

# Assistive Technology for ADHD: A systematic literature review

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## ABSTRACT

This paper reports on a study that aimed to identify different assistive technologies that are currently available to support children living with ADHD. This review is conducted by using a systematic approach by collecting and analyzing academically acknowledged qualitative as well as quantitative studies between 2011 and 2019. For the purpose of this study, assistive technologies were divided into three categories namely: 1) Wearables, 2) Mobile technology and applications and 3) Computer-based technology. It was also found that some believe that the use of technology cannot be the aid to support children living with ADHD in a school environment. These results indicate that even though there are several assistive technology solutions that are currently present, there were mixed conclusions on the effectiveness of utilizing assistive technology as an aid of ADHD.

**Keywords:** Assistive Technology, ADHD, Children, School Performance.

## 1 Introduction

The treatment for Attention Deficit Hyperactivity Disorder (ADHD) is not one of medication alone, thus multimodal treatments are currently recommended when one is treating ADHD [1], [2]. ADHD includes characteristics and symptoms of absent-mindedness, impulsivity, and hyperactivity [3]. Further, an ADHD child will also display signs of other characteristics such as not listening with understanding of the context, being forgetful, struggling to stay still or may be fidgety, being restless and talkative [4]. These behaviors can make it difficult for any educator or parent who needs to teach ADHD children, especially in a mainstream school environment.

An average of 8.4% of children worldwide is estimated to be diagnosed with ADHD, making it one of the most prevalent mental disorders that are currently affecting children [3]. Poor academic performance shows a positive correlation with ADHD.

ADHD may cause a cognitive impairment for people who suffer from the disability and results in a deficit in executive functioning of cognitive processes, problem-solving abilities and working memory [5]. These difficulties have a high impact on academic – and occupational performance [6]. Treatment for ADHD requires one to look at various components, such as individual - and family knowledge, collaboration and support from

educators and other school personnel, management of a child's behavior, as well as medication to treat the psychological aspect [1].

Previously, educators had to rely on individually created visual and audio means of teaching. They used tools such as 16mm projectors and tape recorders as support to better reach and teach children who learn differently [7]. Today, the means of teaching has become more technically orientated and computerized, with different media and audio functions that can support educational environments. An immense number of technological advances have increased humans' dependence on technology and computers to assist them with day-to-day activities.

Assistive Technology (AT) should not only adapt to support each learner's individual needs, but should also comply with the rules and regulations of assessments and examinations [4]. AT is a set of mechanical, electronic or computerized equipment designed for - and used by people with disabilities to help them function in their everyday lives [7]. Each child is different, which means that there is not only one AT solution that can help all children living with ADHD to learn better and that existing AT must be able to adapt to a student's individual need [4]. Hence, AT should not only be designed for students with visible or physical disabilities, but rather for all those who need help in order to succeed in a mainstream school environment.

This paper aims to critically evaluate struggles that children, living with ADHD, have concerning their school performance and how assistive technology can support these learners with their learning and developmental difficulties to excel in a mainstream school environment.

## **2 Research method**

The research question to be answered by this study is: *What aspects needs to be considered when utilising assistive technology as an aid to support ADHD in a school environment?* The following search terms were used: ("Assisting Technology" OR "Assistive Technology" OR "educational technology" OR "app\*") AND ("Learning disability\*" OR "learning difficult\*") AND ("ADHD" OR "Hyperactivity Deficit Attention Disorder" OR "cognitive disability" OR "behavioural disorder" OR "conduct disorders" OR "disruptive disorders") AND ("School Performance" OR "grade average" OR "education") AND ("child\*")

The selection criteria include a set of inclusion criteria and exclusion criteria that was pre-defined by the author based on information needed to answer the research question. The following inclusion criteria were used to select the sources, any article not conforming to this were excluded: (1) Studies in English, (2) Studies where participants were younger than 18, diagnosed with ADHD and/or learning disabilities, (3) Studies where participants display problems signs in regards to school performance, (4) Studies from 2011 to 2019, (6) Studies from peer reviewed journal articles and books using qualitative measures for analysis, seeking to understand the impact ADHD and learning disabilities has on school performance.

### 3 ANALYSIS OF FINDINGS

This section describes the analysis of data found as well as a discussion on each topic. All the findings are divided in sections that relates to the different parts of the research question that served as a guide for this literature review. Of the 32 articles, eight discussed assistive technology intervention for ADHD, eight discussed educator's knowledge of ADHD and possible interventions, six articles discussed ADHD in correlation with learning disabilities, poor executive functioning and poor school performance, six discussed the prevalence of ADHD and five discussed guidelines when developing assistive technology for ADHD. Each of these aspects will be discussed in more detail in the following sections.

#### 3.1 The impact of the environment on a child with ADHD

Figure 1 shows that the school environment for a child with ADHD is influenced by the type of AT technology, the knowledge of the Educator and the performance of the child. Each of these aspects will be discussed in the following sections.

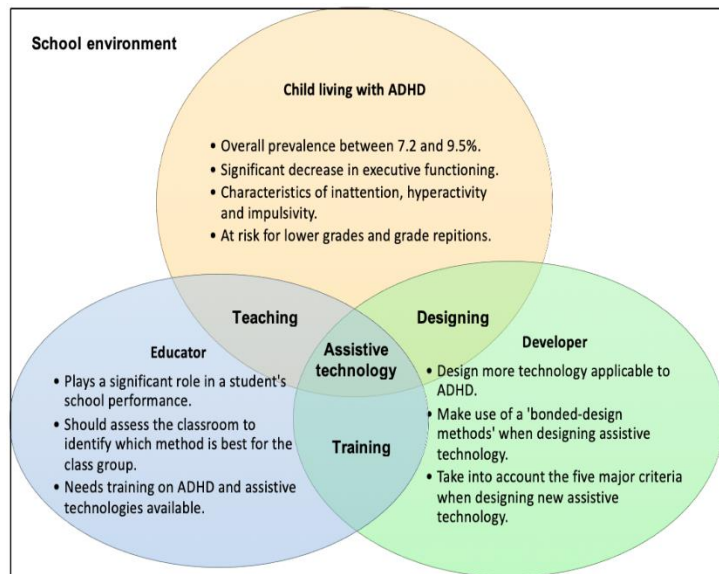


Fig. 1. Summation of the environment that impacts

**The impact of ADHD on a child.** Analyzing the collected research materials, it was found by [9] and [14] that ADHD is one of the most common disorder affecting children.

Children living with ADHD shows a significant decrease in executive functioning [8]. Executive functioning is classified as the cognitive processes that allow us to respond accordingly in certain circumstances. It enables us to make decisions, develop

new habits, evaluate risks, plan, prioritize and sequence activities [15]. Research done by [8] states that ADHD children exhibits a decrease in executive functioning skills. This compliments statements made by [9] and [10], that an average of 75% of ADHD children will have another psychiatric disorder, such as learning disabilities, anxiety, depression and aggression, which is impacting the quality of life and academic success for these children. Children need to use their executive functioning abilities to achieve daily goals in classrooms.

**Educator knowledge and training on ADHD and assistive technology.** Educators may be aware that cognitive abilities plays a significant role in a child's learning process and how this influences their academic success, yet they are less aware of the impact and symptoms of ADHD in the classroom [8]. The majority of textbooks to educate teachers on how to interact and teach children with special needs appropriately, only conveyed brief statements with explanations about learning disabilities in the classroom [11, 12].

In simple terms a classroom is that where children gets taught by an educator, yet the simplicity of this statement is influenced by many factors that vary internally as well as externally [13]. These factors can have a significant influence on the amount of effort that is spent of efficiently teaching children in that environment [13]. Optimal learning for students cannot occur without capturing their attention [14] and teachers should continually refocus a student's attention to the implied target once they notice that they lost their attention [13]. In order for teachers to make the best choice they need to have a prior understanding of the child and what he/she understands of the content as well as good knowledge about what the capabilities are of each specific technology that can be utilized in the classroom [14]. It is common for ADHD children to receive psychological help and medicine to help improve their cognitive processes, yet without the support the educator's understanding of the problem at hand and continuous motivation, these children is at risk of falling behind in school environments [11].

**Developing assistive technology for ADHD.** Assistive technologies refers to a wide variety of technology that can be utilized to support learning, teaching and the assessment of school activities [15]. Computer-assisted technology has been used as a form of special education for children who expressed a need with learning difficulties [15]. Smartphones, iPads and tablets has become more accessible to everyday lives. The capabilities of these devices has also been adopted in many classrooms worldwide as a form of learning and teaching [21].

There is evidence of many different assistive technologies used to improve a child's knowledge and skills when they live with difficulties such as ADHD. Several ongoing studies on many different assistive technologies and many assistive technologies were presented over the past years, yet most of them focus on Autism disorder and not ADHD [11]. People may mistake these two disorders to have many similar characteristics, however they are indeed very different. Thus the technologies developed for Autism disorder cannot automatically be adopted as an assistive technology solution for

ADHD [16]. The challenge with developing these technologies to support children living with ADHD is to keep younger children entertained as well as older children or adolescents [17].

Benton and Johnson [18] argue that researchers and developers should have a 'bonded design' method when designing new assistive technology for children with ADHD. This is when the children who will possibly be users of the program is involved throughout the process [18]. This will help to increasing the value of the technology and make the design better [18]. After empirical research was done in the ADHD domain, [16] identified five major criteria's that assistive technology for ADHD should adhere to: 1) All technologies should be unobtrusive to wear, 2) Systems should be robust enough to handle ADHD behavior in the classroom and outside, 3) Avoid technology that may expose children to bullying and stigmatization in school, 4) The system should always deliver real time and continuous feedback, 5) It should be relatively easy to set up in order to avoid frustration for the child. These devices should recognize certain activities and movements made by a child in the classroom, it should then analyses the data, detect the changes that trigger inattentiveness in class and assist the child to regain attention in a non-intrusive way [16]. Abbott et al. [19] state that technology is increasingly used by humans to become more efficient and this contributed to rapid and multiple changes in the development domains, enabling technology to become cheaper, easily accessible, more efficient, reliable and flexible.

### **3.2 Discussion of different types of Assistive technology for ADHD**

This section aims to provide insight into the different methods that can be used as alternative ways to teach and support children living with ADHD in a mainstream school environment. Four main topics are covered namely: 1) Wearable technology to assist ADHD, 2) Mobile technology and applications to assist ADHD, 3) Computer-based technology to assist ADHD and 4) Arguments against technology intervention.

**Wearable technology that can assist with ADHD.** Wearable technology is known as an accessory that can be worn, whether it is part of one's clothing, implanted in your body or tattooed on one's skin [26]. It is a hands-free gadget, used to make one's life more efficient that can be used in many practical ways by using microprocessors to send and receive information to-and-from the internet [26].

Rijo et al. [16] researched Child Activity and Sensitivity Training Tool (CASTT) as a wearable device for children living with ADHD. This prototype was built around three important components that needs to be taken into account when one is developing assistive technology for special needs, especially ADHD, namely: sensing, recognising and assisting. In 2012, the CASTT device could be combined with Dolce Ultra-lite (DUL) sensors, a smartphone, and HR monitor and an Electroencephalography (EEG) headset to sense the child's physical and psychological state when taking part in different activities [16]. They have found that the DUL sensors, smartphone and HR monitor were all comfortable to use by the children. This was magnified when a child went out for play time and only took off the EEG headset [16].

Finding solutions to help a child living with ADHD is extremely important, as their focus that is kept during the day in the classroom play a big role in their overall end year performance. During the rest of the study [16] made the notification on the smartphone vibrate every 15 minutes. They noticed that the vibrating notifications from the smartphone did not disturb the rest of the children in class, while at the same time reminding the student applicable to stay focused [16]. The average child did return to his current assignment after the smartphone vibrated and afterwards stayed focused for an average of 10 – 12 minutes of the intervention.

There is currently another smart watch called WatchMinder which can be used to help ADHD children set such reminders, with each reminder the watch vibrates [27].

**Mobile applications that can assist with ADHD.** Today, mobile applications are part of the everyday lives of the average human being and the increase in users has come from more people being constantly on the move that can make use of the different applications anywhere at any time to aid several everyday tasks.

The different applications tend to satisfy different needs for different users living with ADHD as everyone living with ADHD does not exhibit the same characteristics and does not struggle with the same difficulties.

The iPad, as a useful mobile technology, has gained a substantial following over the past decade. It is found to be a feasible solution to enhance participation and inclusivity in the classrooms and many schools have adopted the technology as a means of learning and teaching, as it supports a wide range of educational needs [21]. The iPad is a tool that encourages Universal Design for Learning (UDL) in a school environment and allows educators to teach children with different needs in different ways that can help them be successful and improve their overall school performance. Many parents, teachers and children across the world already own smartphones and tablets. Due to this, learning how to use the device will take the minimum amount of time for the applicable party. Educators can use this method to create a more inclusive classroom and incorporate learning methods based on all children's multiple complex needs. In order to implement the use of an iPad successfully the organization or school needs to provide the teachers as well as the learners with the needed support to gain the necessary skills and knowledge to efficiently use the device and the apps applicable [21].

ProceduralPal is a mobile application that aims to aid children living with ADHD and who has access to a smartphone to rehearse common daily tasks [27]. The application allows you to break these tasks up into separate smaller steps that can each be represented by a picture if needed [27]. Users can then view the images and read the instructions to know how to accurately and efficiently complete the task at hand step-by-step [27].

TaskTracker, like ProceduralPal is a mobile application that is designed to aid children living with ADHD to complete daily tasks efficiently. On the app, each user can log certain tasks that they may find difficult [27], [28]. For each task the app has a progress bar, alarm reminders and motivational messages that has been designed to encourage successful task completion with time managed, rather than focusing on remembering to complete the task alone [27][20, 21].

While there are many other assistive technologies that can assist children living with ADHD during execution of everyday tasks and memory, the developers of the mobile applications mentioned above has included some basic needed features that others have not. Both ProcedurePal and TaskTracker are apps that not only focuses on task management, but they also place focus on time management.

The Training Attention and Learning Initiative (TALI) program, is a computerized software that is specifically designed to improve attention skills [22]. When working with this program you have 4 activities to complete on a touch screen tablet or smartphone. Each activity lasts 4 minutes and the exercises for the day takes approximately up to 20 minutes. By using an inbuilt criterion, the software is able to determine the level of difficulty for each individual user and will automatically adjust it regarding their performance in each activity. The developers created a visual and verbal guide in order to sufficiently help the child work on the system and through every activity. When a child's attention is trained, attention can be better maintained during strenuous school activities. [22] found that when the children used this app for a 3 month period, had selective improvements in both short- and long term attention.

**Computer-based training and gamification that can assist with ADHD.** Computer-based training is seen as a form of training done on a computer. A computer has the capabilities to teach a student in more forms than one by making use of audio, video, graphical information and text. The system can be tailored to each individual's needs. This form of training can be beneficial when different students in the class each has different means of processing and gaining new knowledge. When the right training is offered as an intervention to the right children, who experience a deficit in certain cognitive functions, it is evident that this type of training will keep the children engaged and have many noticeable and favorable outcome [22].

Cogmed Working Memory Training is a computer-based application that is aimed to improve attention difficulties, caused by working memory inefficiencies, that children living with ADHD experience [22]. This program is designed to challenge the capacity of its user's working memory and target cognitive functioning that is needed to enhance its user's everyday lives. This goal is reached through cognitive exercises, developed by neuroscientists, that can be done by each user. It is developed in such a way that the difficulty level is set in real-time based on the user's performance when completing the different exercises for the day [22].

Plan it commander is a specific program or software aimed to help ADHD, to play at home, developed by the Ranj Serious Game Project. This program helps the children to plan for certain events by requiring the player to solve many different problems in a certain situation [22, 23]. The game consists ten main mission, all with submissions. These missions consist of activities that improve cognitive functioning by training complex and critical thinking skills, time management, planning and organizing skills [23]. Once the one mission is completed, the next will become available. There is an enclosed space provided where players can ask each other questions and in turn other players provide assistance [23].

**Arguments against computer-assisted technology as an aid for ADHD.** Weisberg [27] argues that even though several new assistive technologies have been developed to assist ADHD and other executive functioning factors over the past years, some solutions may be intrusive. Many assistive devices display reminders and vibrate, this may cause a child living with ADHD to constantly be distracted by the device instead of it aiding the child to be more efficient when completing tasks.

Children who are allowed to substantially increase screen time to assist them with different tasks, may become dependent on media [24]. As the child gets older and child-parent conflict arises, children may seek support from other sources such as media, smartphones tablets and computers [24]. These children are at risk of becoming addicted to these devices and can increase their risk for other comorbid disorders that is common in children living with ADHD, such as anxiety and depression [24]. Side effects may occur when technology is used continuously, such as changes in behaviours, cognitive functioning and emotions [24]. This can be due to the amount of information one needs to process when working on technology and the constant change between platforms used.

## 4 Conclusion

Computer-assisted technology has become more popular as an aid to use in schools worldwide and is especially used to teach children with special needs. This is attributed to the fact that learning technology has gained a reputation of when used appropriately it can substantially improve a child's experience and performance in a mainstream school environment. Even though there are verified arguments why technology is not the best solution to support children living with ADHD in a mainstream school environment, the positive feedback is far greater. Today, there is an increasing need to create an environment where access to education is equal for all students, while also creating a learning process that empowers the child to excel irrespective of their individual abilities or lack of. Attention should be placed on finding new ways to make an impact through different teaching practices to accommodate children living with ADHD learning disabilities or learning difficulties.

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