RESEARCH PAPER

Enhancing Cognitive, Motor, and Sensory Skills in Children With Autism Through Microsoft Kinect Gaming

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ABSTRACT
Autism is a neurological disorder that affects brain information processing and prevents individuals from properly understanding things, hearing, watching, and sensing i.e. struggles with social interaction, verbal-nonverbal communication, and repetitive behavioral actions. Additionally, autistic children have a lack of Cognitive, Motor, Sensory Academic skills, and experiencing significant developmental delays. To enhance academic, motor, sensory, and cognitive abilities, efficacious interventions must be implemented. These interventions are beneficial for a child at the early stage of this disorder. In this paper, the proposed intervention method focuses on implementing gaming methods, such as gamification. A Unity game with the help of Microsoft Kinect is proposed here to provide occupational therapy for autistic children. This Kinect-based game is proposed for autistic children to play in an entertaining manner. Kinect sensor act as learning medium to increase skills of autistic children with intellectual deficiencies and motion based touchless gaming led to improvements of skills. Kinect approach is very suitable to improve cognitive, sensory and motor skills of an autistic. We looked at how this kind of intervention can be used to teach and model acceptable behaviors for Autistic youngsters in their early age as part of a positive behavior support plan. The analysis on three subjects shows the impact of this game for ASD.

Keywords: Autism, Kinect sensor, Participatory research, Unity Game design, Behavior, Child Health
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INTRODUCTION

Autism is an enduring neurological condition. Perverse interpersonal interaction, verbal and nonverbal communication, constrained and repetitive behaviour are characteristics of this disorder. The normal development of social interaction and communication skills [1-2] in the brain is affected by autism. Children with autism may exhibit aggressive and/or self-harming behaviors. They may also engage in repetitive activities, such as hand-flapping, peculiar responses to people or attachments to objects and become distressed at small changes; have strong sensory sensitivities and prefer certain textures to the exclusion of all others. These symptoms generate great concern when a child performs worse than before. Guardians observe abnormal signs in the initial twenty-four months of their kid's life. These indicators consistently increase.

There are both inherited and environmental factors that contribute to autism. Some occurrences are definitely related to pregnancy-related illnesses, such as rubella and alcohol or cocaine and other psychiatric drugs during pregnancy. This is also due to prenatal environment, age in either parent (m>40 years; f>40 years); diabetes, and bleeding during pregnancy.[3] As far as the author is aware, there is no confirmed cause of autism.

Early discourse or behavioural intercessions can help kids with a mental imbalance, increase self-care, social, and relational abilities. Even though Autism Spectrum Disorder (ASD) is not reparable yet, it is conceivable to mediate ahead of schedule in the lives of extremely introverted kids. ASD is typically examined between the ages of 2 and 6 when it is normal. Intercessions are means whose apply at an early phase of life. The benefit of the building up of mediating techniques are simply the experience expanded adequacy, a higher personal satisfaction and a developed legitimate accommodation to society of individuals with ASD. ASD can be interfered in two ways: behavioral or educational interventions, and through therapeutic care. At ASD, therapeutic care is typically not provided directly away. Prompt progress can be demonstrated with early diagnosis and suitable training. Parents and therapists both carry away. The interference toward individualized objectives for every kid, and worked cooperatively to enhance how the kids were reacting socially, playing

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with diversion, and conveying. Occupational therapy is provided as part of the intervention. It implies they may live on their own or with reduced reliance. Therefore, initially, it concentrated on the improvement of the cognitive, physical and perceptual abilities.

By adding digital technology, it can be used to customize computer games for children with limited physical skills, such as employing a gesture interface rather than a mouse or joystick controller skills. The appeal of these games, which use motion-sensing hardware to let users interact with the system and body movements, along with their affordability for kids to play at home, will encourage and involve children with low physical skill levels in physical activity and can function as an organized form of occupational therapy. From the author's point of view, the study offers a novel approach to redesigning PC games into motion-sensing interactive games that are appropriate for young learners.

Serious games aren't made only for fun but also they're made with specific skill sets in mind. It is referred to as a serious rehabilitation game when it is used as occupational therapy. It describes "rehab gaming" as any digitally structured activity that mixes enjoyment and therapeutic tasks. The name is a combination of the words "rehabilitation" and "gaming". Computer technology is used in motion-sensing serious rehab games to monitor gestures or body movements and utilize them to engage with objects displayed on the screen.

The Microsoft Kinect sensor is a computer input device that uses visuals to recognize gestures and body motions. [4] Because Kinect is intuitive, fun, and engaging, it breathes life into computer games. While some Kinect studies examine [5] children's play of already-available commercial Kinect-enabled games, others assess children's play of custom-designed structured games. In order to play the game, kids must insert body part motions that a Kinect sensor has tracked. From the standpoint of the developer, authors offer a novel approach for redesigning current video games so that they are pertinent for skill development. The idea behind this game is to use flashcards to practice new skills. Children with autism discover concealed object pairs in a box by carefully opening each one using the hand delay gesture. Through this game, skill is improved.

Cognitive skills are related to the core mental skills of our brain to think, read, learn, recollect reason, and pay attention for improving decision-making capability, problem-solving, pattern recognition, memory, focus, concentration, and anticipation. Motor skills are simply actions that involve our body using its muscles. When babies start to learn how to control the movement of part of the body through this game, hand stability is improved.

Sensory skills are the demonstration of watching, noticing, touching, testing, and hearing to better participate in daily exercises. Sensory skills are vital to a kid's development and individuals of any age see their surroundings. Approx. 90% of autistic people have sensory processing difficulties. Sensory skill directly impacts motor skill.

On the display unit, autistic children use their gestures to play games.

The child keeps making the same actions until all objects are matched. After interfacing the skill improvement game with a Kinect sensor, the controlled hand movements in either a seated or self-standing situation is considered.

MATERIALS AND METHODS

Virtual Reality (VR) technology finds application in a wide range of fields, including robot control, simulation, education, entertainment, and occupational rehabilitation. The fields of medical, healthcare, and rehabilitation are also developing VR applications.[6] Thus, the work done is too far to make traditional occupational therapy techniques interactive for children with autism is covered in this section.

The presented work [1] showed the valuable results of the current study about the enhancement of children's cognitive, physical, and academic skills using the Kinemes game.[7] They exhibit great promise and validate the preliminary hypotheses regarding the efficaciousness of Kinemes educational intervention within inclusive school settings. These results are consistent with those of other research conducted outside of schools to examine the benefits of computer gaming [8], particularly Kinect-based games.

Experimental Setup Development

The Kinect sensor is released by Microsoft for gaming purposes. It is a motion-sensing input peripheral device to track whole-body moment without utilizing any controller based on the concept of Natural Interaction (NI). The Human-Gadget partnership uses human senses, particularly hearing and vision to support this approach. The device has a depth sensor, an RGB color camera, and a multi-vector microphone (see Figure 1), allowing it to record facial expressions, gestures, speech commands, and body movements. The depth sensor can process scenes in any ambient lighting condition since it combines an infrared laser with a monochrome CMOS sensor. With the depth map of the acquired data, a process known as "skeleton tracking" is used to identify human forms (see Figure 2) and pinpoint the locations of the skeleton's many joints. For instance, locating the user's head, hands, and centre of mass is achieved by tracking their skeleton.

Figure 1. Kinect CMOS Sensor by Microsoft

Figure 2. Color and depth map captured by Kinect Sensor

Skeleton Tracking

The Natural User Interface (NUI) Skeleton Application Programming Interface (API) provides full details about the location of users (up to 2) standing before the Kinect sensor, including complete location and alignment information as shown in Figure 3. The data is provided to an application as a set of endpoints, called "skeleton positions", composed of a skeleton. A user's existing location and posture are represented by the skeleton.

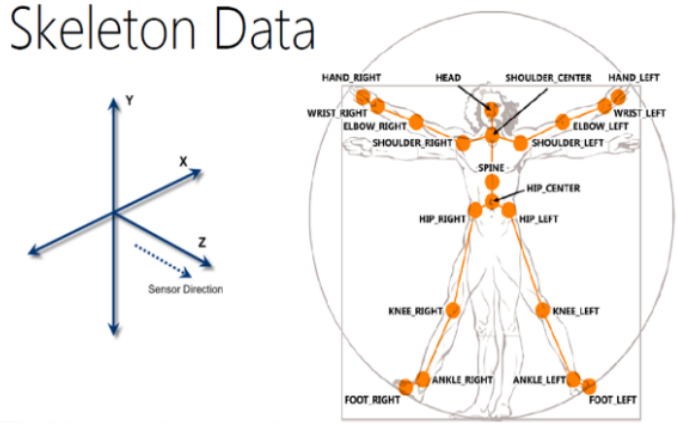

Figure 3. Skeleton Data

Applications of Microsoft Kinect

Although Kinect started off as a ground-breaking gaming device, its benefits are being seen in a variety of areas, including space exploration, healthcare, and skill development[9]. People may engage with a system in a natural way. Kinect is able to portray a room, a person, and the movement of things in three dimensions.

Occupational Therapy

Kinect based systems are widely used for disability person. Similar to autism, dyslexia, dyspraxia, dyscalculia, and Attention Deficit Hyperactivity Disorder (ADHD) [10-11]. These conditions cause problems with motor sensory, and cognitive functions. Youngsters with Special Educational Needs (SEN),

dyslexia, dyspraxia, dyscalculia, and ADHD [12-13], struggle with executive functions like maintaining information in working memory, focusing and visual perception, gross and fine motor planning, and execution as well as cognitive skills related to academic objectives, especially reading, writing, and mathematics. They find it more difficult to develop new abilities and behaviors as a result of these challenges than the majority of kids and teenagers age. Youngsters with SEN should therefore monitor specifically planned educational programs in schools and day care facilities, which are typically individual ones based on each child's special skills, weaknesses, and requirements. Kinect-based systems aid in providing occupational therapy.

Figure 4. Unbox It (Game)

Figure 5. A child with autism playing Unbox It game

Healthcare

Kinect based systems are widely used in hospitals. It helps surgeons to navigate and manipulate through X-Rays and scans of the patients with simple hand gestures, Kinect gesture recognition, and voice commands to communicate with patients just like a human doctor.[14] With the help of Kinect's NUI, it has an application for patients with autism and cerebral palsy in which users play games and Kinect tracks their body movements, analyses them, and prepares a report.

Education

Kinect plays the role of a teacher in smart classrooms. Kinect can convert any white screen into a touch screen with the help of a projector which makes learning easy.[15] Students can see their problems visually and solve them interactively.

Training

Kinect is also used as simulator which creates real time environment for the students[16] and can understand what is happening with system and get knowledge about that.

The Kinemes movement-based Occupational therapy games

A series of movement-based games called Kinemes is designed to assist educators and therapists in completely involving kids in learning activities that enhance their cognitive, motor, and academic abilities. Making use of hand gestures and their own intuitive body movements, children participate in the games in one-on-one interactive sessions supervised by a special therapist or educator who serves primarily as an observer and facilitator. Kinemes games are so extensively configurable that the experienced educator or therapist can adjust the game parameters (such as timing and difficulty level) dynamically, based on each youngster's specific requirements and performances in real time. Kinemes has been working to develop games that integrate academic, physical, mental and perceptual objectives including high degree of customization to meet the needs of the kids and a comprehensive system for tracking development [17].The games were created by combining the intervention protocols supplied by occupational therapists with the K–2 teaching

approaches offered by special educators in a variety of areas (such as arithmetic and literacy).

The game **Unbox It** (see Figure 4 and Figure 5) is on the concept of classic flashcards for improving visual memory. By opening the boxes one at a time using the hand delay motion, the children learn to discover the pairs of objects that are masked inside [18]. It is possible to support the kids' hand stability at various points on a virtual grid, language development objectives, and memory training all at once. Visual memory, early reading, and language development are all combined in this game since the player chooses which set of objects to put in the closed boxes. In order to test their visuospatial working memory, attention, focus, and processing speed in a unique way, players may also confront visual and audio distractions.

Participants and Setting

Three youngsters with Autism Spectrum Disorder enrolled in a comprehensive program at a local autism center. They were considered for this study's and treated as initial subjects. Preliminary data regarding the participant's behavior during the exercises was collected through direct observations and discussions with their mother and the instructor to establish a baseline for that particular behavior. Information gathered from participants was categorized as subjects 1, subjects 2, and subjects 3. Every participant went to the center for early intervention designed for young children diagnosed with ASD. A brief details about the children taken as participants were as follow:

Subject 1

At thirteen years old, he is capable of initiating and responding to spoken language through sentences. He quickly became involved in pretend play. The instructor said that he was developing cognitively well. He had earplugs on and was sensitive to loud noises, so he constantly hopped and leaped around. His reading abilities were developing.

Subject 2

At the age of eleven, the youngster lacked the ability to initiate or reply through spoken language. He laughed easily, and most of the time he answered by declaring that he detested certain sounds and that certain boosts associated to sounds were the source of his ear pain. It was also observed that he was easily distracted by surroundings.

Subject 3

He is ten years old, and he spent much of his time using a measuring tape for pretend play. His colorful speech was limited to identifying everyday objects and people. He licked his right thumb a lot.

Proposed Algorithm

The study is divided into three stages: a) baseline (before intervention), b) intervention using a social story provided via Kinect, and c) withdrawal from intervention (after intervention). The baseline and intervention phases are the first two that are carried out in that order. However, the last phase (on external demands) occurred a week after the intervention was concluded. Prior to the commencement of this study and any data collection, approval was obtained from the families of all the subjects.

Time devoted to each phase

Pre-Intervention Phase – The Process step were shown in Figure 6. Information on the participant's behavior during activities was gathered over the period of four weeks by direct observations and conversations with the educationalist and the participant's mother. Using this data, the exact subject and language for the social narrative's composition were decided.

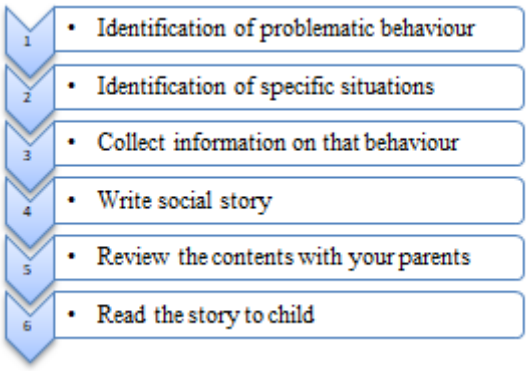

Figure 6. Flowchart for Pre-Intervention steps

Intervention's Stage – In this stage, various steps were taken as shown in the Figure 7. The sessions took around 10 minutes each and were conducted by the therapist or the subject's mother over a period of five weeks. Setting up the teaching area at a table and putting up the screen on the projector or laptop were part of the lesson preparation for the morning sessions, which ran from 11:00 to 12:00 a.m.

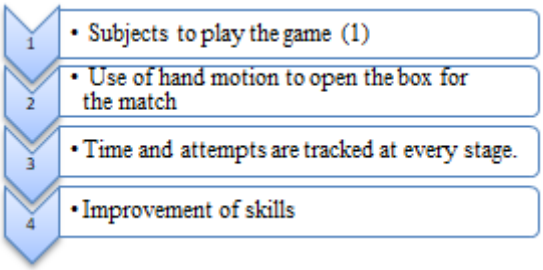

Figure 7. Flowchart Outlining the Intervention's Steps

Post–Intervention Phase

Figure 8 indicated various step taken in this phase. A period of approximately two weeks was employed to examine the child's behavior in natural settings.

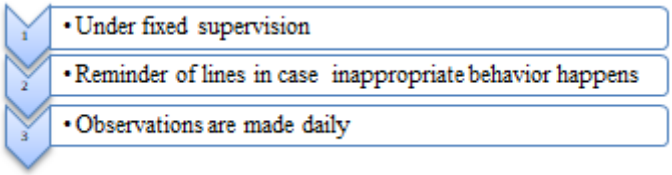

Figure 8. Flow Diagram for the actions taken after Intervention

Reinforcement

When the youngster successfully completed an intervention session, the mother or the teacher would give them a verbal felicitation. This kind of appreciation was also given to a participant for behaved well during the post-intervention phase.

Human Ethics and Consent to Participate: The experimental protocol was approved by the guidelines of SOCH Autism Society and NIT Jalandhar. Each of the processes were successfully carried out in accordance with the appropriate guidelines and regulations. Informed consent for participation and publication was obtained from parents/guardians.

RESULTS AND DISCUSSIONS

Three subjects were used in this article to test the intervention process, and their levels of disability were analyzed in the following areas:

Throughout their training and performance sessions, the participants spent about eight weeks being constantly watched over. The rating was determined by the trainers through observation and analysis of the child.

Subject 1

Three distinct levels namely level 1, level 2 and level3 were used for the instruction and observation. Figure 9 below displays the first subject performance analysis at level 1 in which two matches for objects were played using Kinect. Similarly level 2 with three matches and level 3 with four matches were played by subject 1 and performance analysis is recorded as shown in Figure 10 and Figure 11, correspondingly.

The mother and his trainers were familiar with the child's fundamentals, so they were able to observe him during the first level (Level: 1). Since they had been working with him for the previous five years, the trainers have provided the necessary information.

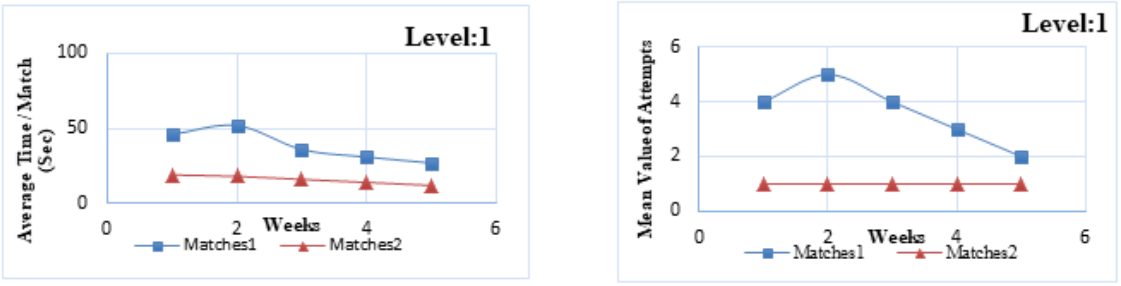

Figure 9. Graphical Representation of Performance Result of Subject 1 during Intervention at Level 1

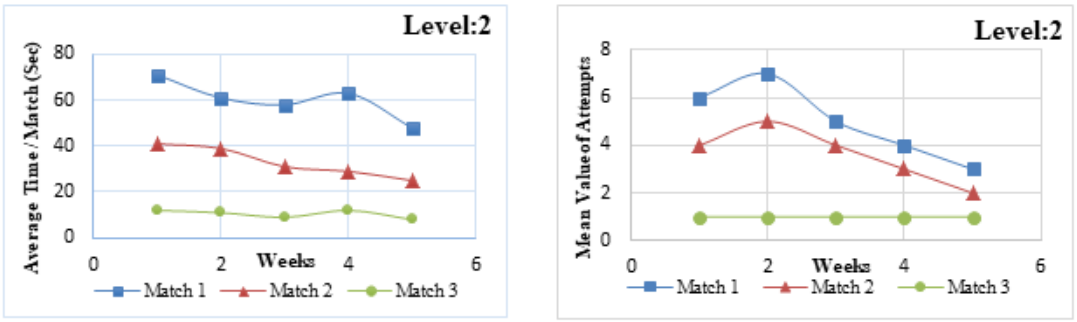

Figure 10. Graphical Representation of Performance Result of Subject 1 during Intervention at Level 2

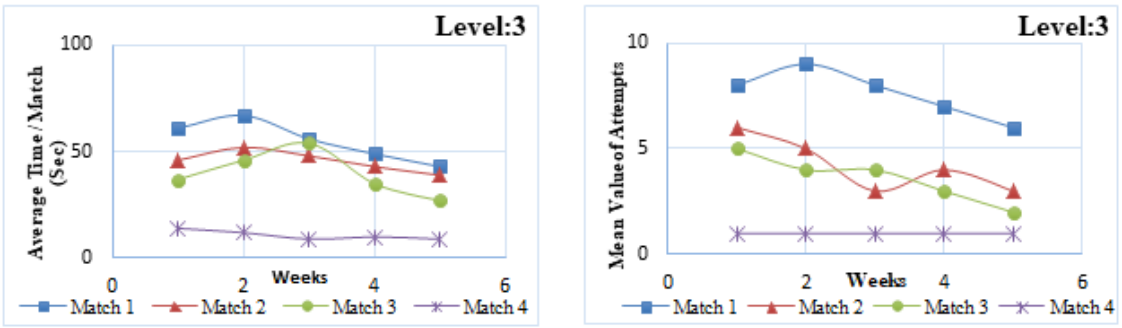

Figure 11. Graphical Representation of Performance Result of Subject 1 during Intervention at Level 3

The authors absorbed skill progress throughout all Levels. The performance of the subjects in each of the three intervention levels is displayed in the various graphs.

Subject 2

There were three levels (Level 1, Level 2 and Level 3) for the training and observation. Figure 12, Figure 13 and Figure 15 below displays the subject 2 performance analysis with two, three and four matches respectively during five weeks.

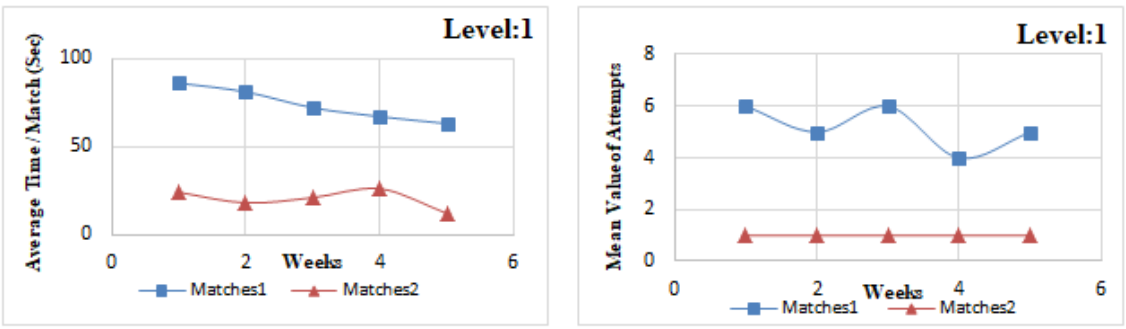

Figure 12. Graphical Representation of Performance Result of Subject 2 during Intervention at Level 1

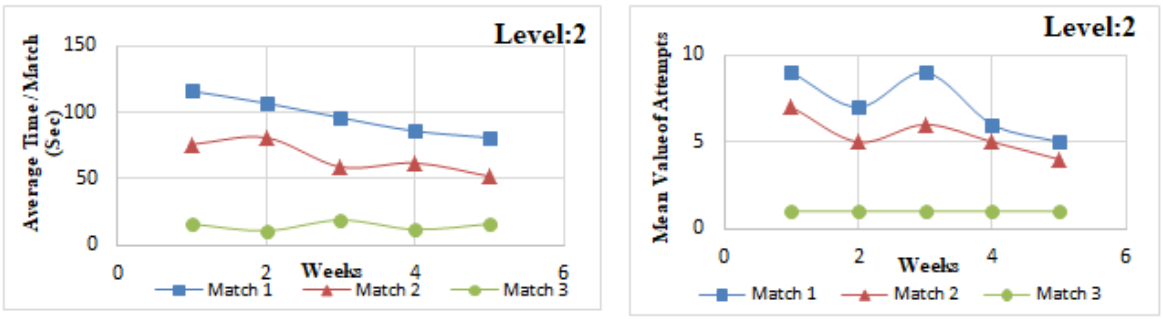

Figure 13. Graphical Representation of Performance Result of Subject 2 during Intervention at Level 2

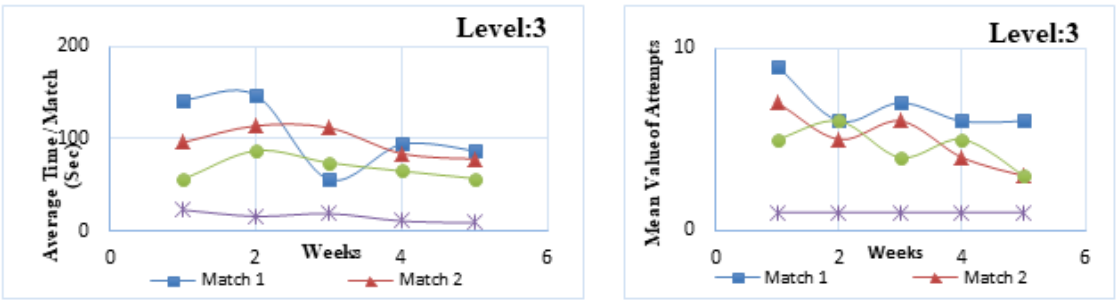

Figure 14. Graphical Representation of Performance Result of Subject 2 during Intervention at Level 3

Subject 3

There were two levels (level and level 2) for the training and observation. Figure 15 and Figure 16 below displays the subject 3 performance analysis with two and three matches at level1 and level 2, respectively during five weeks.

Traditionally, social stories are frequently used to teach autistic children appropriate behavior in various contexts. The objective of this exploratory study was to determine whether providing a social story on a laptop or projector may improve the social behaviors of participants with autism. A personalized approach was taken. The intervention was conducted one-on-one with the students in a preparatory classroom designed specifically for people with autism and occasionally at their homes.

All of the individuals responded effectively to the intervention phases and thoroughly enjoyed using the application. Subject 2 needed to practice more every day, as previously noted, while subjects 1 and 2 showed remarkably improvement from the baseline to pre-intervention phases.

According to the data the improvement rate difference percentage fell within a reasonable range. It is evident that using the program really aided in their comprehension of the material. In addition to this technology intervention, conventional teaching methods are also employed; however, this approach demonstrated a significant improvement within a specific timeframe. This is a result of the autistic children's intense interest

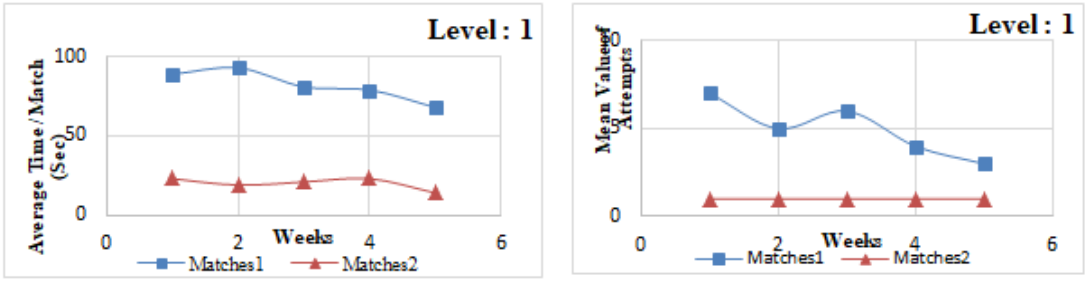

Figure 15. Graphical Representation of Performance Result of Subject 3 during Intervention at Level 1

in using a projector or laptop for play. In addition to the trainers, the mothers of all three subjects thoroughly enjoyed instructing their kids on the application's requirements.

The subjects at the training centers utilized the application twice a day. We were quite meticulous in tracking each subject's performance over the course of all three phases and at all times. We addressed any challenges that the kids might have had and solicited input from the moms and trainers to determine whether the application needed any adjustments.

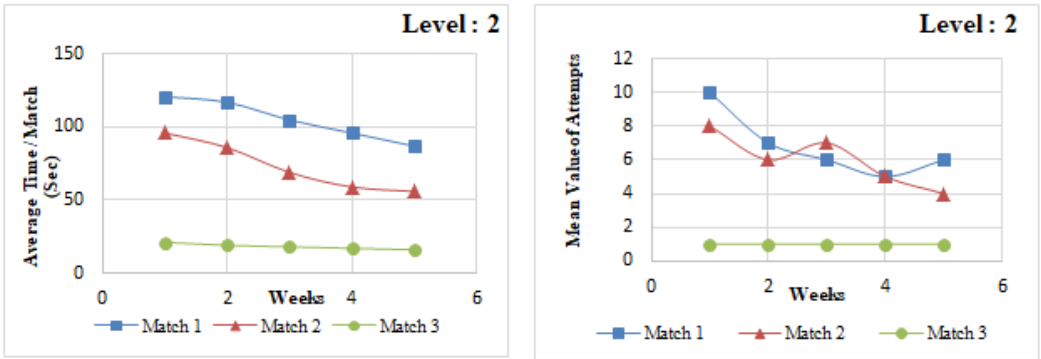

Figure 16. Graphical Representation of Performance Result of Subject 3 during Intervention at Level 2

Data gathered over a period of 20 weeks was analyzed, and the results showed that this approach worked. As predicted, the findings showed that the intervention was successful in altering the subject's point of view and raising their rate of attention to the job at hand.

Table 1: Result Analysis of Subject 1 across Phases

PHASE	**ANALYSIS**	
Baseline	*Consistent, slightly declining trend*	
	Lack of variability	
Intervention (Improvement)	**Level:1**	**Level:2**
	Time < 78sec	Time < 102sec
	Attempts < 11	Attempts < 14
Post Intervention (Better Improvement than Before)	*Cognitive Skills*	
	Motor Skills	
	Sensory Skills	

Table 2: Result Analysis of Subject 2 across Phases

PHASE	**ANALYSIS**	
Baseline	*Consistent, slightly declining trend*	
	Lack of variability	
Intervention (Improvement)	**Level:1**	**Level:2**
	Time < 69sec	Time < 95sec
	Attempts < 9	Attempts < 13
	Level:3	
	Time < 135sec	
	Attempts < 17	
Post Intervention (Better Improvement than Before)	*Cognitive Skills*	
	Motor Skills	
	Sensory Skills	

Table 3: Result Analysis of Subject 1 across Phases

PHASE	**ANALYSIS**	
Baseline	*Consistent, slightly declining trend*	
	Lack of variability	
Intervention (Improvement)	**Level:1**	**Level:2**
	Time < 58sec	Time < 86sec
	Attempts < 7	Attempts < 11
	Level:3	
	Time < 115sec	
	Attempts < 14	
Post Intervention (Better Improvement than Before)	*Cognitive Skills*	
	Motor Skills	
	Sensory Skills	

CONCLUSION

By giving autistic students immediate access to social information, Social Stories aims to reduce potentially confusing educational exchanges. Social story therapies have been utilized by researchers to teach functional skills, modify disruptive behaviors, and enhance social skills in children diagnosed with ASD.

Several gaming platforms were user-friendly, fruitful, and practical for children with ASD, and they dramatically enhanced their cognitive abilities[19-20]. In this study, a game is developed for all ASD-affected persons mentioned in

this paper, and the corresponding assessment and analysis are presented. Kinemes creates a series of educational games that involve movement to assist teachers and therapists in completely engaging children with special needs in activities designed to develop their cognitive, motoric, and academic skills. Children participate by using hand gestures to engage in autonomous interactive spell and natural body motions, supervised by a special educator or therapist who serves primarily as a facilitator and observer. Kinemes activities are extremely adjustable, allowing the learning support educator/teacher to dynamically and in concurrent modify activity milieu (e.g., timing, complexity) based on the individual's execution and particular requirements. This activity's further distinguishing characteristic is that records from children's activities are securely saved on a private cloud, allowing learners and educators to track individual's development and generate movement analysis data for all community members. Kinemes recognized the cutting-edge review on Kinect games-based learning, and literature review. It has been working to develop games that integrate academic, motor, and cognitive objectives with a high degree of adaptability to the demands of the kids and a thorough system for tracking their progress. Such activity gaming consoles were developed for special learning educators distinctively.

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