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Digital technologies for students with ADHD

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Abstract

The creation and growing use of ICT (Technology, In- formation, and Communication), one of the significant technological advancements of recent years, calls into question whether computers are capable of meeting the demands of contemporary education, particularly in the area of special education. According to research, new technologies liberate and open up amazing opportunities for people with disabilities. These technologies go beyond simple information management to support people with special needs and those who have special educational needs by enhancing their learning capacity, academic performance, and functionality. There is a brief mention of a few of the ICT evaluation, diagnostic, and intervention tools for children with attention and hyperactivity problems (ADHD) over the last 10 years in this review. It also relates to how memory and attention are directly related to one another and interact, as well as how we may assess and enhance memory and attention using technology. This paper also discusses the executive function impairment associated with ADHD and how these can be remedied with technological assistance.

Keywords: ADHD; Executive Functions (EF); working memory (WM); assessment; diagnostic; intervention tools; Assistive Technology; Brain Computer Interface (BCI); Biofeedback/Neurofeedback; Natural User Interfaces (NUIs)

1. Introduction

A chronic pattern of inattention and/or hyperactivity-impulsivity known as Attention Deficit and Hyperactivity Disorder (ADHD) impairs functioning or development. According to estimates, 3% to 7% of school-aged youngsters suffer with ADHD [1]. However, other experts claim that the amount might be anywhere from 2.2% and 17.8% [2]. Polanczyk et al. [3] reported a similar variety in figures, ranging from 1% to 20% among kids in the 8–9 grade. They make an interesting point about how regional and demographic factors might be connected to it. In his survey [4], Barkley [3] also connected ADHD and gender, coming to the conclusion that ADHD affects boys more frequently and severely than girls. According to experts, ADHD is a neurodevelopmental condition that impairs a child's functioning on every level (family, school, and social). The majority of the time, people with attention deficit disorder avoid or fail to finish their tasks. They struggle to follow directions, have trouble concentrating on the person speaking to them, and they frequently appear to misplace personal items or other objects, which demonstrates their disorganization. Constant talking, anxiety, and nervousness are common. They are readily distracted by outside environmental stimuli, which leads to impulsive behavior and uninformed blunders [5]. Even the inclination to have trouble managing time, to be impatient, to interrupt others, and/or to provide answers to inquiries without giving them much thought can be signs of impulsivity. In order to diagnose this disorder, the symptoms should occur frequently and last, at least for six months, from a very young age (3-6 years), being apparent both at home and at school. Consequently, there must be significant effects on functionality, on school, social and professional life, which most of the times are determined by the age of the individual. There are two distinct categories of symptoms. The first one emphasizes inattentiveness, while the second concentrates on impulsive and hyperactive behavior. There are three distinct diagnostic categories that correspond to three forms of ADHD, depending on the individual's symptoms: A) ADHD that primarily targets the "careless" type of individual (ADD), who exhibits indicators of inattention that are more severe and frequent but lacks impulsivity and/or

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hyperactivity. B) Hyperactive-compulsive ADHD (HD), which is diagnosed when impulsivity and hyperactivity symptoms occur more frequently and intensely. The attention issues in this group are not severe. C) ADHD mixed type, in which impulsivity, hyperactivity, and distraction all exhibit with the same frequency and severity [1, 2].

2. The needs of students with ADHD

Since their normal behavior obstructs and hinders teaching in the traditional way, students with ADHD have always posed a difficulty for educational systems. Since inclusion in general education classes is the norm in the majority of Western nations, differentiated instruction is essential. Children with ADHD are four to five times more likely than children with typical development to participate in special educational programs and benefits, according to Loe and Feldman [6]. They are also more likely to favor after-school tutoring and remedial assistance. A youngster with ADHD typically does poorly in school as a result of the issues listed above that they encounter on a regular basis. As Fovet [7] points out, electronic distance learning technologies can be used in ways different from how they were intended and intended to be used. Furthermore, as Wilkinson et al. [8] point out in their review, video games and off-line computer games have been of therapeutic value since the early 1980's, without overviewing the fact that restricted playing and interaction potential were offered. These restrictions have been surpassed by on line gaming offered on the internet, which is regarded as a means of transferring therapeutic practice. When playing motivational games, they assert that kids with ADHD, in particular, tend to control their hyperactivity—so long as the games don't require a lot of working memory. It has been demonstrated that individuals with greater WM capacity are better able to concentrate on complex activities than those with less WM capability. This could imply that effective WM training should improve a person's ADHD symptoms. When Conner's Continuous Performance Test 2 was presented as a video game, a group of young adolescents with ADHD performed as well as the control group, according to Shaw et al. [9], whereas the equivalent performance on the test's traditional form was worse than that of the control group [8].

Education systems should establish the proper conditions to enhance learning and guarantee the transfer of skills and information to students with particular educational requirements, such as those with ADHD, in accordance with Drigas and Ioannidou's argument [10]. However, as recent investigations and research have shown, new technology must play a part in order to do this. By providing the necessary experience through the virtual reality it provides, the integration of ICT into the classroom benefits the youngster who is having academic, social, or cultural issues. It should be expanded to include not only use in households but also in society. ADHD is characterized as a multifaceted disorder that must be considered in conjunction with other executive and cognitive skills [11]. It is indicated that all ICT procedures described in their article, have proved to be important to every function concerning attention, self-regulation, motivation, working memory and speech acquisition. At this point, all experts agree that Information and Communication Technology (ICT) gives the opportunity to all people with disabilities and special educational needs to have equal chances at learning, improving their daily routine, increasing self-protection and independence.

3. Digital Tools for Assessment

According to the consensus, reported in Sanches-Ferreira et al. [12], a multimodal approach, such as a combination of behavioral intervention programs, specialized, and family training, is required to effectively address ADHD. These programs may occasionally be carried out independently or in conjunction with the use of the proper medication, depending on the severity of the problem. Additionally, cooperation between parents, teachers, and specialists is crucial for treating ADHD symptoms and integrating the child into a larger social setting. Parents and teachers frequently employ physical interventions that work to reduce symptoms rather than prevent them from occurring. Because of this, it's important to use the right tools to keep an eye on how an ADHD youngster interacts with the world so that you can figure out what the problem behavior's function is and, if necessary, intervene through an intervention program. In an effort to improve the way ADHD is observed, there has been a trend toward abandoning the traditional methods of assessing behavioral changes in favor of the more precise and effective mobile apps that will be made available to parents and educators.

The innovative program "WHAAM" is an excellent example of one of these apps. Its main goal is to include all the various behavioral factors that are taken into account while striving to create a comprehensive portrait of a person's conduct. Furthermore, it enables those who are involved in the care of an ADHD person to communicate with one another appropriately, interact with the person, and develop a useful mediation strategy [13]. Web (PCs) and mobile devices (the mobile version is referred to as "WMA") both provide access to WHAAM (WA). The ability for the two apps to communicate information across platforms is a pretty crucial feature. This network monitors the dysfunctional behaviours of the child at school and at home and shares information about the diagnosis, specific medication and schools that are suitable for the child. While the web version is aimed towards establishing the patient's profile by

forming the network around him/her, gathering data and overall assessing their behaviour and adjusting the interventions accordingly, the mobile one (WMA), offers a much more direct approach. Given that mobile devices are at hand almost anytime and any-place, they can collect the data instantly, with a variety of ways such as ABC charts, thus making the app an extremely handy tool [13]. Moreover, the behavioural intervention plan will be a few taps away from every person that should need it, diminishing the chances of adults (teachers, parents, therapists) mis- handling situations, where the child with ADHD might misbehave, or even having different approaches. This will also touch on the issues that ADHD kids have with their academic achievement, which frequently results in them leaving school too soon. In order to lessen negative behaviors and replace them with positive ones, WA also enables users to perform a functional evaluation, which Horner defines as the use of "a set of strategies used to identify antecedents (those that preceded a negative behavior) and consequences that control the problem behavior" [12]. The WA also determines the TAU-U statistical index using behavioral information gathered from network participants. The statistical indicator TAU-U makes an estimate of the severity of an intervention's impact on undesirable behavior [12].

The Automated Working Memory Assessment (AWMA) is one more example of a technological instrument that aids in the diagnosis of problems with a person's WM. Without employing specific screening tests or instruments made for this purpose, Alloway et al. [5] assert that it can be challenging to uncover potential working memory issues in classroom settings. With its three stage evaluation technique that measures verbal short-term memory, visual-spatial short-term memory, and verbal and visual spatial working memory, this standardized program enables specialists and teachers alike to quickly appraise someone's memory abilities. In order to make a confirmation, it is further separated into two forms: Short Form (AWMAS) for those who are suspected of having memory issues and Long Form (AWMAL) for those who are known to have them.

Urban Screens are a tool used by Craven et al. [14] to support communities while also producing fresh, collaborative observations about ADHD and associated social "stigma". This frame of reference guided the creation of Snappy App's "The Screens in The Wild (SITW)" project. They embrace the idea of using such platforms to raise public awareness about conditions like ADHD and others, referring to the usage of serious games to encourage positive behaviors (exergaming). In the beginning, they combined a psychometric Continuous Performance Test with an engaging smartphone application to enable the assessment of the three common symptoms of ADHD (i.e., inattention, impulsivity, and hyperactivity). The procedure proved to be user friendly, moreover it resulted to the idea of its gamification as an Android smartphone App. In accordance with the format of a conventional CP exam, the Snappy App application presents users with a dependent arrangement of alphabetic letters. Users are required to respond to the "target" and give no reaction to the "non-target" letters. A "game Attention Grabber" on the Screens In The Wild platform (SITW) was later developed using the Snappy App's Web-app version, with an emphasis on the detection of impulsivity and inattention. In order to make the initial app more enticing, it was later redesigned using graphical elements like fruit and other animations, while the web-app was promoted on city screens. The research team aimed at play-testing the Game at the four Screens In The Wild locations existing in the UK, in order to evaluate it.

4. Digital Tools for Intervention

Early on in a child's academic career, teachers may notice signs of ADHD, such as poor attention skills and/or hyperactive and impulsive behavior. Following the prompt discovery, the parents and instructors who are responsible for these children are notified and asked to take precautionary yet efficient action. An improved academic performance and an early dropout can actually be distinguished by the right information, supervision, and cooperation between these adults. It is widely believed that the use of ICT in both regular and special education would not only update the current system and its components but will also introduce new ones. Cognitive Assistive Technologies (CAT) specifically use a number of tools such smartphones with adapted applications, cognitive training games, audio books, voice recognition software, ear plugs, minimalist learning spaces, and more. [15]. CAT stimulate learners, draw their attention on specific tasks and help them retain it. As far as people with ADHD are concerned, studies have confirmed that the new age software will offer a whole other approach to the way diagnostics and interventions are carried out [16]. Researches indicate that computer-based activities seem to have a positive impact on a child's cognitive abilities. Especially children with ADHD are extremely benefited from these activities as these combine both acoustic and visual stimulation helping them to break down complicated meanings and comprehend them. Shaw et al. [9] were one of the earliest research groups to make an effort to shed light on the abilities of kids with ADHD when they were playing video games. They used market-available video games and standardized electronic tools that were previously intended to assess executive functioning in ADHD-afflicted kids. The kids were given a game-like Conner's Continuous Performance Test 2 (CPT2) as well as the video games "The Revenge of Frogger" (set on a laptop) and "Crash Bandicoot 2" (placed on a PlayStation system). Additionally, they provided "The Pokémon Task," a specifically created CPT2 version that resembles a video game. Each game required fourteen minutes of player participation. The player of the game Frogger has to control a frog.There was no option of swimming; instead, the player had to patiently wait until moving wooden chunks and river

turtles appeared, in order to move the frog by using them. In a different case (moving in traffic or wading into the river), the frog lost a life. In the second game, Crash (the hero) had to be transferred around the screen, to collect crystals and points. The movements had to take place in certain moments though, in order to be considered successful and gain points. The procedure of CPT2 was done as normally indicated, by asking the participants to press all the letters except for X. In the gamified version -The Pokémon Task-, the player had to catch as many Pokémons as possible, avoiding however to press on Pikachu, which had substituted the letter X. After participating in all of the games, the players significantly reduced their impulsivity and spontaneous behavior. Compared to their performance on the standard CPT2, they made demonstrably fewer mistakes while working on the Pokémon Task. This corroborated Shaw et al.'s initial prediction about mistake reduction brought on by impulsive behavior during game-like tasks. They concur that computer games are extremely motivating for kids with ADHD, increasing effort and sustaining interest, based on prior research and experimentation. They claim that additional research on the beneficial effects of computer games on the executive functions is necessary, along with more focused research with a larger sample of kids with ADHD.

When participating in digital activities, notably gaming, ADHD children and adults tend to focus and concentrate better [17]. In spite of their lack of enthusiasm, they seem to be drawn to these activities. Plan-It Commander is a new serious game that Bul et al. developed after realizing the lack of game-like training programs that focused on abilities relevant to everyday life scenarios. Its creation was specifically meant to advance behavioral learning and everyday life skills, such as time management, organization, making friends, and other abilities that foster social acceptability, areas in which children with ADHD frequently lag behind. The team conducted a research, the findings of which showed great satisfaction among the participants, after having been involved with the game. Plan-It Commander showed high potential of serving as a significant tool for intervention, in accordance with the rationale of its designers; notwithstanding, a clinical trial is still necessary to ascertain the degree of its efficacy. Craven and Groom [18] present in their survey, three fields on which computer games and tests concerning ADHD focus: human activity in daily situations, education and medical practice. According to them, most of the existing software applies to executive functions with a view to improving them. Through the course of their research, they came to the conclusion that regular players develop stronger cognitive abilities than infrequent or non-players. They demonstrate and suggest brand-new video games built around monitoring activities that boost attention and inhibitory function. The games were created by including crucial components of Go/No Go and Stop Signal Tasks as well as Continuous Performance Tests. They produced "Awkward Owls" and "Wormy Fruit" specifically. Colorful cartoon characters were designed to set the games apart from the competition while simultaneously improving gaze control and making them more interesting to kids with ADHD. Although their research indicated some therapeutic intervention potential, they also advise more study.

The deficiency in executive processes is a key component of the idea of ADHD [19]. Inhibition (self-control and self-regulation), design, working memory, reasoning, cognitive flexibility, and problem solving are among the executive functions. They are in charge of intentional, ongoing, and directed behavior that works towards a specific objective. Executive function deficiencies are the cause of the organizing, time-management, and planning challenges associated with ADHD. Even when the child's EFs get better, the challenges hamper their functionality and last into adulthood. TangiPlan, a collection of tangible objects that symbolize the chores that kids with ADHD must do in their morning routine, was created by Weisberg et al. [19] in an effort to enhance EF. Parents together with children divide the morning tasks in smaller steps from the previous night. Each item is put in the room close to the work that needs to be done the next day. When the task is begun, the child activates the item, and when it is finished, the child deactivates it. While the object is in use, it also displays the amount of time spent on the task, which aids the youngster in efficient time management. TangiPlan is simultaneously connected to a web-based interface, allowing parents to track the fulfillment of their children's morning tasks through their mobile device in real time. By gathering the child's performance data, it will be possible to enhance the TangiPlan in the future by providing specific information about the amount of time the child can devote to certain tasks.

The "Cogmed" program (Cogmed Working Memory Training - CWMT) was used by Chacko et al. [20] to train memory. A computerized training software called Cogmed targets both the verbal and non-verbal parts of working memory and aims to improve it by boosting memory storage. A computer interface that resembles a game is used for the training. There were 25 sessions available, 5 of which were presented each week during the 5-week training period. Coaches who offered encouragement and support were present with the athletes. In a sample of school-aged children (7–11) with ADHD, its effectiveness was assessed in comparison to a placebo version of it. Using The Automatic Working Memory Assessment (AWMA), the subjects' working memory was assessed [5]. All families took part in a start-up session first, in which the characteristics of CWMT were presented. Then, together with the coaches, they were provided with a system of reinforcement and rewarding throughout the whole training session. Parents and educators assessed the curriculum following the training time. They noted improvements in working memory both for verbal and nonverbal information. There was no discernible change in either the capacity or processing of verbal and non-verbal complex working memory, or in other ADHD symptoms including attention, impulsivity, or hyperactivity. Chacko et al. [20]

recommend a longer-term follow-up evaluation of academic achievement. The amount to which CWMT gives beneficial results to teaching schoolchildren with ADHD is uncertain, they add, perhaps due to methodological study limitations.

According to Garcia-Zapirain et al. [21], movement and gestures can help children with ADHD learn more effectively, thus they experimented with a system that also improves hand-eye coordination and gestures. "Net Framework" was used to create a technical platform. With the use of two physiological sensors, namely "The Leap Motion" - a hand movement recognition sensor and the "Tobii X1 Light Eye Tracker," the goal was to help youngsters with ADHD with their attention deficit and to increase their learning ability. These wearable sensors are classified as Natural User Interfaces (NUIs), which include Human-Computer Interaction devices seeking to use already-existing skills in order to enable reciprocal action with specific material.. The users of this dual system had to perform mathematical calculations on the surface of a digital flower (Math Flower Exercise). If the calculation had a correct outcome, the petals of the flower turned green, if not, they turned red. In this way the players-users were provided with immediate visual feedback. An audio feedback was available as well, as a beeping sound was heard at the choice of a petal. At the end of the procedure, the users were given two questionnaires to evaluate the system and the process. The results were unequivocal. The users' performance generally improved, and the hand-eye coordination was found to be very helpful in focusing and keeping the users' attention on the assigned activities. Another approach that differs from the conventional math-solving procedure and offers consumers considerable amusement among other benefits is gesture-based involvement. Given that attention and learning ability were greatly increased, Garcia-Zapirain et al. [21] believe that the dual sensory pattern they tested on could serve as a successful basis for more games, exercises, or puzzle activities. A system called Brain Computer Interface (BCI) uses transmitted brain impulses (through EEG) to let a person control a peripheral device.. Over the last years it has been used as an alternative therapeutic method for users with ADHD, especially children and adolescents, by providing guidance through feedback from the EEG. The main motivation for the development of BCI technology, as referred by X.Y. Lee et al. [22], was to enable patients suffering from amyotrophic lateral sclerosis to handle objects with the use of their brain, due to their limited kinetic ability. The realization that children with ADHD take a lot of medicine to deal with concentration lapses, the side effects of which are unknown, was a second major concern that strongly urged the development of BCI technology [22]. The fact that BCI technology has no side effects and was created in a way that simulates playing a game means that each person using it still views himself as a participant while maintaining a certain level of motivation and benefit. Below, we make reference to several scientific research and experiments in this area, as well as positive and encouraging results on teaching attention to kids with ADHD.

Amon and Campbell [23] evaluated in their study whether the biofeedback tool "The Journey To The Wild Divine" would show effective at addressing ADHD symptoms based on existing biofeedback studies and relaxation techniques. The players' fingers were fitted with three sensors to track changes in skin conductivity and heart rate. Through the course of the game, these variants were turned into the essential "pathways" to advance and complete the game. The "pathway" would be immediately delayed or blocked if the player became frustrated or anxious, which would prevent them from continuing and completing the game. Evidently, players with ADHD found out that only by being calm and concentrated they would proceed in the game. This realization gave them a compelling reason to partake in the entire game-like experience. All of the parents of the children who participated in the study received questionnaires at the conclusion of the study. The biofeedback video game, according to the parents of the experimental group (children with ADHD), improved breathing and relaxing techniques. The results of their study, supported by findings from other biofeedback-related studies, suggested that playing The Wild Divine video game could help children and adolescents with ADHD adopt more positive attitudes and behaviors. However, more research about the long-term consequences of biofeedback is required, according to Amon and Campbell [23].

After realizing a twenty-session BCI focus with beneficial effects on the symptoms of ADHD, Lim et al. [24] evaluated a new, more difficult training game structure based on BCI. They chose EEG-based biofeedback techniques to treat ADHD as a result of research showing that common symptoms of ADHD, particularly inattention, may be successfully trained through BCI-based games. A headgear with dry EEG electrodes was part of their new training gaming system, which was Bluetooth-connected to a PC. CogoLand, a video game created specifically for the purpose and featuring 3D visuals, was the main gaming activity. The player is required to move an avatar with the help of signals transferred by the EEG electrodes. The proceeding rate of the avatar depends on the concentration level of the player. The game was created in three stages, each of which required the avatar to do a different task. This eight-week, three-level intervention program was completed, followed by three follow-up meetings every month. Parents indicated that their child's attention span, hyperactivity, and impulsivity had all improved by the end of the sessions. Additionally, the gains were sustained by the kids who received additional training sessions each month. For kids with ADHD, BCI-based attention training through gaming systems has been helpful, according to Lim et al. [24].

Qian et al. [25] made use of the same video game, CogoLand. They worked on a BCI-based attention training program with the goal of assessing the extent of reorganization of large-scale brain networks in children with ADHD, based on recent studies that shown the effectiveness of EEG-based neurofeedback systems. Clinical assessment and RS-fMRI imaging were also part of the program evaluation. Three sessions per week were held over the course of the entire eight-week treatment. The method involved using a headgear equipped with dry EEG sensors and a Bluetooth connection to a computer. The avatar of the game was powered by the player's attention, as in the previous study. The results that were extracted after the 8-week intervention period were positive, confirming that attention in children with ADHD was improved. Since the salience processing system and the effective regulation between goal-directed and stimulus-driven attention were brought close to normal standards, this resulted in brain network reorganization and was linked to additional behavior improvement. The BCI-based attention treatment has a number of benefits, according to Qian et al. [25], including safety during use, convenience during the operation and when it is used, and the absence of the need for contemporaneous medical care. Despite the encouraging outcomes of their research, they concur that additional research is required to determine how durable the effects of BCI-based treatment are..

Rohani et al. [26] created another BCI system with an emphasis on ADHD intervention for kids. They put up test versions of the games in a Virtual Reality (VR) classroom environment with realistic reproductions and control over ordinary visual and audio distractions. The use of two feedback games necessitated the prompt and accurate definition of pertinent input for each. They were based on the P300 potential, which is a measure of a person's attention or lack thereof. It is "a large positive voltage in the recorded EEG peaking around 300ms after a cognitive attended rare stimulus" [26]. The first game, called “ANISPELL”, was based on the already existing P300 speller By Fawell and Donchin. It comprises sixteen animal images presented random-like, demanding for specific attention on one of the animals and providing in- formation about it at the end of the procedure. The second game, called the “T- SEARCH”, was created after taking inspiration from Frintrop et al. It consists of twelve different pictures presenting an amount of the English letters “X” and “T”. Additionally, they are displayed at a random-like rate of 5 per second. The player must locate the blue "T" symbols before choosing the classification square that contains every blue "T" letter. Both games demonstrated the P300's usefulness in gauging ADHD-afflicted kids' attention spans. Additionally, with the inclusion of the distractions in the online classroom, repetition and training led to growth. When developing neurofeedback devices, Rohani et al. [26] advise employing interactive BCI systems and P300 potential when concentrating on ADHD therapeutic treatment.

The positive and useful contributions that digital technologies provide to the field of education should be highlighted as a final point. Mobile devices (28-31), a range of ICT apps (32-51), AI & STEM ROBOTICS (52-56), and games (57-59) 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 [60-86] accelerates and improves educational practices and outcomes, especially for students with ADHD.

5. Conclusion

To conclude we underline that one of the hallmarks of ADHD is hyperactivity, which causes the youngster to frequently leave his seat in the classroom. Accordingly, the ideas surrounding ADHD have come to focus heavily on inhibition and self-regulation deficiencies. Fortunately, thanks to ICT, the landscape is shifting in terms of executive tasks. The program, which is appropriate for each scenario and function, enhances a person's functionality in everyday settings while also providing enticing and encouraging stimuli delivered through audio-visual ways. Focus is kept on the student's academic obligations by offering positive and/or negative feedback. Over the last years, a lot of attention has been placed on the working memory (WM), the cognitive system responsible for behaviour amongst other functions, the level of which, if lower than average, can often be associated with ADHD. Early detection and, hence, intervention, are critical in cases of WM issues. It can be the difference between a child's future academic success and failure if parents take prompt, appropriate action. As we have discovered throughout our analysis, WM training software can be effective even in its early phases. As we draw to a close, we must make a special mention of the biofeedback and neurofeedback BCI systems that have been created in the previous 10 years and have so far shown promise in improving working memory and reducing inattention.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

References

[1] American Psychiatric Association. (2014). Desk reference to the diagnostic criteria from DSM 5®. American Psychiatric Pub.

[2] Skounti, M., Philalithis, A., & Galanakis, E. (2007). Variations in prevalence of attention deficit hyperactivity disorder worldwide. European journal of pediatrics, 166(2), 117-123. https://doi.org/10.1007/s00431-006-0299-5

[3] Polanczyk, G., De Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The worldwide prevalence of ADHD: a systematic review and metaregression analysis. American journal of psychiatry, 164(6), 942-948. https://doi.org/10.1176/ajp.2007.164. 6.942

[4] Barkley, R. A. (2003). Issues in the diagnosis of attention-deficit/hyperactivity disorder in children. Brain and development, 25(2), 77-83. https://doi.org/10.1016/s0387-7604(02)001 52-3

[5] Alloway, T. P., Gathercole, S. E., Kirkwood, H., & Elliott, J. (2008). Evaluating the validity of the automated working memory assessment. Educational Psychology, 28(7), 725-734. https://doi.org/10.1080/01443410802243828

[6] Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. Journal of pediatric psychology, 32(6), 643-654. https://doi.org/10.1093/jpep sy/jsl054

[7] Fovet, F. (2007, October). Using distance learning electronic tools within the class to en- gage ADHD students: A key to inclusion? In Frontiers In Education Conference-Global Engineering: Knowledge Without Borders, Opportunities Without Passports, 2007. FIE'07. 37th Annual (pp. F3D-15). IEEE. https://doi.org/10.1109/fie.2007.4417842

[8] Wilkinson, N., Ang, R. P., & Goh, D. H. (2008). Online video game therapy for mental health concerns: a review. International journal of social psychiatry, 54(4), 370-382. https://doi.org/10.1177/0020764008091659

[9] Shaw, R., Grayson, A., & Lewis, V. (2005). Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. Journal of attention disorders, 8(4), 160-168. https://doi.org/10.1177/1087054705278771

[10] Drigas, A., & Ioannidou, R. E. (2013). Special education and ICTs. International Journal of Emerging Technologies in Learning (iJET), 8(2), 41-47. https://doi.org/10.3991/ijet.v8i2.2 514

[11] Drigas, A., & Tourimpampa, A. (2014). Processes and ICT Tools for ADHD Assessment, Intervention and Attention Training. International Journal of Emerging Technologies in Learning (iJET), 9(6), 20-25. https://doi.org/10.3991/ijet.v9i6.4001

[12] Sanches-Ferreira, M., Chifari, A., Santos, M., Silveira-Maia, M., Alves, S., Merlo, G., & Chiazzese, G. (2015). The design of an e-learning module centered in the use of an innovative web health application for attention deficit hyperactivity disorder monitoring. In Proceedings of INTED2015-9th International Technology, Education and Development conference. March (pp. 2-4).

[13] Spachos, D., Chifari, A., Chiazzese, G., Merlo, G., Doherty, G., & Bamidis, P. (2014, November). WHAAM: A mobile application for ubiquitous monitoring of ADHD behaviors. In Interactive Mobile Communication Technologies and Learning (IMCL), 2014 International Conference on (pp. 305-309). IEEE. https://doi.org/10.1109/imctl.2014.7011153

[14] Craven, M. P., Young, Z., Simons, L., Schnädelbach, H., & Gillott, A. (2014, October). From Snappy App to Screens in the Wild: Gamifying an Attention Deficit Hyperactivity Disorder Continuous Performance Test for Public Engagement and Awareness. In Interactive Technologies and Games (iTAG), 2014 International Conference on (pp. 36- 43). IEEE. https://doi.org/10.1109/itag.2014.12

[15] Lindstedt, H., & UmbCarlsson, Õ. (2013). Cognitive assistive technology and profession- al support in everyday life for adults with ADHD. Disability and Rehabilitation: Assistive Technology, 8(5), 402-408. https://doi.org/10.3109/17483107.2013.769120

[16] Kokkalia, G., & Drigas, A. (2015). Working memory and ADHD in preschool education. The role of ICT'S as a diagnostic and intervention tool: an overview. International Journal of Emerging Technologies in Learning (iJET), 10(5), 4-9. https://doi.org/10.3991/ijet.v10 i5.4359

[17] Bul, K. C., Franken, I. H., Van der Oord, S., Kato, P. M., Danckaerts, M., Vreeke, L. J., ... & Maras, A. (2015). Development and user satisfaction of "Plan-It Commander," a serious game for children with ADHD. Games for health journal, 4(6), 502-512. https://doi.org/10. 1089/g4h.2015.0021

[18] Craven, M. P., & Groom, M. J. (2015, October). Computer games for user engagement in Attention Deficit Hyperactivity Disorder (ADHD) monitoring and therapy. In Interactive Technologies and Games (iTAG), 2015 International Conference on (pp. 34-40). IEEE. https://doi.org/10.1109/itag.2015.9

[19] Weisberg, O., GalOz, A., Berkowitz, R., Weiss, N., Peretz, O., Azoulai, S., ... & Zucker- man, O. (2014, June). TangiPlan: designing an assistive technology to enhance executive functioning among children with adhd. In Proceedings of the 2014 conference on Interaction design and children (pp. 293-296). ACM. https://doi.org/10.1145/2593968.2610475

[20] Chacko, A., Bedard, A. C., Marks, D. J., Feirsen, N., Uderman, J. Z., Chimiklis, A., ... & Ramon, M. (2014). A randomized clinical trial of Cogmed working memory training in school-age children with ADHD: A replication in a diverse sample using a control condition. Journal of Child Psychology and Psychiatry, 55(3), 247-255. https://doi.org/10.1111/ jcpp.12146

[21] Garcia-Zapirain, B., de la Torre Díez, I. & López-Coronado, M. J Med Syst (2017) 41: 111. https://doi.org/10.1007/s10916-017-0757-9

[22] Lee X.Y., Koukouna E., Lim C.G., Guan C., Lee T.S., Fung D.S.S. (2015) Can We Play with ADHD? An Alternative Game-Based Treatment for Inattentive Symptoms in Attention-Deficit/Hyperactivity Disorder. In: Sourina O., Wortley D., Kim S. (eds) Subconscious Learning via Games and Social Media. Gaming Media and Social Effects. Springer,Singapore. https://doi.org/10.1007/978-981-287-408-5_6

[23] Amon, K. L., & Campbell, A. (2008). Can Children with AD/HD Learn Relaxation and Breathing Techniques through Biofeedback Video Games? Australian Journal of Educational & Developmental Psychology, 8, 72-84.

[24] Lim CG, Lee TS, Guan C, Fung DSS, Zhao Y, et al. (2012) A Brain-Computer Interface Based Attention Training Program for Treating Attention Deficit Hyperactivity Disorder. PLOS ONE 7(10): e46692. https://doi.org/10.1371/journal.pone.0046692

[25] Qian, X., Loo, B. R. Y., Castellanos, F. X., Liu, S., Koh, H. L., Poh, X. W. W., & Lee, T. S. (2018). Brain-computer-interface-based intervention re-normalizes brain functional network topology in children with attention deficit/hyperactivity disorder. Translational psychiatry, 8(1), 149. https://doi.org/10.1038/s41398-018-0213-8

[26] Rohani, D. A., Sorensen, H. B., & Puthusserypady, S. (2014, August). Brain-computer interface using P300 and virtual reality: a gaming approach for treating ADHD. In Engineering in Medicine and Biology Society (EMBC), 2014 36th Annual International Conference of the IEEE (pp. 3606-3609). IEEE. https://doi.org/10.1109/embc.2014.6944 403

[27] Visser, S., Bitsko, R., Danielson, M., Ghandour, R., Blumberg, S., & Schieve, L. et al. (2015).Treatment of Attention Deficit/Hyperactivity Disorder among Children with Special Health Care Needs. The Journal Of Pediatrics, 166(6), 1423-1430.e2. https://doi.org/10.1016/j.jpeds.2015.02.018

[28] Stathopoulou, et all 2018, Mobile assessment procedures for mental health and literacy skills in education. International Journal of Interactive Mobile Technologies, 12(3), 21-37, https://doi.org/10.3991/ijim.v12i3.8038

[29] Kokkalia G, AS Drigas, A Economou 2016 Mobile learning for preschool education. International Journal of Interactive Mobile Technologies 10 (4), 57-64 https://doi. org/10.3991/ijim.v10i4.6021

[30] Stathopoulou A, Karabatzaki Z, Tsiros D, Katsantoni S, Drigas A, 2019 Mobile apps the educational solution for autistic students in secondary education Journal of Interactive Mobile Technologies 13 (2), 89-101https://doi.org/10.3991/ijim.v13i02.9896

[31] Drigas A, DE Dede, S Dedes 2020 Mobile and other applications for mental imagery to improve learning disabilities and mental health International Journal of Computer Science Issues (IJCSI) 17 (4), 18-23, DOI:10.5281/zenodo.3987533

[32] Drigas, A. S., J.Vrettaros, L.Stavrou, D.Kouremenos, 2004. E-learning Environment for Deaf people in the E-Commerce and New Technologies Sector, WSEAS Transactions on Information Science and Applications, Issue 5, Volume 1, November

[33] Drigas, A., Koukianakis, L., Papagerasimou, Y., 2011, Towards an ICT-based psychology: Epsychology, Computers in Human Behavior, 27:1416–1423. https://doi.org/10.1016/j.chb.2010.07.045

[34] Papanastasiou, G., Drigas, A., Skianis, C., and Lytras, M. (2020). Brain computer interface based applications for training and rehabilitation of students with neurodevelopmental disorders. A literature review. Heliyon 6:e04250. doi: 10.1016/j.heliyon.2020.e04250

[35] Drigas, A., & Papanastasiou, G. (2014). Interactive White Boards in Preschool and Primary Education. International Journal of Online and Biomedical Engineering (iJOE), 10(4), 46–51. https://doi.org/10.3991/ijoe.v10i4.3754

[36] Drigas, A. S. and Politi-Georgousi, S. (2019). ICTs as a distinct detection approach for dyslexia screening: A contemporary view. International Journal of Online and Biomedical Engineering (iJOE), 15(13):46–60. https://doi.org/10.3991/ijoe.v15i13.11011

[37] Drigas A, Petrova A 2014 ICTs in speech and language therapy International Journal of Engineering Pedagogy (iJEP) 4 (1), 49-54 https://doi.org/10.3991/ijep.v4i1.3280

[38] Bravou V, Oikonomidou D, Drigas A, 2022 Applications of Virtual Reality for Autism Inclusion. A review Retos 45, 779-785https://doi.org/10.47197/retos.v45i0.92078

[39] Chaidi I, Drigas A, 2022 "Parents' views Questionnaire for the education of emotions in Autism Spectrum Disorder" in a Greek context and the role of ICTs Technium Social Sciences Journal 33, 73-9, DOI:10.47577/tssj.v33i1.6878

[40] Bravou V, Drigas A, 2019 A contemporary view on online and web tools for students with sensory & learning disabilities iJOE 15(12) 97 https://doi.org/10.3991/ijoe.v15i12.10833

[41] Chaidi I, Drigas A, C Karagiannidis 2021 ICT in special education Technium Soc. Sci. J. 23, 187, https://doi.org/10.47577/tssj.v23i1.4277

[42] Xanthopoulou M, Kokalia G, Drigas A, 2019, Applications for Children with Autism in Preschool and Primary Education. Int. J. Recent Contributions Eng. Sci. IT 7 (2), 4-16, https://doi.org/10.3991/ijes.v7i2.10335

[43] Drigas AS, Koukianakis LG, Papagerasimou YV, 2005 A system for e-inclusion for individuals with sight disabilities Wseas transactions on circuits and systems 4 (11), 1776-1780

[44] Stathopoulou A, Spinou D, Driga AM, 2023, Burnout Prevalence in Special Education Teachers, and the Positive Role of ICTs, iJOE 19 (08), 19-37

[45] Stathopoulou A, Spinou D, Driga AM, 2023, Working with Students with Special Educational Needs and Predictors of Burnout. The Role of ICTs. iJOE 19 (7), 39-51

[46] Loukeri PI, Stathopoulou A, Driga AM, 2023 Special Education Teachers' Gifted Guidance and the role of Digital Technologies, TECH HUB 6 (1), 16-27

[47] Stathopoulou A, Temekinidou M, Driga AM, Dimitriou 2022 Linguistic performance of Students with Autism Spectrum Disorders, and the role of Digital Technologies Eximia 5 (1), 688-701

[48] Vouglanis T, Driga AM 2023 Factors affecting the education of gifted children and the role of digital technologies. TechHub Journal 6, 28-39

[49] Vouglanis T, Driga AM 2023 The use of ICT for the early detection of dyslexia in education, TechHub Journal 5, 54-67

[50] Drakatos N, Tsompou E, Karabatzaki Z, Driga AM 2023 Virtual reality environments as a tool for teaching Engineering. Educational and Psychological issues, TechHub Journal 4, 59-76

[51] Drakatos N, Tsompou E, Karabatzaki Z, Driga AM 2023 The contribution of online gaming in Engineering education, Eximia 8, 14-30

[52] Chaidi E, Kefalis C, Papagerasimou Y, Drigas, 2021, Educational robotics in Primary Education. A case in Greece, Research, Society and Development 10 (9), e17110916371-e17110916371, https://doi.org/10.33448/rsd-v10i9.16371

[53] Drigas, A.S., Vrettaros, J., Koukianakis, L.G. and Glentzes, J.G. (2005). A Virtual Lab and e-learning system for renewable energy sources. Int. Conf. on Educational Tech.

[54] Lytra N, Drigas A 2021 STEAM education-metacognition–Specific Learning Disabilities Scientific Electronic Archives 14 (10) https://doi.org/10.36560/141020211442

[55] Ntaountaki P, et all 2019 Robotics in Autism Intervention. Int. J. Recent Contributions Eng. Sci. IT 7 (4), 4-17, https://doi.org/10.3991/ijes.v7i4.11448

[56] Demertzi E, Voukelatos N, Papagerasimou Y, Drigas A, 2018 Online learning facilities to support coding and robotics courses for youth International Journal of Engineering Pedagogy (iJEP) 8 (3), 69-80, https://doi.org/10.3991/ijep.v8i3.8044

[57] Chaidi I, Drigas A 2022 Digital games & special education Technium Social Sciences Journal 34, 214-236 https://doi.org/10.47577/tssj.v34i1.7054

[58] Doulou A, Drigas A 2022 Electronic, VR & Augmented Reality Games for Intervention in ADHD Technium Social Sciences Journal, 28, 159. https://doi.org/10.47577/ tssj.v28i1.5728

[59] Kefalis C, Kontostavlou EZ, Drigas A, 2020 The Effects of Video Games in Memory and Attention. Int. J. Eng. Pedagog. 10 (1), 51-61, https://doi.org/10.3991/ijep.v10i1.11290

[60] Drigas A, Karyotaki M (2017) Attentional control and other executive functions. Int J Emerg Technol Learn iJET 12(03):219–233 https://doi.org/10.3991/ijet.v12i03.6587

[61] Drigas A, Karyotaki M 2014. Learning Tools and Application for Cognitive Improvement. International Journal of Engineering Pedagogy, 4(3): 71-77. https://doi.org/10.3991/ijep.v4i3.3665

[62] Drigas A., Papoutsi C. (2020). The Need for Emotional Intelligence Training Education in Critical and Stressful Situations: The Case of COVID-19. Int. J. Recent Contrib. Eng. Sci. IT 8(3), 20–35. https://doi.org/10.3991/ijes.v8i3.17235

[63] Kokkalia, G., Drigas, A. Economou, A., & Roussos, P. (2019). School readiness from kindergarten to primary school. International Journal of Emerging Technologies in Learning, 14(11), 4-18. https://doi.org/10.3991/ijet.v14i11.10090

[64] Papoutsi, C. and Drigas, A. (2017) Empathy and Mobile Applications. International Journal of Interactive Mobile Technologies 11(3). 57. https://doi.org/10.3991/ijim.v11i3.6385

[65] Angelopoulou, E. Drigas, A. (2021). Working Memory, Attention and their Relationship: A theoretical Overview. Research. Society and Development, 10(5), 1-8. https://doi.org/10.33448/rsd-v10i5.15288

[66] Drigas A, Mitsea E, Skianis C 2021 The Role of Clinical Hypnosis & VR in Special Education International Journal of Recent Contributions from Engineering Science & IT (iJES) 9(4), 4-18. https://doi.org/10.3991/ijes.v9i4.26147

[67] V Galitskaya, A Drigas 2021 The importance of working memory in children with Dyscalculia and Ageometria Scientific Electronic Archives 14 (10) https://doi. org/10.36560/141020211449

[68] Chaidi I, Drigas A 2020 Parents' Involvement in the Education of their Children with Autism: Related Research and its Results International Journal Of Emerging Technologies In Learning (Ijet) 15 (14), 194-203. https://doi.org/10.3991/ijet.v15i14.12509

[69] Drigas A, Mitsea E, C Skianis 2022 Clinical Hypnosis & VR, Subconscious Restructuring-Brain Rewiring & the Entanglement with the 8 Pillars of Metacognition X 8 Layers of Consciousness X 8 Intelligences. International Journal of Online & Biomedical Engineering (IJOE) 18 (1), 78-95. https://doi.org/10.3991/ijoe.v18i01.26859

[70] Drigas A, Karyotaki M 2019 Attention and its Role: Theories and Models. International Journal of Emerging Technologies in Learning 14 (12), 169-182, https://doi.org/10.3991/ijet.v14i12.10185

[71] Drigas A, Karyotaki M 2019 Executive Functioning and Problem Solving: A Bidirectional Relation. International Journal of Engineering Pedagogy (iJEP) 9 (3) https://doi.org/10.3991/ijep.v9i3.10186

[72] Bamicha V, Drigas A 2022 ToM & ASD: The interconnection of Theory of Mind with the social-emotional, cognitive development of children with Autism Spectrum Disorder. The use of ICTs as an alternative form of intervention in ASD Technium Social Sciences Journal 33, 42-72, https://doi.org/10.47577/tssj.v33i1.6845

[73] Drigas A, Mitsea E, Skianis C. 2022 Virtual Reality and Metacognition Training Techniques for Learning Disabilities SUSTAINABILITY 14(16), 10170, https://doi.org/10.3390/su141610170

[74] Drigas A,. Sideraki A. 2021 Emotional Intelligence in Autism Technium Soc. Sci. J. 26, 80, https://doi.org/10.47577/tssj.v26i1.5178

[75] Drigas A, Mitsea E, Skianis C.. 2022 Subliminal Training Techniques for Cognitive, Emotional and Behavioural Balance. The role of Emerging Technologies Technium Social Sciences Journal 33, 164-186, https://doi.org/10.47577/tssj.v33i1.6881

[76] Bakola L, Drigas A, 2020 Technological development process of emotional Intelligence as a therapeutic recovery implement in children with ADHD and ASD comorbidity. . International Journal of Online & Biomedical Engineering, 16(3), 75-85, https://doi.org/10.3991/ijoe.v16i03.12877

[77] Bamicha V, Drigas A, 2022 The Evolutionary Course of Theory of Mind - Factors that facilitate or inhibit its operation & the role of ICTs Technium Social Sciences Journal 30, 138-158, DOI:10.47577/tssj.v30i1.6220

[78] Karyotaki M, Bakola L, Drigas A, Skianis C, 2022 Women's Leadership via Digital Technology and Entrepreneurship in business and society Technium Social Sciences Journal. 28(1), 246–252. https://doi.org/10.47577/tssj.v28i1.5907

[79] Drigas A, Bakola L, 2021The 8x8 Layer Model Consciousness-Intelligence-Knowledge Pyramid, and the Platonic Perspectives International Journal of Recent Contributions from Engineering, Science & IT (iJES) 9(2) 57-72, https://doi.org/10.3991/ijes.v9i2.22497

[80] Drigas A, Karyotaki M, 2016 Online and Other ICT-based Training Tools for Problem-solving Skills. International Journal of Emerging Technologies in Learning 11 (6) https://doi.org/10.3991/ijet.v11i06.5340

[81] Mitsea E, Drigas A,, Skianis C, 2022 Breathing, Attention & Consciousness in Sync: The role of Breathing Training, Metacognition & Virtual Reality Technium Social Sciences Journal 29, 79-97, https://doi.org/10.47577/tssj.v29i1.6145

[82] Mitsea E, Drigas A, Skianis C, 2022 ICTs and Speed Learning in Special Education: High-Consciousness Training Strategies for High-Capacity Learners through Metacognition Lens Technium Soc. Sci. J. 27, 230, https://doi.org/10.47577/tssj.v27i1.5599

[83] Drigas A, Karyotaki M, Skianis C, 2017 Success: A 9 layered-based model of giftedness International Journal of Recent Contributions from Engineering, Science & IT 5(4) 4-18, https://doi.org/10.3991/ijes.v5i4.7725

[84] Drigas A, Papoutsi C, 2021,Nine Layer Pyramid Model Questionnaire for Emotional Intelligence, International Journal of Online & Biomedical Engineering 17 (7), https://doi.org/10.3991/ijoe.v17i07.22765

[85] Drigas A, Papoutsi C, Skianis, 2021, Metacognitive and Metaemotional Training Strategies through the Nine-layer Pyramid Model of Emotional Intelligence, International Journal of Recent Contributions from Engineering, Science & IT (iJES) 9.4 58-76, https://doi.org/10.3991/ijes.v9i4.26189

[86] Drigas A, Mitsea E, Skianis C, 2022 Intermittent Oxygen Fasting and Digital Technologies: from Antistress and Hormones Regulation to Wellbeing, Bliss and Higher Mental States BioChemMed 3 (2), 55-73