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Digital technologies for autistic spectrum disorder students' education

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Abstract

Abstract: This report's objective is to offer a thorough study of studies looking at ICT tools for kids with autism spectrum disorders. ICT assessment tools and ICT intervention tools are two categories for them. The evaluation describes each tool's background, functionality, and relationship to this scientific discipline while explaining specific technological features. The result is that a variety of ICT technologies can help with ASD diagnosis. ICT intervention tools, on the other hand, cannot be very promising. This is because there is now no effective way to cure these illnesses completely. Furthermore, since the tests haven't been conducted for a long time, the results cannot be relied upon.

Keywords: Assessment; ICT; Intervention; Special education; ASD; SEN; Asperger Syndrome; AS; CBI; ASC

1. Introduction

1.1. Autistic Spectrum Disorder (ASD)

Autistic disorder, Asperger Syndrome, and Pervasive Development Disorder - Not otherwise Specified (PDD-NOS; American Psychiatric Association, 2000) are all Pervasive Development Disorders that fall under the umbrella term of Autism Spectrum Disorders (ASD). The large range of impairments or disabilities that kids with ADS have is referred to as their "spectrum" of conditions. Even for students with high functioning autism syndromes like Asperger (AS), social interaction and social communication are key areas of weakness. Even though they may be skilled in academic and professional duties, students with AS frequently struggle in class or at work due to social pressures.

1.2. Information and Communication Technology (ICT)

Due to the rapid pace of technological advancement and its effects on the educational landscape, the presence of information and communication technologies (ICT) in society is a reality that needs specific consideration and ongoing evolution [1]. In an effort to enhance their teaching perspective using ICT equipment, the majority of institutions have included this technology into their educational institutions. In actuality, the amount of ICT equipment in schools has grown dramatically over time [2].

Technology is an essential component in the education of pupils who have special needs because it enables them to access tasks that would otherwise be out of their reach. The use of new technology as effective teaching tools may be the answer to some of the particular educational demands of pupils [3].

Because it is dependable, consistent, free from social pressures, and specialized in its focus of attention, computers are popular and preferred among people with ASD [4]. Computer-based programs are therefore seen as practical tools for therapeutic and educational purposes. Applications have been created, for instance, to teach social skills [5]. They are

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free to work at their own speed and comprehension level. Lessons can be reviewed repeatedly. Due to the ability of the applications to offer tailored feedback, they can keep their interest and motivation [6]. ICT tools will be evaluated for their effectiveness as assessment and intervention tools for people with ASD in the categories listed below.

2. ICT Tools

2.1. ICT assessment tools

According to a study published in 2012 by Jasni Dolah et al., using the Autism Spectrum Quotient (ASQ), adults with average intelligence who are undergraduate students at the Sains Malaysia University were assessed for their level of autism symptoms. ASQ consists of an online survey as well as a questionnaire with 50 Likert Scale items that was published in 2001 by Simon Baron-Cohen. One choice must be chosen by each respondent at a time. The closed-box responses range from "Definitely Agree" to "Definitely Disagree" in terms of agreement. The estimations are performed using SPSS statistic software and an ANOVA. The study was carried out as a result of the sharp rise of autism cases both globally and in Malaysia. The questionnaire includes questions relating to the efficacy of this instrument towards identification of ASD, awareness of how alternative methods can help in learning ASD and if these instruments are the proper ones for recognizing ASD. The instrument's goals include figuring out what proportion of people in each age/race group have low and high levels of ASD, analyzing ASQ comments, and suggesting alternate techniques for diagnosing ASD. The majority of respondents had an average score for autistic symptoms overall, according to these findings, which were based on the scoring point established by ASQ. The gender-based score distinguished between female ASD sufferers in Malaysia. Malays are more affected than Chinese and other tribes, according to the race score. In conclusion, society has to become more informed about ASD and stop treating these signs as taboo. The creation of pertinent materials is essential for the treatment of ASD [7].

Chapter 8 of Noel Kok Hwee Chia et al.'s (2013) work, "Learning Activity System Design for Autistic Children Using Virtual Pink Dolphins," is presented here. The Virtual Pink Dolphin Project is a virtual reality program that can enhance the outlook for kids with ASD and provide a protocol for raising their standard of living. Children are required to follow visual instructions to manipulate the dolphins in this project's learning game including virtual reality dolphins. The kids will direct the dolphins to do specific tricks in three different levels of difficulty. After finishing each stage successfully, kids will receive prizes. A tutorial is offered to beginners. The Institute for Media Innovation in Singapore serves as the project's host. The Institute is interested in further research for an enhanced VR-based treatment that teaches communication, social interaction and daily living skills to ASD children with ASD [8].

Researchers Salvatore Maria Anzalone et al. investigated how children with autism spectrum disorders (ASD) and kids with typical development (TD) interacted with a robot in a 4-D environment during a Joined Attention (JA) in 2014. In order to record motions and details about the children's general response, a miniature humanoid robot named Nao and a perception system built on an RGB-D sensor were employed. In particular, ASD instances were identified using a real-time system that gathered experiment data and an offline system that ran certain algorithms on the data to analyze it. Each child's postures, including their depth image, head stance, face, and skeleton track, were calculated by the algorithms Constrained Data Models (CLM) and Generalized Adaptive View-based Appearance Model (GAVAM) that were then analyzed into a child's possible problematic behavior of gazing and posture. Both categories (ASD & TD), but notably ASD children, responded better when Nao was changed with a human. Nao the robot could therefore be considered an evaluation tool for patients of ASD. Nao, on the other hand, can be employed as a machine learning robot in an effort to create customized therapy exercises with predetermined attention-recovery strategies. 32 children participated in the experiment at the Pitie Salpetriere Hospital Ethics Committee in Paris, with half of them having ASD and the other half being TD pupils from the city. The conclusion was that the results in both child groups dependent on the interaction partner and should not be taken seriously as they were only validated on a small group [9].

2.2. ICT intervention tools

2011 saw the introduction of a project by J. Lozano, J. Ballesta, and S. Alcaraz Murcia that sought to integrate those who had trouble using technology by promoting digital inclusion in the media. Software to teach individuals with autism spectrum disorders about emotions is described in their paper as "Apren de con Zapo. The textbook "Proposals for the Acquisition of Social and Emotional Competencies" is used to educate and evaluate the social and emotional competencies of students with ASD. Through interaction with the main character, the clown Zapo, who the learner gets along with while completing the program's different activities, it creates a controlled atmosphere. The outcomes demonstrated that this type of instructional software can assist students with ASD in completing exercises meant to develop their grasp of emotional abilities, foster their capacity for working in pairs, and facilitate peer interaction. Teachers and family both took notice of these findings [10].

The study "Multitouch tabletop technology for people with autism spectrum disorder" was presented by Weiqin Chen et al. in 2012. a review of the available research. With the use of post-WIMP (Window, Icon, Menu, and Pointer) technology, users can interact naturally without the usage of a mouse pointer on a touch screen with a wide physical area. The most significant multitouch systems include FTIR (Frustrated Total Interaction Reflection) tabletops, Microsoft Surface, Diamond Touch, Smartboard, and Microsoft Surface. These devices come with the following software: Trollskogen (The Troll Forest), Sides, Collaborative Puzzle Game (CPG), Raketeer, and Join-in-Suite. The primary benefit of these technologies is that they give consumers appealing communication and teamwork capabilities. The conclusion is that there is still a need for assistance among autistic people, their families, and the professionals who help them [11].

Rung-Yu Tseng and Ellen Yi-Luen Do presented "Facial Expression Wonderland (FEW) - A Novel Design Prototype of Information and Computer Technology (ICT) for Children with Autism Spectrum Disorder (ASD)" in 2010. Facial Expression Wonderland is referred to as "FEW" in shorthand. Because playing helps youngsters focus, the program's goal is to educate children with ASD how to recognize facial emotions through a game. In the three stages of the game, which each have voice coaching, they must match pictures of face expressions with pictures of emotions. The impacts of FEW still need to be estimated and validated in the future [12].

The "Use of computer-based interventions to improve literacy skills in students with autism spectrum disorders" was the main topic of Sathiyaprakash Ramdoss et al's study from that year. The review, for the use of CBI on enhancing literacy skills in ASD kids, was based on 12 studies. The numerous software applications utilized in the research show that CBI is a strategy for delivering interventions rather than an intervention in and of itself. Thus, the software program's efficient teaching techniques, such as prompting and reinforcement, are crucial to its success. Programs meant to impart teaching include Teach Town, Baldi/Timo, the Alpha Program, and Delta Messages. The following factors contributed to the difficulty in determining the level of success of these interventions:

- The tiny participant sample
- The participants' lack of prior computer usage expertise and understanding.

Two pertinent strategies were found in the examined studies:

- Only make CBI available to people who have prior computing experience.
- Before starting CBI in literacy, effectively teach pupils on the relevant hardware and software.

Even if knowing how to operate a computer is a valuable skill, learning to read and write may not benefit from it. Furthermore, it is well-known that Asperger Syndrome patients struggle to recognize facial emotions; as a result, they can have a similar problem with photographs. However, there is a voiced worry that CBI use with ASD students may hinder their social connections and skills. Research is anticipated to determine whether adding certain characteristics to CBI, such as animated faces or multi-channel feedback, will be successful [13].

Virtual Words: A New Opportunity for persons with Lifelong Disabilities by Karen Stendal et al. (2012) examined how persons with lifelong disabilities, such as ASD, can establish social interaction. It is promising because using a virtual environment successfully only requires a few basic abilities. Everyone can enjoy social interaction with others, regardless of their disabilities, as long as there are no significant assistance needs. However, since each individual in this virtual environment can assume the appearance of an able-bodied avatar, it is in their preferences to disclose their limitations. In Second Life, an island named "Brigadoon" is where persons with Asperger Syndrome can meet others who have the same condition, while a club called "Wheelies" is where people in wheelchairs can meet others. Virtual worlds have been utilized to teach and socialize people with intellectual disabilities, making them an intervention tool [16]. But it's unclear if everyone will be able to transfer the talents they acquire through this procedure to the real world [14].

Based on Gold's research, which claims that music therapy can intervene and encourage a positive transformation [18], David Lima and Thais Castro (2012) introduced "Music Spectrum, a V.R. Music environment for Children with Autism". The Music Spectrum Model's development process was broken down into 4 stages:

- Requirements
- Project
- Implementation
- Evaluation

To be thoroughly tested for gameplay interaction before being put on an open-source platform, the application is now implemented in Apple Inc.'s iOs operating system. The user has control over the input. For initial testing, four 2-D displays have been created.

- A user has the option to register or log in. On the same screen, language choices are also accessible.
- Social Profile: You have access to options to Edit Profile, View Friends, Group, and Activity.
- Violin performance
- Violin playing, from a theoretical level to actual songwriting.

The intention is to motivate the ASD individual to take part in more active interactions, such as learning an instrument or joining a social group [15].

Lesley Abbot and colleagues (2004) described a cross-national collaboration of mainstream and special education schools in Northern Ireland and the Republic of Ireland using ICT in their research article titled "The global classroom: advancing cultural awareness in special schools through collaborative work using ICT." Schools collaborated in pairs and selected a single subject to study. It was being communicated by:

Computer conferencing that was asynchronous and offered Text-based conferences

Digital publication of instructional materials

Videoconferences that allowed students to communicate online.

- The research set out to determine: I. How ICT conferencing and videoconferencing can promote cultural awareness.
- The development of students' ICT and literacy abilities through conferences.
- How well students are doing in oral and written communication using videoconferencing.

The outcomes included the accomplishment of the aforementioned objectives as well as an improvement in self-esteem, desire for academic aspirations, and excellent composure in public speaking during videoconferences, notably in children with special education needs (SEN) [17].

Research on "applications of technology to teach social skills to children with autism" was carried out in 2011 by Florence D. DiGennaro Reed et al. Six inclusionary criteria were used to the publications with an overview of literacy search techniques. (1) The number of pages should not be more than four, and the article should be published in a peer-reviewed journal. (2) To compare the results of treatment, reliable experimental technology was required. (3) The study's main objective was to address a social skill. (4) To address the social skill gap, a technology-based intervention had to be put in place. (5) Participants needed to have a diagnosis of autism or a consanguineous disease and be 18 years of age or younger. (6) English has to be the article's primary language. The review concentrated on the following variables after providing an outline of the coding procedures: (a) The intervention may be delivered via a robot, a computer program, an iPod or other mobile device, a virtual reality environment, a movie or DVD, a tactile prompt, or other technology. (a) The topography of the desired social skills included nine conversational skill groups. Finally, the findings supported the incorporation of technology into social skills deficit therapies [19].

As part of the EUFP7 ICT 3-year Project ASC-Inclusion, which aims to develop ICT solutions to help children affected by ASD, Stefano Piana et al. presented "a set of full body movement features for emotion recognition to help children affected by Autism Spectrum Condition" in 2013. It focuses especially on the creation of educational games that teach kids how to recognize and express their emotions through facial expressions, speech, gesture, and whole-body movement. This approach first observes ASC kids while they interact with people or engage in serious play and assesses how well they can express and comprehend their emotions. Secondly, it enhances children's emotional cognition through interactive multimodal feedback. It's important to understand how the body moves because particular gestures convey emotions like fear, excitement, wrath, or surprise. The interpretation of additional elements, such as movement speed and directness, is also being looked at. Professional-grade optical motion capture devices and video cameras are used to record these movement data. The data are then improved using techniques like Dictionary Learning and Sparse Coding. Support Coding Techniques are used to complete the categorization assignment. Once they have been improved, low-cost RGB-D sensors (like the Kinect) are used with the creation emotion analysis algorithms. Since the framework has only been tested on adult actors, conclusions about ASD kids must wait [20].

According to a 2011 paper by Wendy Keay-Bright titled "Is simplicity the key to engagement for children on the autism spectrum?," an ASD youngster is more likely to feel less anxious when using a simple program. The major goal was to pique interest and encourage conversation. Reac Tickles and Pah! were two software packages that the author suggested. Reac Tickles allows kids to effortlessly create shapes, marks, and colored patterns using any input method (mouse, keyboard, microphone, touchscreen), fostering their creativity. A voice-operated game called Pah! responds to volume variations as compared to background noise. In contrast to ReacTickles, the Pah! game, according to the data, encourages less user innovation. The report outlined the necessity to educate technology through simple software tools, so that a SEN child will use it without the intervention of a tutor [21].

In 2008, Wendy E. Keay-Bright published a paper detailing the results of her study, "Tangible Technologies as Interactive Play Spaces for Children with Learning Difficulties: The Reactive Colours Project," which included (a) the creation of adaptable sensory software called ReacTickles and (b) the effects of embodied user interfaces on learning for autistic children. Regarding its tangible technological input devices, ReacTickles is being researched. The ReacTickles keyboard helped ASD youngsters gain confidence as they loved exploring on their own, and the ReacTickles Interactive Whiteboard assisted them in socializing as they invited others to participate by using their fingers to draw forms, morphs, and colors [11].

The COSPATIAL project was studied by S.V. Cobb et al. (2010) in their study "An integrative approach for designing collaborative technologies for social competence training in children with autism spectrum conditions." In the aforementioned study, two collaborative technologies—collaborative virtual environments (CVEs) and shared active surfaces (SASs)—are being examined as potential medium to improve social competency skills learning for both autistic and typically developing children. COSPATIAL operates alone with the Cognitive Behaviour Therapy (CBT) guiding principles. For directing intervention efforts, CBT provides a multimodal framework that takes cognition and behavior into consideration. Because of this, personalization, user-centered design (UCD), and understanding autism are important aspects of educational technology. To conclude, COSPATIAL offers facilitation on social competence towards children with autistic spectrum conditions but the main challenge is whether our chosen technologies can develop social competence as required by the CBT [23].

A report titled "Introducing Session on ICT-Based Alternative and Augmentative Communication" was delivered by Zeljka Car et al. in 2012. The goal of alternative and augmentative communication (AAC), which was developed to help people with complicated communication needs, is to improve speech, literacy, learning, employment, and quality of life. AAC is based on the use of graphic and textual symbols to represent specific objects, actions, or concepts. Symbol-based human-to-human and human-to-machine communication is made possible in a computer and networking context by ICT-based AAC services. ICT-based AAC services are essential for the lives of people with severe SEN, including those with intellectual and communication disabilities, as they are socially isolated and can only interact with others online. Finally, it is desired that parents take part in the study and creation of ICT-based AAC services. Parents emphasize that alternative forms of communication should be based on large images without distracting details, secondary motives should be avoided, a clear and simple font like Arial is recommended, and vivid colors like red, which are the quickest to reach the brain, can be used to emphasize words [24].

The study "Towards co-design with users who have autism spectrum disorders" by Peter Francis et al. (2009) advocated for the notion that people with ASD can take part in the design of digital assistive technology (DAT), provided that the parties involved have high functioning autism (such as Asperger Syndrome) and that co-design is carried out in a conventional manner. Amongst DAT, some are highlighted: Boardmaker and PECS, the visual assistant and Jogger , PDA-based products of Able Link Technologies are tools that basically provide prompting. Moreover, projects as the “Mobility for all”, the” Isaac” and “Virtual Environment Systems” help ASD people develop social skills in ways they prefer and have already disclosed [25].

In 2012, Margarita Lucas da Silva wrote about an application called Troc@s that was created to give kids with ASD access to fully customisable tools. The benefit of the application is that it helps autistic children communicate. As a result, it can be utilized for both pleasure and instructional reasons. It includes stories, pictures, videos, and audio. The goal of this application was to make it easy for the tutor to adjust the contents. Web technologies are employed. Additionally, with simple HTML and CSS coding, the instructor can modify the application to suit each child, have total control over the program, and interfere at all levels. The evaluation will be finished once it has been addressed to the satisfaction of both the instructor and the students [26] and [27].

Theresa Doyle and Immaculada Arnedillo-Sanchez (2010) provided a framework for caregivers (teachers and parents) to use in order to assist them develop customized social stories using multimedia context for children with ASD. Children were to be taught the "hidden code"—the dos and don'ts—of everyday life. In particular, six themes were covered:

around the house, taking care of oneself, at school, social skills, traveling, and things to avoid. Each person's needs were taken into account when tailoring the story. They included step by step instructions, role play, all emphasized mostly in visual structure (colorful images, animation, sounds) and less in text, since they cannot stay focused on it. This framework assisted in raising caregivers' knowledge of the demands of the children, which appeared to improve the latter's reaction. Caregivers who are having trouble using the framework could benefit from further training [28].

In order to build HANDS, J. Mintz did a study in 2012 on the significance of particular elements, such as credibility and Kairos, which are some of the guiding principles for the design of persuasive systems, according to Fogg [30]. With the help of their instructors and parents, HANDS is a project built on a smartphone application that improves the incorrect social and life conduct of children with ASD. Through the use of software that is integrated into a web-based toolkit, teachers can intervene in students' diary functioning and offer an effective computer-human contact that is identical to teacher-student engagement, supporting them in key junctures of daily life. On the other hand, parents give teachers input about their child's preferences and unique characteristics, and they are likely to step in like teachers in the future, provided they have the technological know-how to do so.

In order to manage their social skills, they may use prompts to assist them remember what needs to be done or texts to give them advice in difficult-to-handle emotional situations. Money management, time management, using public transit, and other life skills interventions are included.

Considering the usage of smartphone/PDA technological tools in teachers' mediation towards behavioral concerns of children, this research was applied to male ADS students from 4 schools in the UK, Denmark, Sweden, and Hungary with positive outcomes. There is undoubtedly a chance that in the near future, persuading mobile applications may help ASD kids with their social and life skills [29].

In 2009, Kostandinidis Evdokimos et al. reported on current developments in the teaching of children with special needs, including work done in the Lab of Medical Informatics at the Aristotle University of Thessaloniki in Greece. The TEACCH Method, Robotic Systems, Virtual Environments, Avatars, Interactive Environments/Software Platforms (with the use of animated graphics or movies), (Treatment and Education of Autistic and related Communication Handicapped children) and Special Input Devices, all set to rehabilitate autistic children through attractive education. The platform works on virtual and semi-virtual environments. The first one includes modules that require image identification, listing pictures according to time sequence and practice on emotional awareness. The latter contains modules that are used in our daily lives, including things, actions, words, and other things. The platform has been improved with an instructor avatar who speaks in the user's native tongue. The avatar also has the added benefit of a personalized platform that corresponds to his level and needs, and it exhibits emotions in accordance with circumstances. Additionally, written language, Makaton symbols, and sounds are used to guide the user. The outcomes are encouraging because recent research has demonstrated that the more engaging an ICT tool is, the more intervention in the child's problem is accomplished. However, there is still much room for advancement; technology could expand their capabilities, particularly with wearable sensors, which could give autistic people a more accurate input [31].

L. Millen et al. (2010) discussed "the development of educational collaborative virtual environments for children with autism" and the benefits that can accrue to them, particularly if they are involved in the design process. Next, two projects will be evaluated: (1) AS Interactive was a research to investigate whether young adults with Asperger's Syndrome might practice and rehearse social skills in virtual environments. Different stakeholders provided input at different phases of the design and development of VE through the use of a user-centered design methodology. It was investigated how best to get user feedback on the examination of VE content, layout, interface, and functioning. (2) COSPATIAL was the second research that investigated the use of cutting-edge technologies to promote the social competence development of both ASD children and their peers who were typically developing. Similar to the AS Interactive, teachers were also involved in the design process even if students weren't. Instead of the single user VEs created by the AS Interactive Project, it used collaborative virtual environments (CVEs). In conclusion, systems like this that involve young consumers in the design process have some promise. The scarcity of study in this area makes it difficult to determine how exactly this can be done [32].

3. Conclusions

Because of its co-morbid variants (including Timothy's Syndrome and Rett's Syndrome), triad of deficits (including stereotyped behavior, speech, and social interaction), and spectrum of severity, from moderate to profound, autism is an exceptionally challenging illness to treat. The care for kids with ASD is getting better thanks to some cutting-edge technologies. The intervention procedure for autistic children is being improved by software that provides customization options. If ASD individuals, particularly high functioning ones, or their parents participate in the design

process of such technology, sharing information on the ASD person's preferences, greater results can be achieved. Since there have been a significant increase in autistic cases in recent years, it is essential that society become aware of this and stop treating it as a taboo subject.

To sum up, it is critical to create the learning technologies that are appropriate for ASD individuals. ICT adaptation for SEN situations is still difficult, but we must learn how to fully utilize this technology to offer people with autism, their families, and the professionals who support them, the best care possible.

The positive and useful contributions that all the digital technologies provide to the field of education should be highlighted as a final point. Mobile devices (39-43), a range of ICT apps (44-56), AI & STEM ROBOTICS (57-71), and games (72-74) are some examples of the technologies that enable and improve educational processes including evaluation, intervention, and learning. Additionally, the use of ICTs in conjunction with theories and models of metacognition, mindfulness, meditation, and the development of emotional intelligence [75-109], as well as with environmental factors and nutrition [35-38], accelerates and improves educational practices.

Compliance with ethical standards

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Disclosure of conflict of interest

The Author proclaims no conflict of interest.

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