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Article

BrightSpaces: Interactive 3D Learning for Children on the Spectrum

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Abstract

This research offers a specific 3d learning environment using the most recent technological hardware and software. The learning environment's hardware includes a projector and a specially designed room structure, as well as a Kinect device for gesture recognition. The application Autism Spectrum was developed on Filter and Dart and incorporates activities for varying learning levels, such as matching and challenging puzzles. Integration strategies for software and hardware incorporate Kinect for gesture interaction, synergetic fluid learning, and sensor-based requirements. Children with autism offer great insights for the continuous evolution of the design and development of new learning tools. The research investigates how well environments enable the development of cognitive and social-emotional skills and how adaptive they are in learning styles. Addressing the challenges of technology supports the development of new initiatives. The autism study results emphasize research and development projects for new educational games, collaboration activities, and 3d learning environments for children with autism.

Keywords: Autism Spectrum Disorder; 3D Learning Environment; Special Education; Educational Technology; Visual Learning.

1. Introduction

The convergence of technology and education has created a new era of opportunities, especially in assisted learning environments that are specifically designed to meet the diverse needs of people with autism spectrum disorder (ASD) [1]. Amazing Care is the impact of one in 54 people in the US TSAI struggle with this nervous development. Creative Initiative "Autism Learning" Inspired The need to close the differences in education these children face [2]. The degree of violation varies, but in highly racial people, these symptoms can lead to social exclusion and creation impaired friendship and employment maintenance and maintenance (for affected adults) [3] . Traditional intervention approaches generally require intensive support to solve problems with direct supervision of a well-trained professional. However, professional assistance and equipment are not always the cost of interference and inaccessible costs of affordable shortages make it accessible to many people with races therapists who need to develop new and effective tools to assess and intervene in TSA [4]. In recent years, rapid advances have been made in the development of Virtual Reality Technology (VR) and its use for relaxation and education. Virtual reality has become an effective approach in many areas of healthcare. Diagnosis [1], rehabilitation [5], surgical training [6] and psychiatric treatment [7]. Wide Applications technology has encouraged many researchers to consider the possibilities and efficiency of virtual reality implementation. Techniques for assessing and treating race [8, 9] . This article attempts to provide an updated review of the emerging field to summarize the current perspectives and identify future directions. At its core, the initiative aspires to wield a profound social impact by affording autistic children access to a tailored learning environment. Recognizing that conventional two-dimensional (2D) educational resources often fall short of sustaining the interest, engagement, and drive necessary for meaningful learning in children with ASD, the project sets out to chart new territory. The limitations of existing educational tools manifest in the form of limited engagement, shorter attention spans, and inadequate learning outcomes.

The articulation of goals and objectives for "Autism Learnability" is comprehensive and forward-looking. The overarching goal is to create a 3D learning environment that not only addresses the cognitive, social, and emotional development of autistic children but does so in a manner that is engaging, individualized, and socially interactive. The project aims to facilitate skill acquisition, monitor progress, ensure accessibility and usability, involve parents in the learning process, and strive for continuous improvement based on user feedback and technological advancements.

1.1. Objective

The objective is to advance 3D learning environments, focusing on the expansion of educational games. It discusses plans to introduce new interactive modules designed to improve sensory and cognitive skills. The emphasis is on ongoing innovation in investigating game-based learning to address evolving needs in education. It aims to create a flexible and responsive platform that accommodates a broader variety of learning objectives and preferences through the inclusion of additional learning games.

It examines possibilities for cooperative R&D to promote additional advancements. Enhance comprehension of the connection between special education and technology, which facilitates collaboration among educators, practitioners, and technologists. The aim is to foster collaborative efforts to share knowledge, utilize shared experiences, and enhance the creation of engaging learning settings for children with autism.

1.2. Literature Review

Table 1. A Related Work Table

Year	Author	Approach	Methodology	Strength	Weakness
2010	Yufang Cheng et. al. [10]	Using a 3D Empathy Framework from a Collaborative Virtual Learning Environment (CVLE) to Enhance Empathy Education for Children with Autism Spectrum Conditions (ASC).	Three ASC children participated in a pilot program using the CVLE-3D Empathy System, which improved their understanding of empathy in everyday situations and increased	Creative application of technology to overcome the empathy deficit in ASC with fruitful results in the real world.	Limited generalizability, small sample size, and some technological issues.

			their empathic response scores.		
2011	Alessandro Trivilini et.al. [11]	Presents a new multi-modal 3D learning environment for autism that integrates iconic language for better accessibility and emphasizes user-centered design using the ICF paradigm.	Improves reliability through empirical testing with Esagramma, integrates FruitPath and WigWag approaches for user guidance, and uses the ICF* model for user profiles	Uses the ICF* model for user profiles, includes WigWag and FruitPath methods for user guidance, and uses Esagram for empirical testing to increase trust.	Limited variety of materials due to time constraints, variability in wig mark identification among users, and imprecise cognitive understanding of user actions during testing.
2015	Yufang Cheng et.al.[1]	Using a single-subject, multiple-probe design to investigate the effectiveness of a 3D social awareness (3D-SU) system with a virtual head-mounted display (HMD) in improving social skills in children with autism spectrum disorder (ASD).	Using immersive 3D scenarios and assessing non-verbal communication, social arousal and social cognition using the Social Behavior Scale (SBS) and Social Event Checklist (SEC) during the initial, intervention and maintenance phases over six weeks.	Demonstrating significant improvements, especially in social initiative and cognition demonstrating the unique and engaging intervention platform of the 3D- SU system; positive feedback from teachers about the motivating effect of the system.	Acknowledging limitations, including a small sample size and the need for further investigation of generalizability
2017	Yiyu Cai et. al. [9]	Creating a dynamic learning environment for children with autism spectrum disorders using virtual reality technologies.	Comparison of immersive room and VR lab capabilities, integration of Kinect sensors and stereographic projectors.	Showcasing the latest technology and specially designed ASD learning environment solutions	Potential disadvantages include resource intensity and focus on specialized VR solutions, especially in the high-end immersive space.
2018	Lan. et. al. [12]	A design-based, qualitative approach focused on creating a Second Life	The two-cycle study combines classroom observations, videos, post-study interviews, and parent	Tailored instruction for students receiving special education, comprehensive data collection, and	Limited long-term evaluation, small sample size and reliance on

		3D virtual world for special education children to learn Mandarin.	comments to suggest principles for human-computer interface (HCI) design.	supporting evidence for the effectiveness of virtual environments.	Second Life technology.
2019	Maooadah S et.al. [13]	Creating the AutiVE system, a virtual reality (VR) environment based on Applied Behavior Analysis (ABA) therapy to help children with Autism Spectrum Disorder (ASD) feel less anxious and more comfortable in unfamiliar situations.	Integrating interfaces from the site and Unity landscapes, using the AutiVE system with the OculusGo headset and connecting to the phpMyAdmin database to enter the children's data. Nine autistic children were used as test subjects of the System using observations.	ABA therapy concepts are integrated into a virtual reality platform, offering children with ASD a realistic and immersive environment in which they can easily adapt.	Limited testing sample size, potential technical difficulties, and the need for additional research on the long-term effects and generalizability of the AutiVE system.
2020	Noah J et.al.[8]	To explore three-dimensional collaborative virtual learning environments (3D CVLEs) as intervention tools for individuals diagnosed with autism spectrum disorder (ASD), emphasizing their unique features and potential to address social-communicative challenges.	The study explores the possibilities of 3D CVLE, including controlled scenario practice, stimulus customization, and automated data collection that meet the individualized needs of learners with ASD.	Realizing the benefits of 3D CVLE to develop knowledge and skills in a safe and controlled manner.	Raising concerns about over-reliance on virtual environments and ethical considerations regarding the use of head-mounted displays in virtual reality for individuals with ASD; calling for further research, particularly in areas such as interpersonal social interaction and interventions for adults with ASD.

2022	Alessandro Frolli, et al [14]	VR emotional training and traditional ASD social skills therapy are compared.	Sixty ASD Level 1 patients were randomized to VR or therapy to determine how quickly emotions were learned.	A randomized assignment, multiple skill assessmentand comparative design.	The focus on short-term outcomes, the relatively short intervention period, and the sample size of 60 participants are potential limitations that could limit the generalizability of the results to long-term efficacy.
2023	Federic a Caruso et.al.[12]	The study uses a systematic literature review approach to comprehensively explore the immersive virtual reality (IVR)- based serious gaming (SG) landscape for individuals with autism spectrum disorders (ASD).	Examining IVR-based Serious Games (SG) for Autism Spectrum Disorders (ASD) focusing on team composition, HCI methodologies and offering a custom design framework	Finding Differences in Team Diversity, Challenging HCI Practices and Providing Practical Recommendations for a Custom SG Design System Adapted to ASD	Insufficient information about the writing team and possible gaps in the analysis of all relevant literature.

2. Materials and Methods

2.1. Architecture

This software development project is connected to the Autism Learnability initiative, which is specifically tailored to address the distinct educational needs of children with autism. This detailed examination analyzes the app's engaging functionalities, intuitive design, and overarching aim of fostering a distinctive and captivating educational journey.

2.1.1. Flutter Framework:

Adopting the Flutter framework is a tactical choice we made for our software development initiatives. This subsection discusses the resources that Flutter provides for designing attractive and adaptive applications. Autism Learnability offers cross-platform capabilities and a seamless, customizable interface that ensures a uniform user experience on various devices.

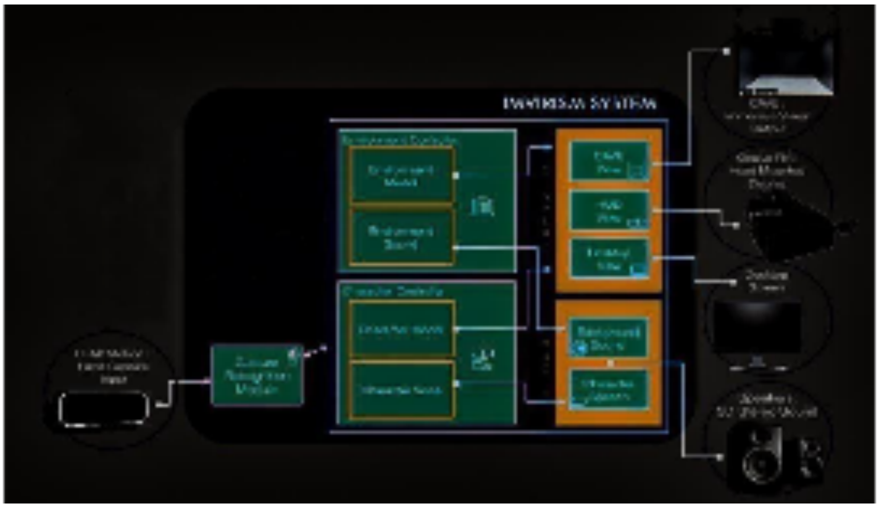

Figure 1. Architecture

2.1.2. Dart Language

The primary instrument utilized to ensure various elements of our application communicate effortlessly is the Dart programming language. This subsection examines how Dart facilitates efficient communication among different components, thus enhancing the overall responsiveness and optimal performance of the Autism Learnability project.

2.1.3. The Autism Learnability Application's Features

The wide range of features included in the Autism Learnability app demonstrates our commitment to providing engaging and diverse learning opportunities.

- **Matching Activity:** An in-depth analysis of the nature of the matching game, focusing on how interactive matching activities help improve cognitive skills. This section focuses on certain design decisions that address the sensory preferences of autistic learners.
- **Puzzle Challenge:** A comprehensive examination of the Puzzle Challenge module, highlighting its role in promoting spatial thinking and problem-solving skills. The talk provides insight into the design choices that make this module both challenging and accessible.
- **Color Education Module:** A thorough examination of the color learning module that explains its function and promotes color perception and learning. Dynamic images and interactive elements are discussed to demonstrate how individual design elements affect the learning process.
- **Number and Counting Activities:** An in-depth analysis of activities that demonstrate how interactive exercises improve mathematical understanding and numeracy. Design decisions that promote participation and understanding are emphasized for full understanding.

2.2. Hardware Configuration

2.2.1. Kinect Device

Using Gesture Recognition to Change How Students Interact: The center of our hardware configuration is the interactive device known as Kinect. This motion tracking technology enables children with autism to engage with their learning environment in a more fluid, instinctive, and real-time manner.

2.2.2. Projectors

The Implementation of an Immersion Learning Environment: A projector is necessary for any immersive learning environment. The interactive and educational content is carefully projected, transforming the environment into a multi-sensory, engaging, and immersive learning experience.

2.2.3. Physical Environment Tailored to the Needs of Autistic Children

There is a systematic design to the spatial arrangement, the color schemes and layout, and every design element to ensure that the children with autism are safe and comfortable. This design promotes optimal learning.

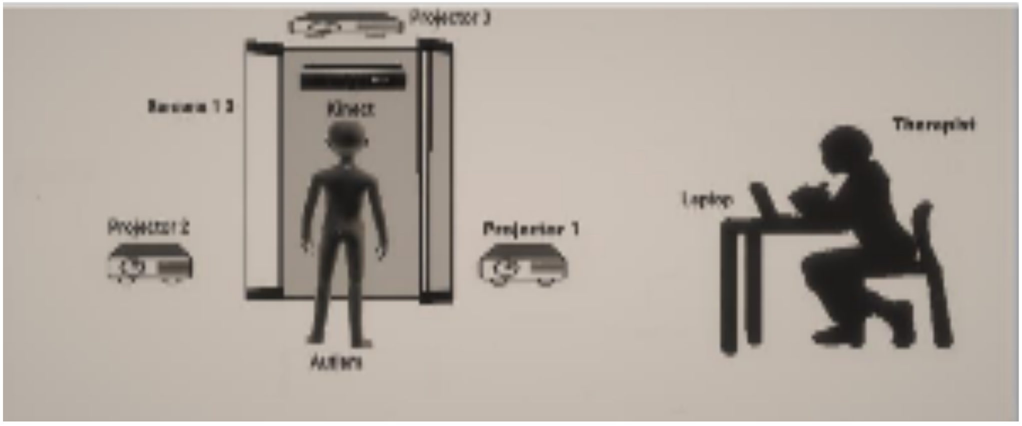

Figure 2. 3D Physical Environment for Autism

2.3. Integrated Hardware Setting up for Enhanced Learning

An effective educational experience for autistic children requires creating an enriching learning environment. The construction of this space is highly personalized and goes outside the traditional learning space windows to cover interactivity, sensory elements, and the physical environment. Design and planning are done to incorporate user-specific elements, as well as interaction and planning frameworks. A rich and inclusive environment is achieved through flexible and adaptive frameworks for every learner. Attention to design, even at the basic level, provides immediate enhancements to the experience and has far-reaching effects on development and well-being for children with autism. In other words, creating an enriching learning environment is an active effort informed by thoughtful design intent focused on every child's educational experience.

- **Utilizing Kinect as a Mouse for Gestural Interaction:** The use of the advanced Kinect device as a mouse to facilitate gesture-based interaction exemplifies a seamless integration of hardware and software. This part examines the innovative approach of the Autism Learnability program in utilizing Kinect's gesture recognition features to offer a user-friendly, interactive learning setting. Single movements are examined thoroughly, demonstrating how they convert into significant interactions and connect the disparity between actual movement and virtual engagements.
- **Creating a Consistent Educational Framework:** This section explores the thoughtful design factors necessary for achieving a seamless learning experience through the effective integration of hardware and software components. By combining the Kinect device with the Autism Learnability program, we intend to provide a smooth and captivating educational experience. The conversation covers immediate responsiveness, synchronization techniques, and the general effect on user involvement and awareness.
- **Addressing the Sensory Requirements and Preferences of Children with Autism:** This section outlines the intentional strategies employed during the integration process to foster an

inclusive educational setting that acknowledges the varied sensory needs and preferences of children with autism. We aim to lessen sensitivity and enhance the user experience by reworking hardware and software elements to suit various sensory profiles. Certain features like adjustable settings and sensor-friendly design choices are emphasized to showcase the commitment to customizing the educational experience for the requirements of every learner.

Figure 4. Learning Modules

3. Results

This section carefully evaluates the effectiveness of 3D learning environment using both quantitative and qualitative metrics. Using empirical evaluations, they quantify the effects of immersive settings on learning outcomes, user enjoyment, and cognitive development. In the conversation, the effectiveness evaluation methods, data analysis, and the impact of results on the field of special education as a whole are discussed.

Although children with autism have a wide range of learning styles. While incorporating adjustable settings and customizable features, it is designed to meet a variety of learning requirements. Collecting direct observations and input from autistic children interacting with the 3D learning environment is essential to develop user-centered design. The qualitative component provides insights into how users interact with the program, navigate the immersive environment, and respond to the integrated hardware elements. The goal is to enhance the learning environment by incorporating end-user perspectives and experiences based on real-world interactions.

The aim of integrating elements of play into learning activities is to enhance memory retention, critical thinking, and abilities for resolving issues. Instances from the Matching Game, Puzzle Challenge, and various other modules demonstrate how technology assists children with autism in enhancing their cognitive abilities more effectively and in a more enjoyable manner.

The effects of 3D learning environments on social and emotional growth, emphasizes the dedication to comprehensive development. It aspires that the app's interactive and socially stimulating scenarios will assist autistic learners in improving their communication, empathy, and emotional regulation skills. Case studies and real-world instances underscore the positive impacts noted in social and emotional areas.

It also acknowledges the diverse educational possibilities across the autism spectrum. It seeks to provide an inclusive and accessible learning experience by customizing the program to accommodate various learning styles, sensory sensitivities, and cognitive skills. The discussion addresses adjustments implemented to fulfill personal needs, ensuring that every user attains optimal learning outcomes.

4. Discussion

This part provides a critical analysis of the difficulties encountered in the development of 3D learning environment technology. From software complexities to hardware integration issues, it transparently addresses emerging issues and implements calculated solutions. The focus is on the iterative process of solving technical problems to guarantee the continuous operation of the immersive setup. It provides insights that can guide future advances in the connection between technology and special education, outlining our approach to problem-solving.

Adapting educational solutions presents clear obstacles due to the heterogeneous spectrum of autism. This subsection explains the subtle strategy used to address individual differences on the autism spectrum. It covers the customization options built into the hardware and software to support and meet the diverse requirements of autistic learners, from sensory sensitivities to various cognitive scores. This environment describes pragmatic approaches and flexible methods developed to promote inclusion in 3D learning contexts.

4.1. Future Work

A crucial component of the future vision is the incorporation of this 3D learning space into official educational programs and institutions. The aim is to create a smooth integration that improves the educational experience of autistic children in the classroom by coordinating our extensive educational platform featuring established curricula. This creative approach seeks to connect cutting-edge technology with conventional educational practices.

5. Conclusions

Our article promotes the cognitive, social, and emotional growth of individuals with special needs and provides an interactive, adaptable, and stimulating learning environment. An effectively crafted, inclusive educational setting can influence the learning experiences and overall well-being of individuals with autism. Ultimately, we consider the future and examine the consequences of our results for upcoming studies in this field. This part addresses possible avenues for upcoming research and development, elaborating on identified issues, solutions, and opportunities for collaboration. By acknowledging the evolving characteristics of technology in special education, we aim to inform and direct future initiatives, promoting ongoing innovation and enhancement in educational assistance for children with autism. We also aim to create mirrorless projection for implementation in virtual learning environments that assist children in obtaining special education more effectively and organically. Various studies assessing the advantages of offering interactive learning environments for children with ASD will be presented individually.

- Collaborate with autism centers to conduct pilot studies and gather feedback from therapists and children.
- Develop additional learning modules encompassing various academic and social skills.
- Explore integration with other assistive technologies to tailor the experience further. Investigate the potential for multiplayer functionality to promote social interaction.

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