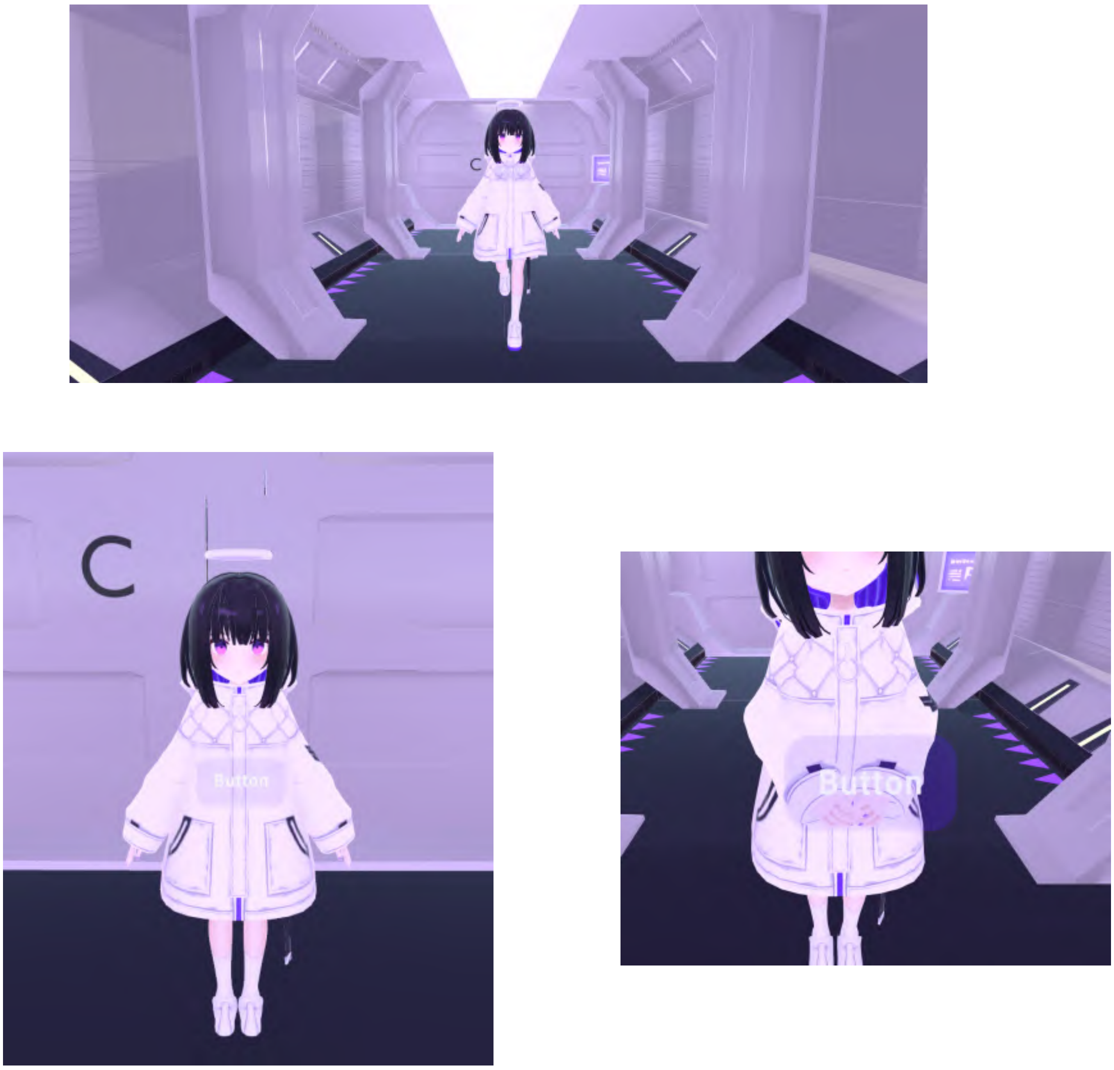

Figure 4.2: Welcome Scene

4 Doors Scene

This scene serves as the main navigation interface within the application. It allows the user (the child) to select from multiple therapeutic activities via a magical corridor environment featuring distinct gateways.

4.1 Environment Setup

- **General Design:** The scene is constructed as a 3D corridor with a magical visual theme to promote curiosity and engagement.
- **Lighting and Effects:** Directional lighting is used along with subtle particle effects around each gateway to enhance visibility. Visual effects like glow and bloom are applied via the Post Processing Stack.

4.2 Therapeutic Gateways

- **Count:** The scene includes 6 gateways, each leading to a distinct therapeutic mini game.
- **Placement:** Gateways are arranged in a circular layout or along the corridor walls to ensure clear visibility within the player's field of view.
- **Scene Loading:** Each gateway is linked to a separate scene using `SceneManager.LoadScene()` triggered by its corresponding button.

4.3 Interaction Buttons

- **Design:** In front of each gateway is a red cylindrical button mounted on a slim pillar, positioned at a height suitable for hand interaction in VR.
- **Interaction Mechanism:** Buttons use the `XR Interaction Toolkit` and are activated either by direct hand contact or ray based selection (`XR Ray Interactor`).
- **Feedback:** Upon interaction, a sound cue is played. To prevent multiple triggers, a boolean flag `isLoading` is used.

4.4 User Interaction Characteristics

- **Free Choice:** The child can navigate the corridor freely and select any gateway in any order.
- **Transition:** Each button loads a specific therapeutic game scene using `SceneManager.LoadScen` where `X` denotes the scene index.

4.5 Design and Therapeutic Goals

- Empower the child with a sense of control by allowing them to choose which activity to start.
- Offer a structured yet flexible navigation experience that minimizes anxiety.
- Support visual distinction between gateways and their associated games using consistent icons and colors.

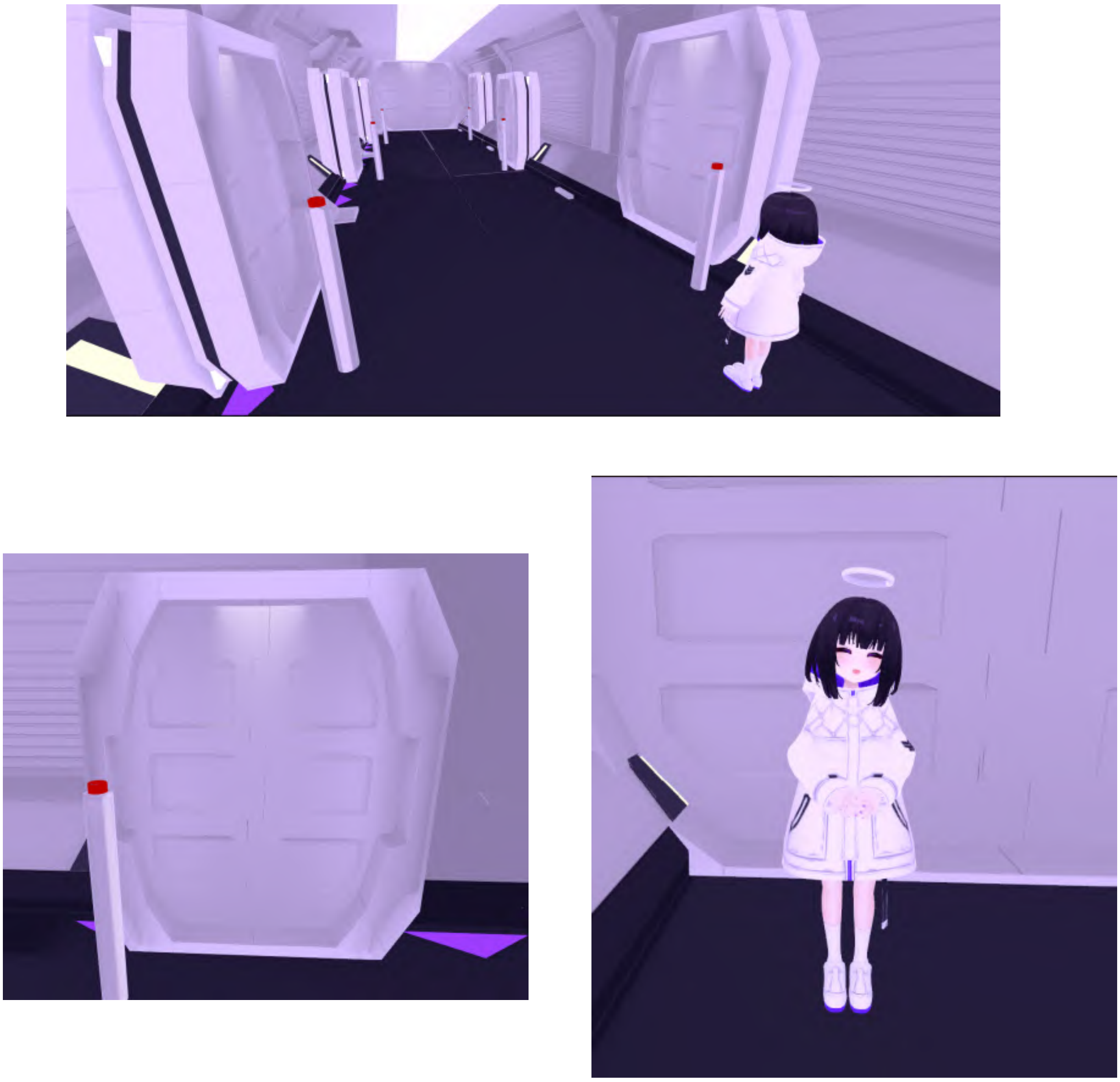

Figure 4.3: Doors Scene

5 Magical Storytelling Playground

This scene takes place in a peaceful, enchanting magical world, where the child faces a beautiful castle surrounded by a calm, dreamy environment. It is designed as an open ended sandbox environment rich with interactive elements.

5.1 Environment Setup

- **Visual Theme:** The world features soft lighting, magical particles, and a scenic background including a fantasy castle and floating terrain.
- **Audio Ambiance:** Gentle background music and occasional environmental sounds (e.g., birds, chimes) are used to maintain a relaxed and immersive atmosphere.
- **Physics Settings:** Gravity is disabled globally or per object to allow floating or free placement in 3D space.

5.2 Interactive Elements

- **Types of Objects:** Includes magical and familiar items such as flying airplanes, teddy bears, toy soldiers, vases, and others.
- **Interactivity:** All objects implement components such as `XR Grab Interactable` to support picking up, moving, and rotating via hand tracking or controllers.
- **Object Manipulation:**
  - **Resizing:** Users can pinch or stretch objects using two-handed gestures, implemented using custom gesture recognition or XR toolkit extensions.
  - **Free Placement:** Objects can be positioned anywhere in 3D space without constraints (no snapping or surfaces required).

5.3 User Interaction Characteristics

- **No Objectives or Rules:** The scene does not follow a game structure; instead, it encourages free form exploration and storytelling.
- **Creative Freedom:** Children can invent their own narratives by combining objects, positioning them, and acting out roles or events.
- **Persistence:** (Optional) The system may store object states for session continuity if needed.

5.4 Therapeutic and Design Goals

- **Imaginative Play:** Supports unstructured creativity and fantasy based play, aiding in emotional exploration.
- **Spatial Awareness:** Encourages understanding of 3D space, orientation, and relationships between objects.

- **Cognitive Flexibility:** Helps children with ASD practice open ended thinking, decision making, and symbolic representation.
- **Fine Motor Skills:** Enhances hand control through gestures like grabbing, resizing, and placement.
- **Self-Expression:** Provides a non verbal outlet for the child to express ideas, stories, or feelings through interactive storytelling.

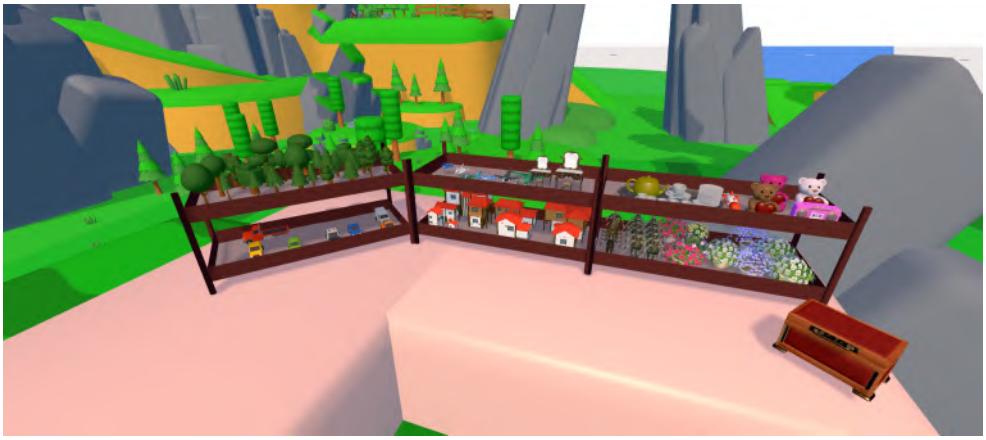

Figure 4.4: Magical Storytelling Playground scene

6 Shape Matching Game

This scene features an interactive shape matching activity designed for cognitive and motor skill development. The game play revolves around manipulating 3D shapes and recognizing spatial relationships.

6.1 Environment and Object Setup

- **3D Shapes:** A collection of interactive 3D primitives (e.g., spheres, cubes, cylinders, pyramids) is instantiated in the scene. Each shape is tagged appropriately (e.g., `"Shape_Cube"`, `"Shape_Sphere"`).
- **Silhouettes:** Corresponding target outlines (silhouettes) are placed on the opposite side. These are semi transparent, slightly yellow tinted mesh placeholders using a custom material with alpha transparency.
- **Layout:** Shapes and their corresponding silhouettes are positioned in a mirrored fashion to encourage left to right matching.

6.2 Interaction Logic

- **Grab Mechanism:** Shapes are configured as `XR Grab Intractable` objects, enabling the child to pick them up using hand controllers.
- **Placement Detection:** Each silhouette area includes a collider and a shape-specific trigger script to detect correct matches.
- **Error Handling:** If a shape is released in the wrong spot, a soft error sound is played via an `AudioSource` to indicate the mismatch gently.
- **Positive Feedback:** As the correct shape approaches its corresponding silhouette (within a defined proximity threshold), a positive audio cue is played (e.g., chime or soft bell), guiding the child toward the correct placement.
- **Snap System:** When the shape is correctly positioned, it smoothly snaps into place using a leaped transform transition and becomes non intractable.

6.3 Educational and Therapeutic Objectives

- Develop visual discrimination by requiring children to identify and match shapes accurately.
- Enhance spatial reasoning through the need to rotate and align shapes with their outlines.
- Improve fine motor control via VR based object manipulation.
- Support problem solving and confidence building with clear, real time feedback.

6.4 Accessibility and Usability

- The design is intentionally minimal and intuitive, accommodating various cognitive levels within the Autism Spectrum.
- The interaction flow is forgiving no time limits or failure states are enforced.
- Audio and visual feedback are soft, non intrusive, and tuned to avoid overstimulation.

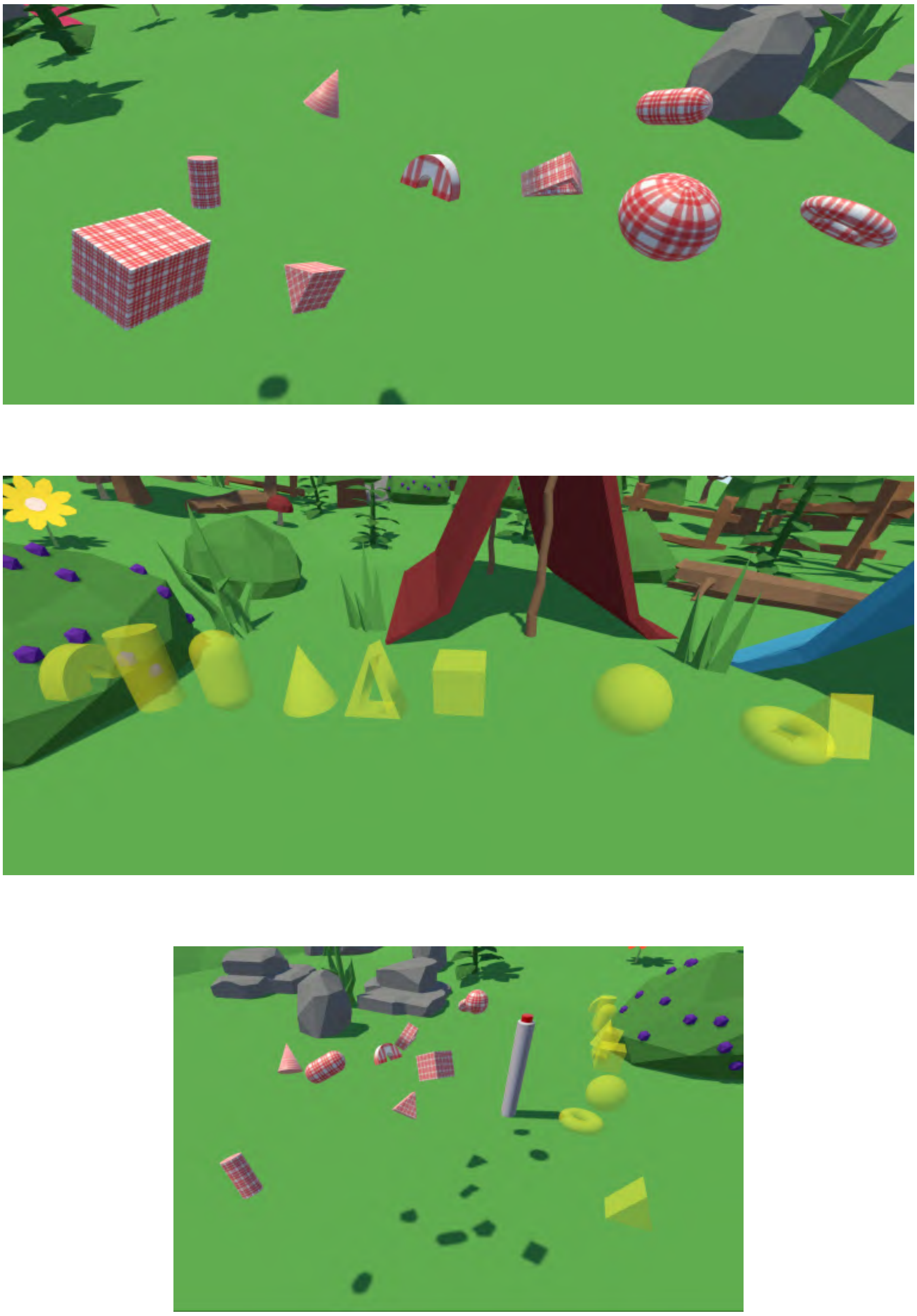

Figure 4.5: Shape Matching Puzzle Scene

7 Eye Contact Challenge

This scene is designed to encourage and improve eye contact in children with ASD by offering a simple, playful, and positive interaction within a safe virtual environment.

7.1 Environment Setup

- **Setting:** The scene places the child in a calm, minimalist environment with soft lighting and a soothing color palette to reduce visual overstimulation.
- **Audio:** A light ambient background sound plays continuously to maintain a relaxed atmosphere.

7.2 Interactive Character

- **Model:** A friendly teddy bear is positioned at eye level and directly faces the player, creating an opportunity for direct gaze.
- **Animation:** The bear is animated using an `Animator Controller` with idle and celebratory states.
- **Prompt:** The bear initiates interaction by asking, in a gentle voice, Can you look into my eyes?, using a pre recorded audio clip.

7.3 Eye Contact Detection

- **Mechanism:** Eye contact is detected by checking the alignment between the player's head orientation and the bears face using the VR headset's tracking data.
- **Threshold:** If the user maintains alignment for at least five continuous seconds, it is registered as successful eye contact.

7.4 Feedback and Reinforcement

- **Positive Response:** Upon success, cheerful music plays and the teddy bear transitions to a joyful dance animation.
- **Verbal Praise:** A voice line such as Great job! is played to reinforce the positive behavior.
- **Repeatability:** After a short delay, the scene resets, allowing the child to repeat the activity as needed.

7.5 Design and Therapeutic Goals

- Provide a controlled and non threatening context to practice eye contact.
- Reinforce social behavior using immediate, clear, and positive feedback.

- Support repeatable, short interactions tailored to children with difficulty maintaining gaze.
- Promote emotional regulation and build confidence through gentle encouragement.

Figure 4.6: Eye Contact Challenge Scene

8 The Magic Word

This scene is designed to provide a calm and engaging environment that encourages verbal interaction and vocabulary development in children. It combines visual stimuli with speech recognition to create an interactive and educational experience.

8.1 Environment Setup

- **Scene Design:** The child is placed in a cozy, enclosed virtual space with soft lighting and minimal distractions to promote focus and comfort.
- **Object Layout:** At the center of the environment, there are 22 slender flower like structures arranged in a straight line. Each is topped with a neutral white sphere, except for the final one which is topped with a glowing crystal.

8.2 Interactive Elements

- **Speech Activation:** When the child approaches a flower, a card appears in front of the sphere displaying its label (e.g., 'Red') in Arabic.
- **Speech Recognition:** The system uses a speech recognition module (e.g., Unity + external STT API or plugin) to detect if the child clearly says the word.
- **Reactions:** Upon correct recognition:
  - Color balls change from white to their corresponding color: `Red, Blue, Green, Yellow, black, Pink`.
  - Special behavior balls:
    - **Small** ball shrinks in size.
    - **Big** ball grows in size.
    - **Disappear** ball becomes invisible or fades out.
    - **Jump** ball plays a jump animation in place.
  - The final crystal responds to the keyword **Reset** by restoring all balls to their initial white state.

8.3 Feedback and Reinforcement

- The system avoids harsh penalties for unrecognized speech to maintain a low pressure experience.

8.4 Design and Therapeutic Goals

- Encourage the child to engage with the environment using Arabic vocabulary verbally.
- Reinforce the connection between spoken words and visual actions through immediate feedback.

- Foster an enjoyable, safe space for experimenting with language without fear of failure or judgment.

Figure 4.7: The Magic Word Scene

9 Animal Interaction Forest

This scene introduces the child to a cheerful, colorful forest environment upon entering the virtual world. It is designed to encourage gentle interaction and reinforce sensory and cognitive concepts through playful engagement with animals.

9.1 Environment Setup

- **Visual Design:** The forest is constructed with vibrant, saturated tree models and a pleasant natural setting. Colors are intentionally chosen to be non-threatening and visually engaging.
- **Lighting:** Soft ambient lighting is used to create a calm atmosphere without harsh shadows.
- **Audio:** Ambient forest sounds play continuously to support immersion.

9.2 Interactive Animals

- **Animal Types:** The scene includes six friendly animal models: a horse, a chicken, a deer, a dog, a cat, and a corgi.
- **Positioning:** Animals are spaced across the environment to promote exploration and movement.
- **Interaction Mechanism:** Each animal is equipped with a collider and interaction component (e.g., `XR Grab Intractable` or custom trigger zone). When touched, the animal plays a corresponding sound clip (e.g , the cat meows).
- **Animation (Optional):** Simple idle or reactive animations may be included to increase believability (e.g., tail wag, head turn).

9.3 User Interaction Characteristics

- **Encouraged Exploration:** The child is free to walk around the environment and interact with animals in any order.
- **Cause and Effect Learning:** Every time the child touches an animal, a clear auditory response reinforces the concept that actions lead to reactions.

9.4 Therapeutic and Educational Goals

- Reduce tactile defensiveness and fear of touching living creatures or people.
- Improve understanding of animals and encourage emotional connection.
- Teach the fundamental cognitive concept of cause and effect.

9.5 Design Features:

The environment is calm and welcoming, with soft lighting, minimal visual elements, and ambient background audio to prevent sensory overload. At the entrance to the corridor, a guide character designed as a young girl offers non verbal cues and remains visible throughout the scene, serving as a constant visual anchor.

When the button is pressed, a gentle haptic and visual response is triggered to confirm interaction. The door then opens to reveal a white transition screen, followed by a brief loading time of approximately two seconds, before the therapeutic game begins. This sequence ensures a smooth and predictable transition, which is essential for maintaining a sense of control and emotional stability in children with Autism Spectrum Disorder (ASD).

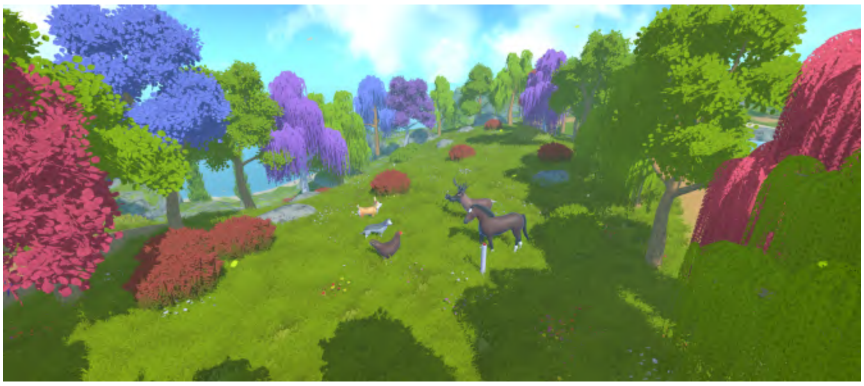

Figure 4.8: Animal Interaction Forest

9.6 Therapeutic Objectives:

- Promote executive functioning by allowing the child to make decisions independently
- Support the development of hand-eye coordination through interactive button-based input
- Enhance visual-spatial perception by encouraging spatial navigation and recognition
- Build self confidence by positively reinforcing successful interactions with visual and auditory feedback

The scene also features an unobtrusive auto-assist system that gently guides the child without overwhelming or distracting them, thus preserving a safe and engaging environment that encourages independent exploration.

10 Focus Cups Game Scene

The Focus Cups game is designed to enhance visual attention, hand eye coordination, and aiming precision skills that are often underdeveloped in children with Autism Spectrum Disorder (ASD). This scene features a set of colorful cups arranged in a pyramid formation.

10.1 Scene Setup

- **Cup Arrangement:** The cups are instantiated as 3D objects arranged programmatically into a stable pyramid shape. Each cup is a physics-enabled rigid body to allow realistic interactions.
- **Materials and Colors:** Each cup uses distinct, vibrant materials to aid visual discrimination.

10.2 Launching Tool

- **Types:** The player is equipped with a launching tool, which can be either a tennis racket for direct hits or a trebuchet style launcher for controlled aiming.
- **Mechanics:**
  - The launcher allows the child to place a ball inside, pull back via grab and pull mechanics implemented with the XR Interaction Toolkit, and release to launch the ball.
  - Physics forces are applied on release to simulate realistic ball trajectory.

10.3 Reset Functionality

- The child can reset the game state at any time:
  - Refill balls (instantiating or resetting ball objects).
  - Reset cup positions to their original pyramid layout.
  - Return the launcher to its default resting position.
- Reset triggers are implemented as UI buttons or physical interactable objects in the scene.

10.4 User Interaction and Feedback

- The interaction is designed to be forgiving and encourage repeated attempts without pressure.
- Visual and auditory feedback (such as sounds on hits or resets) reinforce engagement and provide clear cues.

10.5 Therapeutic Objectives

- Improve concentration, motor control, and precision within a supportive and playful environment.
- The simplicity and engaging mechanics make the game appropriate for children with mild to moderate ASD, particularly those with challenges in attention and fine motor skills.

Figure 4.9: Focus Cups Game Scene

Part II

Analysis & Therapeutic Impact

1 Comparison with Existing VR Projects for Children with Autism Spectrum Disorder

1.1 Detailed Overview of Existing Projects

In the field of Virtual Reality (VR) development for children with Autism Spectrum Disorder (ASD), several pioneering initiatives aim to support emotional, cognitive, and behavioral skills. Below are some of the most notable projects:

1.1.1 Floreo

- **Developer:** Floreo Inc. (USA)
- **Target Group:** Children aged 5–18 with ASD
- **Interaction Mode:** VR headset with guided sessions by a therapist or parent
- **Content:** Over 200 lessons covering greetings, facial expressions, and social interactions
- **Goal:** Improve social and behavioral skills in a safe environment
- **Technology:** Meta Quest, iPhone VR, therapist dashboard
- **Outcomes:** Improved social responses shown in pilot studies
- **Strengths:** Extensive content, structured guidance, user-friendly
- **Weaknesses:** Subscription-based, English only, internet required

1.1.2 Autism VR

- **Developer:** UK academic institutions in partnership with autism centers
- **Target Group:** Children aged 6–14
- **Interaction Mode:** Independent exploration in VR environments
- **Content:** Simulated everyday scenarios (e.g., doctor's visit, shopping)
- **Goal:** Reduce anxiety and prepare children for real-life situations
- **Technology:** Unity-based, HTC Vive, Meta Quest
- **Outcomes:** Reduced anxiety levels through exposure
- **Strengths:** Realistic scenarios, clinical testing
- **Weaknesses:** No emotional training, not suitable for severe autism

1.1.3 BRAVE VR

- **Developer:** MindTech and NHS (UK)
- **Target Group:** Adolescents and children with ASD and social anxiety
- **Interaction Mode:** Therapist-led exposure therapy in VR
- **Content:** Gradual exposure to public speaking, transport use, etc.
- **Goal:** Help children manage social anxiety
- **Technology:** Realistic environments with sound and tasks
- **Outcomes:** Improved coping after several sessions
- **Strengths:** Evidence-based, structured therapy
- **Weaknesses:** Therapeutic focus only, not suitable for young children

1.1.4 Smileys

- **Developer:** European educational initiative
- **Target Group:** Children aged 4–10 with ASD
- **Interaction Mode:** Game-based VR using cartoon avatars
- **Content:** Recognition of emotional facial expressions
- **Goal:** Develop emotional awareness
- **Technology:** Unity, 3D characters
- **Outcomes:** 30% improvement in emotional recognition
- **Strengths:** Child-friendly design, engaging visuals
- **Weaknesses:** Limited depth, no progression or real-life context

1.2 Comparative Analysis

Criteria	**Floreo**	**Autism VR**	**BRAVE VR**	**Smileys**	**Proposed Project**
Age Range	5–18	6–14	10+	4–10	3–7
Content Focus	Social behavior	Real life prep	Anxiety therapy	Emotion recognition	Multi skill(focus, emotion, interaction)
Interaction Mode	Guided sessions	Independent	Therapist-guided	Simple gameplay	Hands, gaze, voice, full body VR
Localization	No	No	No	No	Yes (Algeria-focused)
Skill Progression	Moderate	Low	High	Weak	Adaptive and expandable
Strengths	Rich lessons, therapist tools	Realistic scenarios	Evidence-based	Fun and visual	Multi skill, flexible, local context
Weaknesses	Subscription, language barrier	Lacks emotional dimension	Not for young kids	Basic, short-term	Still a prototype

Table 4.2: Comparison Between Existing Projects and the Proposed VR Prototype

1.3 Summary of the Comparison

This comparison highlights that while existing VR projects provide valuable tools for supporting children with ASD, they often focus on a single developmental aspect such as social behavior, emotional recognition, or anxiety reduction. In contrast, the proposed project offers a more comprehensive and flexible experience, supporting multiple developmental goals simultaneously (attention, emotion, interaction, focus) in a playful yet therapeutic environment.

Additionally, it is designed for children aged 3 to 7 and takes into account the limitations of under-resourced regions such as Algeria. This local and inclusive approach, along with future adaptability, makes the prototype a promising foundation for future therapeutic VR applications.

1.4 What Distinguishes Our Project from These Initiatives

Firstly, we offer an **integrated collection of therapeutic games** that do not focus on a single skill but include improvements in attention, hand eye coordination, and motor precision. This diversity makes our approach more comprehensive and targeted towards a broader range of skills needed by children with ASD.

Secondly, our design considers **different levels of support required by children** by providing calm visual environments with warm colors and flexible interactions that allow children to experience the games at their own pace without pressure, enhancing their sense of safety and control.

Thirdly, we incorporate **psychological and emotional support elements** explicitly, such as a welcoming scene featuring a friendly character that makes the child feel secure and builds trust before game play begins. This aspect is crucial for achieving effective and comfortable engagement.

Fourthly, we focus on providing an **advanced sensory and motor interactive experience**, where games like "Focus Cups" utilise realistic physical launching tools that enhance fine motor skills in an enjoyable and motivating way.

Finally, we ensure that the child has **full control over the game play experience**, allowing them to choose when and which game to play, with easy options to retry and reset scenes. This promotes the child's independence and encourages repeated attempts and learning without fear of failure or pressure.

Through these features, we present a unique project that combines therapy, education, and fun, focusing on providing a safe and stimulating environment for children with Autism Spectrum Disorder (ASD) that supports their comprehensive sensory, motor, and emotional development.

2 Summary of Therapeutic Game Scenes

- **Welcome Scene**
  - Reduces anxiety and builds trust
  - Introduces the VR world in a calm and friendly manner
- **Doors Scene**
  - Encourages decision-making and spatial awareness
  - Builds confidence through interactive feedback
- **Focus Cups Game**
  - Enhances hand eye coordination and aiming skills

  - Improves concentration and fine motor abilities

- **Magical Storytelling Playground**
  - Stimulates imagination and creative thinking
  - Supports spatial manipulation and encourages free play

- **Shape Matching Puzzle**
  - Develops visual discrimination and spatial reasoning
  - Encourages problem solving with real time feedback

- **Eye Contact Challenge**
  - Promotes social engagement and eye contact
  - Builds confidence and reduces anxiety around gaze

- **The Magic Word**
  - Develops language skills and pronunciation
  - Connects words with their effects in an interactive way

- **The Friendly Forest**
  - Reduces fear of touch and improves social understanding
  - Teaches cause and effect through interaction with friendly animals

3 Overall Benefits

- Promotes attention, focus, and emotional engagement
- Uses positive feedback to build self-confidence
- Offers safe, non-judgmental play experiences
- Avoids sensory overload through careful design
- Allows free manipulation of the virtual environment
- Supports children across different ASD severity levels

4 Expert Opinions

4.1 Dr. Houssam Makhlfi Frantz-Fanon Hospital, Blida

According to Dr. Houssam Makhlfi, Head of Department at Frantz-Fanon Hospital in Blida and a specialist in Behavioral Psychology, Child and Developmental Psychology, and Autism Spectrum Disorders in children, the development of a virtual reality (VR) game specifically tailored for children with autism represents a highly valuable therapeutic and educational tool, especially when grounded in principles from cognitive and behavioral psychology.

He emphasized the following points:

- **Behavioral Impact:** The VR game offers autistic children the chance to engage in structured behavioral scenarios within a safe and controlled environment, which significantly aids in reducing anxiety and enhancing behavioral flexibility.
- **Audio and Sensory Regulation:** The games calm auditory elements help prevent overstimulation and foster better engagement through clear, soft instructions.
- **Visual Design:** Its visually minimalistic and structured environment enhances focus and promotes emotional comfort.
- **Long-Term Benefits:** With continued use, the game can contribute to improvements in emotional regulation, communication, and decision-making skills.

Dr. Makhlfi concluded that the integration of such VR tools in therapeutic settings is highly beneficial, provided they are used under the supervision of qualified professionals.

4.2 Ms. Fatiha Nouioua El Bahdja Psychological Clinic-Biskra

Ms. Fatiha Nouioua, a clinical psychologist with over 15 years of experience in psychological consultation and therapy, currently runs the El Bahdja Psychological Clinic. She specializes in various disorders, including Autism Spectrum Disorders.

Ms. Nouioua expressed strong support for the games concept and therapeutic potential, particularly for children with mild autism. She believes the game is already suitable for clinical application in her practice and sees real value in its current form. However, she also emphasized the importance of future enhancements to enrich its therapeutic scope. She expressed a clear interest in applying the game with her patients and provided constructive suggestions for potential features that could broaden its usability and effectiveness.

4.3 Ms. Fatima Ouanoughi Ouanoughi Institution for Psychological and Orthophonic Training - Biskra

Ms. Fatima Ouanoughi, founder of the Ouanoughi Institution for Learning, Training, and Psychological Orthophonic Consultation, expressed great enthusiasm for the VR game. She described it as highly promising and immediately applicable in her institution.

Ms. Ouanoughui emphasized her desire to implement the game across all therapeutic stages under her supervision. She highlighted the potential of the game to evolve into a comprehensive intervention tool through structured development and ongoing collaboration. Her feedback included numerous ideas for additions and improvements that could further enhance the games educational and therapeutic impact.

5 Conclusion

In summary, the eight carefully designed scenes collectively create a comprehensive and supportive virtual environment tailored to the diverse needs of children with Autism Spectrum Disorder. Each scene targets specific developmental skills, ranging from emotional readiness and social engagement to language acquisition, motor coordination, and cognitive flexibility. By blending therapeutic objectives with playful and interactive experiences, the VR application fosters learning in a safe, engaging, and pressure-free setting.

Moreover, the thoughtful design prioritises sensory comfort and gradual skill building, ensuring that children of varying ASD severity levels can benefit at their own paces. The integration of positive reinforcement and intuitive feedback further encourages sustained motivation and confidence.

Overall, this multi-scene approach highlights the potential of virtual reality as an innovative tool to enhance therapeutic interventions, supporting children on the autism spectrum to develop essential skills that promote their communication, social interaction, and personal growth.

Conclusion and future work

One of the most complicated and difficult developmental disorders affecting children globally is autism spectrum disorder (ASD). Innovative and readily available intervention strategies are particularly needed in areas like Algeria that have limited treatment resources. Through the creation of a serious game, this thesis explored the potential of virtual reality (VR) as a supportive tool for early intervention in children with autism.

We created an interactive virtual reality experience suitable for people with varying levels of autism severity (mild, moderate, and severe) using Unity and the Meta XR SDK. The design of the game placed a strong emphasis on social engagement, communication, emotional identification, and focus skills that are frequently impacted in children with ASD. The use of game-based learning in a virtual setting allowed us to create engaging, safe, and controlled experiences that can be tailored to the needs of each child.

The early results of the game testing showed that the children responded well to it and became more engaged. The promise of virtual reality (VR) as an assistive therapeutic tool was highlighted by improvements in attention, emotional reaction, and interaction with virtual environments. Although this prototype is only a starting step, it shows that incorporating VR into autism therapy is both feasible and promising.

Based on the development process and the initial findings, several future directions are proposed to enhance the impact and utility of the game:

- Expand testing in a broader population and in collaboration with autism therapy centers to validate the long term impact of the game.
- Develop additional game levels with increasing complexity to better match the progression of each child's cognitive and behavioral development.
- Integrate a database system that allows therapists and specialists to track and monitor the progress of children using the game, facilitating personalized therapeutic follow-up.
- Include a wider and more accurate range of autism symptoms, including subtle and specific behaviors, to improve diagnostic and therapeutic coverage.
- Encourage interdisciplinary collaboration between developers, psychologists, and spe-

cial education professionals to ensure the alignment of therapeutic goals with technical features.

- Explore complementary technologies, such as eye tracking and biometric sensors, to personalize the VR experience based on real-time behavioral and physiological responses.

This work contributes to the growing body of research on the use of immersive technologies in special education. It provides a strong foundation for future efforts to develop engaging, therapeutic, and adaptable VR applications that aim to improve educational outcomes and the overall quality of life for children with autism.

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