INVESTIGATING THE STRESS LEVELS OF CHILDREN WITH SPECIAL NEEDS IN VIRTUAL REALITY SNOEZELEN ROOM ENVIRONMENT FOR LEARNING

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ABSTRACT

As the number of children with special needs increases, the number of enrollments in special schools also increases. The common impairments faced by special children include difficulties in concentration during learning due to learning disabilities, communication problems, sensory sensitivities, and restrictive or repetitive behaviour. Some special needs children were uncomfortable wearing any equipment during learning, while developing a Snoezelen room can be expensive and requires high maintenance. A VR Snoezelen room can overcome the above problem and help special needs children feel relaxed and comfortable. This research aims to study the special needs children's responses in the Virtual Reality (VR) Snoezelen room system for learning. This research collected data via the experimental session on the stress levels of the special needs children before and after using the system. There were 10 special needs children who participated in this research, who were diagnosed with autism spectrum disorder, Down syndrome, and learning disabilities. Each participant was given three to five sessions based on the child's performance for them to complete the given tasks. The results show that 2 out of 10 participants had increased stress levels during first-time use of the VR Snoezelen room. After the second session, all the participants' stress levels were reduced after using the VR system. This virtual system can increase special children's concentration, improving their memory skills in learning while feeling relaxed when using the system.

Keywords: VR system; Children with Special needs; Autism Spectrum Disorder; Down Syndrome; Attention-Deficit/Hyperactivity Disorder; Learning Disabilities; Snoezelen room; Stress Levels.

1.0 INTRODUCTION

Special needs children are those unique children who need special care, extra attention, love, and proper education to deal with their daily life, or need support from caretakers or parents in doing things or socializing in school or at home. Parents and caretakers must be patient and tolerant in taking care of them to deal with mood swings, crises, anger, and financial challenges. There may be no immediate cure for these children, but it is treatable over time with the proper diagnosis or treatment, depending on the child's condition [1]. These special children may also need a wide array of diagnoses or therapy based on the child's condition or recommended by therapists or specialists. These children may frequently need medical testing, hospitalization, equipment, or accommodations for disabilities.

Early intervention during preschool or under age three is important to help children's developmental growth in skills, academic, emotional, behavioral, and social, and to decide what sort of support is needed while waiting for the right diagnosis to improve their quality of life [2-4]. That is why parents need to seek professionals' advice to help their children receive the right services, therapy, medication, and education needs. Treatment and diagnosis can be quite complicated and time-consuming, depending on specific needs, such as medications to control special needs conditions [5]. The cost of diagnosis and treatment services can be expensive because children may require many different therapies depending on the severity of the symptoms.

Special needs children usually have learning difficulties, restrictive or repetitive behaviours, sensory sensitivity, medical issues, developmental delays, mental health issues, food allergies, social and communication problems that last for a lifetime [6]. However, most special needs children have difficulties concentrating during learning due to learning disability, signs, and symptoms of special needs [1, 7, 8].

Special children could easily be distracted by sound, movement, or hyperactivity [1]. These children will easily get bored, stressed out, and depressed while at home, as they cannot sit in the same spot for more than 5 minutes compared with the activities at schools or centres [9, 10]. These may cause stress, anxiety, aggressive or self-injurious behaviours. Children with special needs can be in many categories, such as autism spectrum disorder (ASD), Down syndrome, learning disabilities, etc. Children with special needs are often skilled at using computers or modern technologies because they were exposed to them at home or in school. With the help of new technological approaches using sensors and virtual reality, various activities and interaction tools for learning platforms have been developed to provide a smart learning environment for special children to improve their education [11]. Sensors can help teachers or researchers monitor user progress and response to learning materials in real-time, provided an internet connection is available, and provide users with more effective learning experiences compared to traditional methods [12].

The Snoezelen room can be one of the best solutions to calm special needs children to minimize stress and improve their response towards learning. It is like a therapy room that provides many different types of functions, such as training, teaching, and learning methods, during treatment to make things more interesting and fun to learn. It has been proven that many special schools, hospitals, and centers use Snoezelen rooms to help children with special needs reduce stress levels and feel more relaxed and safer with the elements and learning materials inside the room. After the treatment, the children will be able to communicate, be active, have social interaction, and increase their knowledge [13]. There are a few studies that combine learning elements with Snoezelen room treatment for special children that include applied behaviour analysis, occupational therapy, sensory integration therapy, or more than one therapy using picture, word, colour, listening to audio, watching video, and touching objects for treatment and learning simultaneously [6, 8, 14-20].

Many special needs children could not go to the centres or access Snoezelen room therapy due to their conditions and limitations. Thus, a virtual Snoezelen room for special needs children to access therapy and lessons easily from home, by selecting suitable educational and training videos, can be considered. Examples of virtual reality with Snoezelen apps include the Virtual Reality Snoezelen Cave, Deep Virtual Reality, Virtual Reality Meditation, and Virtual Reality Snoezelen Room, among others. These special needs children love to learn abstract things like playing video games, watching videos, animation, colour, listening to music instead of words, and playing with modern technology such as smartphones, laptops, and computers [21]. This system consists of the Snoezelen room effects, such as touching, lighting, and sound effects, to allow special difficulties in concentrating and learning due to learning disability, signs, and symptoms of special needs. special children to feel calm and relaxed in a virtual Snoezelen room.

Although much work has been carried out in investigating the effectiveness of technologies for special needs children's learning, little work has focused on investigating the stress level of children with special needs in learning using the learning technologies. This research aims to investigate the stress level of special needs children in the Snoezelen room environment learning. For achieving the objective of this research, this research has conducted an experimental study with the focus group on their responses in the Snoezelen room environment using the VR system.

The remaining paper is sectioned as follows: Section 2 provides research background, which includes the review of the multisensory environment, such as the Snoezelen room, and the existing virtual reality applications developed for children with special needs. Section 3 describes the methodology used in this study in carrying out the data collection and the experimental study on the selected participants. Section 4 shows the results of the experiments conducted in this study. Lastly, Section 5 presents a discussion of the participants' responses and stress levels before and after using the system. Section 6 concludes the overall study.

2.0 RESEARCH BACKGROUND

Virtual Reality (VR) can be used in many areas, such as our smartphones, sports, entertainment, rehabilitation, and training purposes, to minimize human error, is cheaper, and can be managed easily [22, 23]. As technology advances, VR technology is widely introduced to improve the current education level and sensory integration apps to meet international standards. Many people are familiar with the term Virtual reality, but do not know the benefits of this technology other than gaming. There are reports showing positive outcomes of VR combined with modern technologies in special education [11, 24, 25]

VR can replicate the physical Snoezelen room in the form of a 3D world simulation, created using computer technology, enabling users to interact within that world [26]. A Snoezelen room or multisensory environment (MSE) is also known as a cave relaxation room, accompanied by a therapist. It has been used in hospitals, clinics, centers, and schools worldwide for people with special needs [27]. Existing Snoezelen research obtained positive results from people with developmental disabilities. It is designed to stimulate patients' senses using dim lighting, colour effect, touch, scents, taste, movement, sounds (listening to Quran or soft music), and textures to deliver a calm, relaxed, and safe space inside the multisensory environment and reduce stress. For example, elements used

in Snoezelen rooms are bubble glass tubes, fiber optic threads, ball pool, interactive panel, plush toys to play with, and white beanbags to sit or rest on for the person to feel a pleasant sensation with surrounding things like unique experiences and interesting light effects [28, 29]. The virtual spaces that allow special children to feel as if they are inside that world, exploring freely in a 360-degree view or interacting with objects in stereoscopic vision and spatialized sound. This method enables enhanced VR technology by reducing the cost of developing a physical Snoezelen room and the time for special children to have treatment and education at the same time.

Table 1: Existing Virtual Reality applications developed for children with special needs

No	Application	Purpose	Findings
1	VR Relaxation Space Room	Relaxation	Enable children with autism to feel relaxed through the dim lighting effect, music, video, reading, and the calming environment. However, the user is unable to grab the things inside the room.
2	VR florea	Education	Used to teach and train children with autism to learn social and communication skills in different environments or scenarios, understand emotions, overcome phobias, how to use a toilet/an airplane, storytelling, test their problem-solving skills, and perform various skills. Use interactive animation to help them learn to overcome their problems in daily life. However, the system needs to be controlled or monitored by the teachers or parents.
3	Rangi	Games	VR puzzle games are used for autism therapy. However, this system needs to be controlled or monitored by the teachers or parents.
4	VR Snoezelen room	Games and Training	Game-based learning consists of an animation effect created by Aatevr to invoke calmness for users with autism and other developmental disorders. However, this system needs to be controlled or monitored by the teachers or parents.
5	Blue Room	Training	A room created by Newcastle University to help autism children with autism overcome their fears and phobias in a 360-degree virtual environment, alongside a therapist using an iPad to control a variety of scenarios. However, this system needs to be controlled or monitored by the teachers or parents.
6	Sketchup, Vivecraft, tiltbrush and Medium apps	Education	Used for drawing and sketching to create 3D painting or 360 architecture using a paintbrush or tools. However, this system needs to be controlled or monitored by the teachers or parents.
7	Deep VR, Guided Meditation VR	Medication and rehab	Used soft music and breathing controller for meditation to reduce the level of stress, anxiety, and depression by controlling breathing and mind relaxation in a peaceful environment. It requires a breathing belt controller to record the data, and some samples of target behaviour do not meet due to missing data.
8	Neuro Rehab VR, Applied VR, Limbix, Psious and Verapy	Medication and rehab	Existing professional VR therapy platforms approved by professional therapists are used to treat anxiety, phobias, pain management, and rehabilitation needs. The kit, equipment, and the therapy can be expensive, depending on the patient's level of treatment needed.
9	AR Flashcards with VR headset	Education	Scanning animal alphabet using flashcard games to teach children words, sound, zoom in, played in 3D action, interaction between the elements. The system runs based on scanning flashcards. There was a limited number of flashcards per set. Education was taught in 3D animation and video.
10	Discovery VR	Exploring and education	Discovery TV channel that enables children to explore the natural location in 360 degrees and interact with our planet in a futuristic way. It is based on the video played, which has limited interaction.

The MSE is specifically designed to match the user's current motivation, interest, leisure, relaxation, therapeutic, and educational needs. Snoezelen intervention bring positive effect on special needs children and adult with the simulation or element inside Snoezelen room to improved their behaviours, development skills and recovery therapy to overcome pain, fear or phobia in both physical and emotional, increase the level of attention, feel relax, encourage them explore and decreasing the frequencies of aggressive and self-injury [7, 27-31]. The Snoezelen approach was more effective for individuals with special needs than traditional classroom [7, 31-33]. However, developing a physical Snoezelen room is costly as it requires a large amount of space to construct a physical Snoezelen room with lighting, furniture, and therapy equipment [30, 34]. Table 1 is an example of a VR technology application used to educate special needs children.

The majority of the system was only focused on language learning [35, 36], therapy [37-41] and gaming for non-educational purposes [42, 43]. There is a shortage of educational content in VR learning apps on the market to teach or treat children with special needs, as the original idea of VR was designed for gaming purposes. Some of the content in these applications might be unsuitable for educational purposes, as the focus is on playing games [42, 43].

Table 2: Comparison of the existing applications based on the features used for research simulation

Type of VR application	Exploring environment	Education	Game	Puzzle	Colouring	Drawing	Soft music
VR Relaxation Space Room	/						/
Rangi				/			
VR florea	/	/					
VR Snoezelen room			/				/
Blue Room	/	/					
Sketchup, Vivecraft, tiltbrush and Medium apps					/	/	
Deep VR, Guided Meditation VR	/						/
Neuro Rehab VR, Applied VR, Limbix, Psious and Verapy	/						/
AR Flashcards with VR headset		/					
Discovery VR	/	/					

Table 2 shows the categories of the apps based on seven different features, such as exploring environment, education, games, puzzles, colouring, drawing, and soft music. These systems were mainly developed for relaxing, education, gaming, and therapy purposes.

An example of a system for relaxation is the VR relaxation space room, which allows users to explore the environment in 360 degrees, accompanied by soft music and a dim light effect, to help them relax in the space. Users can also read books and watch videos for learning purposes. This system provides user-limited interaction with the object inside the room [37].

Examples of systems for educational purposes are VR florea and AR Flashcards with a VR headset for educating and training children with special needs in learning, overcoming their problems in daily life, and improving communication skills with others in different scenarios that replicate the real world. However, AR flashcards make use of a limited number of flashcards per set, severely degrading the learning process [36]. VR Florea was not available for Android devices, and children were unable to explore by themselves because the system was controlled by a teacher or parents using an iPad [35]. Discovery VR allows users to explore the environment in 360 degrees for educational purposes in a video-based based, and users have limited interaction with the objects inside the system [36]. The above three systems utilized 3D animation and video to teach special needs children, as they tend to enjoy abstract concepts. Sketchup, Vivecraft, Tiltbrush, and Medium apps allow users to draw, colour, and sketch to help users release stress or relax while learning [36]. Special needs children love to watch videos; animated effects, drawing, and colour. The existing applications help children with special needs relax and improve their memory, concentration, and communication skills in learning by making educational content more engaging for them.

Examples of systems for gaming are Rangi and VR Snoezelen room, which allow special needs children to play games only for therapy, without educational purposes, to help users relax, release stress, improve their memory skills, and test their problem-solving skills while playing games [42, 43]. They used a game-based learning method to make learning materials more engaging for children with special needs, who often enjoy playing games.

Systems for therapy are Deep VR, Guided Meditation VR, Neuro Rehab VR, Applied VR, Limbix, Psious, and Verapy. They were designed for special needs children therapy alongside therapists or specialists to guide and monitor them throughout the session for educational purposes. These systems use soft music to help special children feel calm and relaxed, to improve their breathing flow during therapy sessions. The equipment used was expensive, required a breathing belt to record data, and was guided by specialists [38, 39, 41]. Blue room requires a physical room to help special needs children overcome their phobias in different scenarios and be controlled by a therapist using an iPad [40]. These systems were used for meditation and therapy to help reduce the level of stress, treat phobias, pain management, and rehabilitation needs in special needs children by controlling breathing and promoting relaxation of the mind after the treatment. The VR system could help in improving therapy, reducing the cost of equipment and maintenance.

According to Table 2, no application combines all seven features for special needs children. The research gap reflects that the research aim is to combine education, gaming, and elements in Snoezelen rooms with VR to help children with special needs improve their concentration in learning and make educational content more engaging compared to traditional classroom methods, such as reading books.

Based on the characteristics of children with special needs and the benefits of the Snoezelen room, assist researchers in identifying the stress levels of these children in the Snoezelen room environment, which could be applied to virtual reality simulations. The existing application in Tables 1 and 2 above helps researchers to identify the types of existing applications' features and elements that could be used in developing the VR simulation to help special needs children be more focused and enjoy the learning.

The need to investigate the special needs children's stress level before and after learning in a VR environment is to help researchers evaluate or study the effectiveness of using VR learning on special needs children and to determine whether the child enjoys using the system in learning or the child feels agitated, uncomfortable, or stressed out after using the system.

Based on the previous studies, many of the special needs children's stress levels were improved when learning in special education centres or schools (special classes, Snoezelen room, and virtual system) as compared to regular classrooms due to a lack of support in the educational system, such as resources and assistants needed [44, 45]. Unlike special education centres or schools, the majority of the activities, facilities, or services provided by the regular schools were not tailored for special needs children [46]. For example, children with special needs were often less likely to do well in their educational development compared to non-disabled children when they feel stressed out or struggle with their academic performance. Some individuals may require more time or need to work harder to complete tasks in a regular classroom. While in a special school, intent to focus on the children's social and emotional well-being with the help of educational and teaching aids, most likely the child will be able to focus and perform well in their learning in a safe environment. [47].

The investigation of stress level in the majority of the previous studies above was rated based on the survey forms distributed to the caretakers, teachers, or parents' evaluation and observation on the special needs children's responses and performances in the classroom or at home, and not in real time, which will give more accurate results [48, 49].

This research makes use of the real-time results of the children's stress levels before and after using the VR system in the Snoezelen room for learning.

3.0 METHODOLOGY

This research aims to study the special needs children's responses in the Snoezelen room or classroom that could be applied to VR simulation. An experimental approach was used to record the stress level of the children with special needs in learning before and after using the VR simulation.

3.1 Participants

The data collection was conducted at Yayasan Faqeh and Pondoku at Nilai, Negeri Sembilan, and Petaling Jaya, Selangor. The three centres chosen in this study were specialist centres that have a few expert teachers who take care of the special needs children diagnosed with ASD, Down syndrome, and learning disabilities. There are 20 to 30 special needs children of a younger age (5-17 years old), and three to seven experienced teachers looking after these children. Each class has around 10 children with at least one or two experienced teachers to monitor and guide the children when needed during lessons. These centres do provide education programs, activities, and

training for special needs children to learn after school. These programs or activities can help improve their knowledge, daily routine, and help them overcome their problems. The centres used traditional learning methods in the classroom, such as storybooks, reading pen, videos, audio, colour, flashcards, and exercise methods to teach and improve special needs children's memory skills.

10 special needs children from 3 different centres mentioned above were chosen for this study. The average age of the participants was 14.3 years old. Fig. 1 shows a snapshot of the data collection process at the center. As shown in Table 3, the oldest participant is 17 years old and the youngest is 7 years old. Most of the participants were teenagers and familiar with using technology. Most of the participants were male; there were only two female participants. 70% of the participants were diagnosed with autism, followed by 20% with learning problems, and 10% were children with Down syndrome. Most participants were at a mild level, and one participant was at a moderate level. According to data collected from the first survey, only one out of ten participants had previously used VR at home. Although most of the participants have no experience in using VR, they are good at using gadgets, willing to try to explore, follow instructions, and guidance from both teachers and researchers.

Fig. 1: Data collection process involving special needs children at the selected centers

Table 3: Participants' details

No.	Participants Code	Age	Gender	Type of disorder	Level of disorder
1	SN	16	Male	Autism	Mild
2	ML	7	Male	Autism	Mild
3	FS	17	Male	Autism	Mild
4	AR	11	Male	Learning disabilities	Mild
5	AS	13	Female	ASD	Mild
6	IN	15	Male	Autism	Mild
7	CA	16	Female	Slow Learner	Mild
8	NL	14	Male	Autism	Mild
9	LI	17	Male	Autism	Moderate
10	IH	17	Male	Down Syndrome	Mild

3.2 Instruments

3.2.1 Checklist

The purpose of the checklists is to record the tasks the child needs to complete for each session, as indicated in Table 5.

3.2.2 Heartbeat Indicator

The Samsung health application is the heart rate indicator tool used in this study to measure participants' heartbeat (BPM) and stress level in real-time before and after using the system for each session recording during the experiment. This tool requires participants to place their finger properly at the heart rate sensor located at the back of the smartphone [50]. The stress level result will be shown in a range (low to high), and the heartbeat result will

be shown as a percentage after the measurement reaches 100 percent. Stress level can detect participants' mood to wear the HMD used for VR learning [48, 49].

3.3 Experimentation

3.3.1 VR Snoezelen room for special needs children learning

This VR system includes all seven features, such as exploring the environment, education, games, puzzles, colouring, drawing, and soft music for special needs children. Based on Tables 1 and 2 above, games and puzzle designs are created for users to play without educational content. However, this system does provide educational content combined with games (mix and match words) and puzzles for special needs children to play and relax while learning. Besides playing games. The proposed VR Snoezelen room can provide videos of lessons with educational content and colourful words to help children with special needs in learning. The reason to propose this VR learning method with elements of a Snoezelen room is to create a relaxing environment for special needs children and educate them to learn how to read and pronounce words by listening to sounds or watching educational videos. This VR system is portable, cheaper, and easier to manage compared to the cost of developing a physical Snoezelen room. The system replicates a real Snoezelen room in 3D form by using a black background, sound (listening to the Quran or soft music), colours, and videos to create the education content more interesting and fun to learn for special needs children. The VR technology allows users to explore the environment by viewing things in 360 degrees in a safe environment, and encourages users to explore freely. Special needs children love abstract things such as watching videos instead of reading books, listening to soft music, drawing, and colouring, which can help them feel calm and relaxed while inside the Snoezelen room. Table 4 presents the activities provided by this system, which combines all seven features mentioned above, making educational content more interesting and enjoyable for children with special needs.

Table 4: Example of 7 features activities provide in the system

Features	**Activities and purposes provided**
Explore environment	- View 360-degree background - Grab and touch object - Improve gazing on the object - Encourage user to explore and try new things
Education	- Follow to Read and listen - watching Education videos (play and pause) and select other videos to watch - Help them to focus - Learn to use VR headset
Games	- Mix and Match words to correct slot - With sound allow user to listen - follow to read the words - Memorize the word - Improve their memory and problem solving - Help them to relax while learning
Puzzle	- Rotate puzzle to correct position - Improve their memory and solving skills - Help them to relax while learning
Soft music	- Learning from listening to the sound - Natural sound to relax - Hear different types of sound - Choose different type of sounds
Colouring	- Select picture and colour the picture according number or randomly - Help them to relax after learning - Improve their solving skills
Drawing	- sketching help them to release stress

Wearing the head-mounted display (HMD) device offers better immersion in the content to improve user concentration and focus in learning and reduce getting distracted by the surroundings.

3.3.2 Process of conducting data collection

The researcher gets the special needs children's consent using the consent forms. All the data recorded will be kept confidential without revealing the participants' personal data or names in the articles to protect their privacy. The names of the participants will be recorded in code.

This research has obtained approval from Universiti Malaya Research Ethics Committee (UMREC) and authority from centres (Yayasan Faqeh and Pondoku) for conducting the experiment at the premises and for children with special needs. Before the experiment was conducted, researchers had distributed the participant information sheets and consent forms to all the participants' parents for data collection to get permission to conduct the experiment according to Universiti Malaya Research Ethics guidelines. The 10 participants are those who obtain confirmation from the teacher and parents' consent forms to participate in this research.

3.3.3 Conducting the experiment

The experiments consist of three sessions for each participant, during which each participant is expected to complete the experiment within the allotted time. However, some participants might need to take up to five sessions to complete all the tasks in the checklist due to user performance. The experiment was conducted at the centres with ample space around the child to prevent the child from getting injured when wearing the VR.

Based on Fig. 2, the experiment was conducted in a vast room with an office chair and a table to place the researcher's laptop [51]. The participant sits on a comfortable chair that prevents participants from getting injured and allows them to rotate the chair to view the virtual environment in 360 degrees. The researcher records each participant's heartbeat rate and level of stress before conducting the experiment to collect real-time data. Next, the participant is required to put on the head-mounted display (Gear VR) and adjust to a comfortable position to view the VR contents. Participants can use the system for 30 to 40 minutes to prevent dizziness and other issues. [52]. Researchers need to guide participants when participants have trouble using the system. There will be a break in between the sessions for 10 minutes for special children to rest and prevent cybersickness after using the system [53]. After the break, participants can decide whether to continue using the system or stop the session. Throughout the experiment, teachers or parents were allowed to accompany the child inside the room by standing at the side or beside the participant together with the researcher to monitor and observe the participant's stress level and performance in using the system through the AnyDesk screen mirroring application displayed on a laptop in real-time with an internet connection.

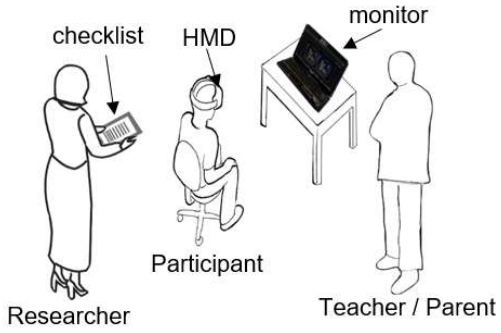

Fig. 2: Visualization of the experiment inside the room

In Session One, the researcher introduces the system's function to participants, encourages them to try using the system to relax, and helps users learn. Once participants are familiar with the system's functions, they can begin using it. During each session, the researcher records the user's stress level before using the system. Researcher ticks the tasks such as learning the functions, exploring the classroom, Snoezelen room environment, and other activities as shown in Table 5. The data was collected using a real-time screen mirroring application on a laptop while monitoring user performance inside the VR system.

In session two, the participant got familiar with the system. Participants try to do different tasks in the system. During session two, the researcher records the participant's heartbeat rate and the stress level before using the system. The researcher continues recording or ticking the new tasks, such as performing some practices after learning, playing puzzles, colouring, and drawing, as shown in Table 5. Research records the participant's heartbeat rate and the stress level again after using the system.

In session three, some of the participants can complete the tasks in the checklist. During the 3rd session, the researcher records the participants' heartbeat rate and the stress level before using the system. Participants were allowed to freely explore the environment once they had completed all the tasks to help the researcher observe the participants' response towards the system, whether they still remembered the functions and could complete the activities accordingly. The researcher records the participant's heartbeat rate and the stress level after using the system.

Additional sessions four and five are for those participants who have not completed all the tasks in the checklist for sessions one to three, resulting from being slow learners, feeling tired easily, needing more time to learn or complete the tasks, and having difficulty solving the activities, such as dragging and dropping objects into the correct slot. During sessions four and five, the participants perform tasks such as continuing to explore scenes that participants have not visited previously, as shown in Table 5 for sessions four and five. Once the remaining participants had completed all the tasks in the checklist, they were allowed to explore freely within the environment. The researcher records the participant's heartbeat rate and the stress level before and after each session. Table 5 summarizes activities participants are required to complete through sessions 1-5.

Table 5: Activities for each session are listed in the checklist

Sessions	**Activities**
Session 1	- Learn the basic function of the system (Select button using gaze method or click on the button), grabbing and releasing object. - Explore the environment by viewing things in 360 degree in home page. / Give a simple briefing on different environment. - Introduce classroom page to user for user to watch video while studying by playing and pause the video or select different videos to learn. - Allow user to gaze on the words to read and listen to the correct pronunciation. - Snoezelen room to relax and play with element (object, sound, colour) or puzzle to play. - Allow user to choose any scene to visit. - Allow user to continue or stop the session.
Session 2	- Continue encourage user to explore new environment user have not visited. - Introduce education exercise for user to do using drag and drop method to match the word to correct slot with audio to teach the children. - Colouring according the number or randomly. - Allow user to play puzzle by rotating the puzzle pieces to correct position to form a picture. - Drawing to release stress. - Allow user to choose scene they love to visit.
Session 3	- Continue explore different scene. - Allow user to freely choose scene they love to visit or instruct them to choose scene they had not visited. - Some children might not able to complete all the task and will continue in next session depends on the child ability in learning new things.
Session 4	- Continue explore different scene which have not done in previous session which have not done in previous session. - Allow user to choose scene they love to visit or instruct them to choose scene they had not visited.
Session 5	- Continue explore different scene. - Allow user to choose scene they love to visit.

3.4 Measurement

3.4.1 User's Survey

To evaluate the elements and contents used in the VR system in terms of its suitability for children with special needs in learning, whether the children can perform all tasks listed in the checklist, and whether they can understand and remember all the functionalities required to interact with objects inside the system. The user survey uses response scales, such as a Likert scale, with options ranging from 1 (strongly disagree) to 5 (strongly agree). It enables the respondent to select their answer based on the scale provided for each question. Google Sheets will be used in survey design to help researchers store the parents' or teachers' feedback based on their observations of the child's behaviour.

3.4.2 Heart Beat and Stress level

The Samsung health application uses a heart rate sensor located at the back of the smartphone to measure the participant's heartbeat (BPM) and stress level before and after using the system for recording during the experiment.

Heartbeat result was recorded in percentage based on the participant's heartbeat rate detected by the Samsung application. The heartbeat result will show together with the stress level after measurement reaches 100 percent to determine the participant's real-time stress level.

The stress level result will show the participant's stress levels range from low to high after measurement reaches 100 percent. The stress level is recorded on a scale ranging from 1 to 10. Scale Low (1-3, green) is in a relaxed mode, Moderated (4-7, yellow to orange) is at a manageable level of stress, and High (8-10, red) is where the participant is experiencing the most extreme stress level. From the stress level results, the researcher was able to identify whether the child can wear the device and feel enjoyment and relaxation in learning after using the system. The researcher will conduct this step for recording participants' stress levels before and after the experiment for each session until the user has completed all the tasks in the checklist [54].

3.5 Data Analysis

A pivot chart was used to generate and organize the data, including stress level and BMP graphs and tables, calculate the average age of all participants, and count the number of participants by gender or from each centre. The researcher uses Microsoft Excel to record and analyse participants' stress levels, and BMP to include the results in a pivot chart.

An ANOVA test was used to analyse the stress level of the special needs participant in the experiment. From the analysis, we could determine whether the participant was enjoying or relaxing while learning after using the system. This could help researchers determine the F-value, p-value, F-crit value, and df value, as well as the probability analysis of the participants' stress level decrease or increase after the experiment. The t-test was used to analyse the stress level results for each session.

4.0 RESULTS

The results in Tables 6 and 7 show that all 10 participants' BMP reading and stress levels were reduced after using the system, based on the pre- and post-test results throughout the sessions.

Table 6: Stress level reading in range 1-10

Session	1st		2nd		3rd		4th		5th	
Child	Before	After	Before	After	Before	After	Before	After	Before	After
SN	6	3	10	1	10	6	NA	NA	NA	NA
ML	2	4	1	1	4	1	NA	NA	NA	NA
FS	6	1	8	2	5	4	NA	NA	NA	NA
AR	10	4	10	1	10	2	3	2	2	1
AS	4	1	10	4	2	1	NA	NA	NA	NA
IN	2	1	10	9	6	4	NA	NA	NA	NA
CA	5	1	1	2	10	1	8	6	NA	NA
NL	1	1	2	1	1	1	1	1	NA	NA
LI	6	10	10	9	9	8	10	1	9	7
IH	2	1	1	1	2	1	NA	NA	NA	NA

It is proven that a VR system can influence participants' stress levels by decreasing stress levels after using the system in learning for all participants after a few sessions of training. Based on the observation, participants enjoyed watching videos, listening to sound, and doing various activities inside the system. This could also help special children to concentrate on learning Arabic. Most of the children wanted to try again, express their thoughts, and be willing to explore new things.

Table 7: BMP reading in percentage

Session	1st		2nd		3rd		4th		5th	
Child	Before	After	Before	After	Before	After	Before	After	Before	After
SN	88	81	101	89	103	94	NA	NA	NA	NA
ML	83	88	71	61	93	85	NA	NA	NA	NA
FS	90	97	94	81	89	82	NA	NA	NA	NA
AR	104	90	108	76	109	86	90	83	89	80
AS	90	76	104	86	83	70	NA	NA	NA	NA
IN	85	74	108	109	97	93	NA	NA	NA	NA
CA	85	87	77	86	112	79	95	97	NA	NA
NL	69	68	76	72	74	69	82	67	NA	NA
LI	105	114	108	106	97	95	106	98	102	93
IH	83	79	76	74	83	80	NA	NA	NA	NA

4.1. Special needs children's stress levels

Hypothesis 0 is that all the participants' stress levels decrease after using the system.
Hypothesis 1: Hypothesis 0 is rejected because the stress levels of all participants increase after using the system.

Table 8: Anova reading before and after using the VR system

Type of disorder	**df**	**F**	**P-value**	**F crit**
ASD	9	1.377051	0.232599	2.137528
Down syndrome	5	65535	0	0
Learning disabilities	9	1.63463	0.250098	3.38813

Based on Table 8, autism spectrum disorder (ASD) has no significant difference among the seven participants' stress levels before and after using the system. For example, for the 1st and 2nd sessions, participants' stress levels increase because they are not familiar with the system and don't know how to use it based on the data set. The null hypothesis is accepted as all the participants' stress levels decrease after using the system, and they feel excited and happy to use the system. The results for Down Syndrome show a significant difference in stress levels among participants before and after using the VR system. The null hypothesis 0 is rejected as some of the participants' stress levels increase after using the VR system.

Table 9 shows that there is no significant difference among the 10 participants' stress levels after using the system for 1st session. The null hypothesis is accepted because all the participants' stress levels decrease after using the system.

Table 9: T-test on stress level reading for each session

Session	**df**	**T**	**P-value (T<=t) two-tailed**	**t crit**
1st	18	1.351 023	0.193427	2.100922
2nd	18	1.850942	0.080657	2.100922
3rd	18	2.146511	0.045711	2.100922
4th	6	1.242118	0.26054	2.446912
5th	2	0.325396	0.775769	4.302653

Next, in the 2nd session, it shows that there is no significant difference among the 10 participants' stress levels after using the system. The null hypothesis is accepted because all the participants' stress levels decrease after using the system. For example, throughout the 1st to 2nd session, user stress level decreases because they are more familiar with the system, feel excited and happy to use the system based on the data set.

Followed by 3rd session shows that there is a significant difference among the 10 participants' stress levels after using the system. The null hypothesis is rejected, and the alternative hypothesis is accepted because some participants' stress levels increase after using the system. The statistical result shows that the probability of user stress level increases might be due to the fact that the data size is too small to prove that the user had reduced the stress level after using the system. The researcher has recorded the children's stress levels for the second round of the 3rd session, and the t-test for this is shown in Table 10.

For the 4th session, there is no significant difference among the five participants' stress levels after using the system. The null hypothesis is accepted because all the participants' stress levels decrease after using the system. Finally, for the 5th session, there is no significant difference in the stress levels of the three participants after using the system. The null hypothesis is accepted because all the participants' stress levels decrease after using the system. Throughout the 4th to 5th session, the children's stress level decreases because they are more familiar with the system, feel excited and happy to use the system based on the data set.

In Table 10, the ASD results show that there is no significant difference in the stress levels of the six participants after using the VR system. The null hypothesis is accepted because all the participants' stress levels decrease after using the system. Except for the child with Down syndrome, during the 3rd session, the results show that the researcher cannot define the hypothesis and significance due to the sample size being too small. Learning disabilities results show that there is a significant difference between the 2 participants' stress levels after using the system. The null hypothesis is rejected, and the alternative hypothesis is accepted because some participants' stress levels increase after using the system due to 1st time user. However, according to the collected data, both participants' stress levels were reduced due to the sample size being too small.

Table 10: T-test on stress level reading for the 3rd session

Type of disorder	df	T	P-value (T<=t) two-tailed	t crit
ASD	12	1.044466	0.316854	2.178813
Down syndrome	0	0	0	0
Learning disabilities	2	17	0.003442	4.302653

4.2. Issues with the 1st session of the experimental study

There are two autism children with autism out of 10 participants, with stress levels increasing in the 1st sessions. As mention in section 3.1 above, those participants who participate in this experimental study are 1st time user, do not have experience in using VR system, they are not familiar with the function of the system and don't know how to use it or having fear in wearing the head-mounted display or scared to try new things based on the observation and feedback from both the parents and teachers. Both participants need to be taught from the sketch and guided a few times to do tasks by the researcher or the teacher. During the 2nd session, there is one participant who is a slow learner and shows increased stress level after using the system due to being unfamiliar with the function of the system, for example, having problems in dragging and dropping the word into the correct slot in the exercise. However, the stress levels of these three participants decreased in sessions 3-5 because they were familiar with the system's functions. Their behaviours also change; they become excited, enjoy the learning materials, and want to use the system again.

5.0 DISCUSSION

Based on the overall results of the stress levels collected from the experiment, most of the participants had reduced stress levels after using the system compared to the stress levels before the experiment was conducted. The ANOVA test and the T-test are being used to analyse the effectiveness of the system in reducing the children's stress levels after using the system. Based on the tests, there is no significant difference among the nine participants with ASD, and learning disabilities stress levels decrease after using the system once the user is familiar with the system. For example, there are some users whose stress levels increase in 1st sessions because they are 1st time users, have fear of wearing the head-mounted display, and are not familiar with the system's functions. All participants' stress levels decrease after the 2nd session, and it is proven in the T-test results as well

The T-test results for session one show that there is no significant difference among all participants' stress levels, which decrease after using the system, as the t value is less than the t critical value, and the p value is more than 0.05. because 20% of participants' stress levels increase after using the system. Only 80% of participants reported decreased stress levels after using the system, according to the dataset. There are two participants: ML, who is the youngest participant and was diagnosed with mild autism, and LI, who was diagnosed with autism at a moderate level, was stressed out after using the system due to 1st time user, not familiar with the functions, or

scared to try new things. He needs to be taught and guided a few times to do tasks by a researcher or a teacher. The researcher needs to guide him to try a few times.

In the second session, it is shown that all participants' stress levels decrease after using the system. 90% of participants' stress levels decrease after using the system, according to the data set, as users become familiar with the function of the system, explore without guidance, are willing to try new things, can wear the head-mounted display, feel excited, enjoy watching videos, and want to use the system again. Participant CA has been under stress after using the system because she is not familiar with the function of the system, for example, having problems with dragging and dropping the word into the correct slot in the exercise.

In the 3rd session, there is a significant difference where the t value is greater than the t critical value, p value in two-tailed less than 0.05, which shows that participants' stress levels increase after using the system. However, the data shows that 100% of the participants' stress levels decrease. In the 4th to 5th sessions, all participants' stress levels decrease after using the system, as the t-value is less than the t-critical value, and the p-value is greater than 0.05. 100% of participants' stress levels decrease after using the system. The results showed a positive outcome throughout the sessions, where the system helped special needs children decrease their stress levels once they became more familiar with its functions. They felt excited and happy to use the system, based on the data set.

6.0 CONCLUSION

The proposed VR Snoezelen room learning system can provide parents or teachers with an additional choice of learning material or platforms to bring benefit to children with special needs in education, encourage them to try new things like using VR technology, and increase the level of concentration, memory, and development skills. This could improve the child's communication skills, like expressing their thoughts, sharing experiences with others, and reducing stress levels after using the system. The participants were having fun using the elements inside the VR system while learning. Children felt excited and wanted to use it again after finishing the whole session (post-testing in the 3rd or 4th session) as the VR system can be used online and offline. Teachers or parents can view and monitor users' performance while inside the VR system using the AnyDesk screen mirroring application. Some children do not need guidance as they can explore it by themselves. It can reduce teachers' or parents' workload in taking care of special students, enhance learning, and release stress. This VR system helps to reduce the cost of developing a physical Snoezelen room and maintenance.

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