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Learning with ADHD: A Review of Technologies and Strategies

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Abstract

As part of our continuing efforts to improve inclusion in teaching and learning, we examined cognitive needs in online learning, specifically relating to attention deficit hyperactivity disorder (ADHD). Through a narrative literature review and environmental scan, we analyzed current knowledge reported in ADHD research to understand its impact on learning for students diagnosed with ADHD and examined the interventions and strategies that support their executive function and focus needs, specifically in an online learning context. We used the lens of a Technology–Content–Pedagogy (TCP) framework to organize and interpret the strategies for supporting students with ADHD in online learning.

Keywords

Cognitive disability, attention deficit hyperactivity, executive function, behavioural intervention, online learning, adaptive strategy.

Introduction

Article 24 of the United Nation's Convention on the Rights of Persons with Disabilities (UNCRPD) recognizes education as a fundamental right of persons with disabilities. Following the onset of the COVID-19 pandemic, online learning has received increasing focus. For learning to be inclusive, we need to find new ways to accommodate students with disabilities online (Gin et al. 12). Of the different types of disabilities, cognitive disabilities are the least understood outside of medical or specialized environments (Blotnicky-Gallant et al. 16).

Attention deficit hyperactivity disorder (ADHD) is one of the most common cognitive disabilities, estimated to affect 8–10% of children and 5–6% of adults worldwide (Ng *et al.*, 123). Before reaching 18 years, three girls are diagnosed with ADHD for every six boys diagnosed (Dalsgaard et al.). By the age of 25, an estimated 15% of people diagnosed with ADHD as children still have a full range of symptoms, and 65% still have some symptoms that affect their daily lives. ADHD remains undiagnosed in many individuals. ADHD is marked by an ongoing pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development, which could impact learning (National Institute of Mental Health).

The accessibility team from [D2L Corporation](#), a global learning platform company based in Ontario, Canada, collaborated with the University of Toronto on a 4-month research project to explore cognitive needs in online learning. Due to the short duration, we focused on ADHD as it is highly prevalent and impacts students' ability to focus during class, engage in learning, complete tasks, and keep up with assessments. We explored the nature and impact of ADHD and the interventions used to manage it. Based on that, we identified a set of teaching and learning strategies for educators focused on technology, content, and pedagogy to support students with ADHD in online learning.

Research Objectives and Questions

Our research objectives were (a) to examine the prevalence and characteristics of ADHD and the resulting challenges in the context of learning, and (b) identify mechanisms for educators to support online students with ADHD. Our study was driven by two research questions:

1. What is the impact of ADHD on the experience of learning?
2. What are the strategies and tools that help manage online learning with ADHD?

Methods

We conducted a narrative literature review (Rumrill Jr and Fitzgerald 166) using the following databases: PsycInfo, PubMed, Scopus, CNAHL, Cochrane Collaboration for systematic reviews, ERIC, and Web of Science. We used combinations of the following search terms: ADHD, ADD, Attention-Deficit Hyperactivity Disorder, online learning, distance learning, blended learning, intervention, LMS, learning management system, executive function, behavioural, technology, assistive technology, strategy, accessibility. We initially identified abstracts of 48 original research papers and meta-analyses published in English between Jan 1, 1990, and June 30, 2021, then selected 30 for in-depth review. Of these, we identified 12 papers (including 4 meta-analyses) as key to our analysis as they contained information that matched key topics connecting ADHD to learning. In addition, we conducted an environmental scan (Choo 29) using Google search with the same terms as for the literature review. We accessed 35 websites and found 17 pages with relevant information that were included in the analysis. We summarized key findings from each study and then identified patterns using qualitative content analysis techniques by tagging and organizing those findings (Berg 304). We used an online learning framework described in the next section to interpret the findings.

TCP Framework for Online Learning

Based on Chandrashekar and Wang's (2019) Platform-Process-Content framework and Koehler and Mishra's (2009) Technological-Pedagogical-Content-Knowledge model, we built the Technology–Content–Pedagogy (TCP) framework (see Figure 1).

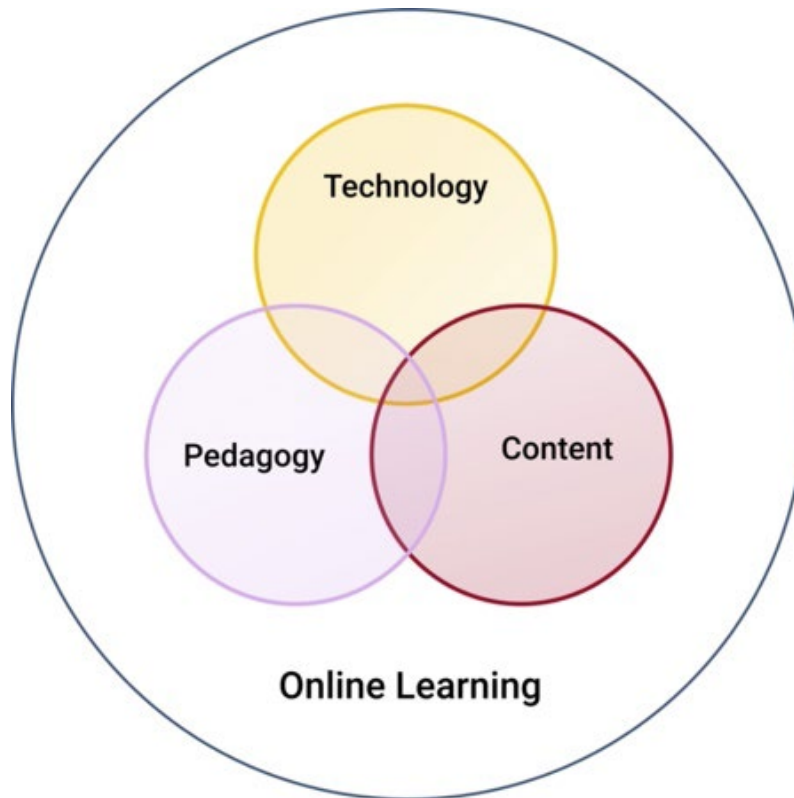


Fig 1: Technology–Content–Pedagogy (TCP) framework

This framework comprises three layers within the online learning space. First, the *technology* layer, relating to accessing and interacting with the online learning platform and all associated tools. Second, the *content* layer, relating to producing and consuming accessible learning and assessment content. Third, the *pedagogy* layer, relating to facilitating inclusive pedagogical practices that support Universal Design for Learning (UDL) principles. UDL is a framework to improve and optimize teaching and learning for everyone (CAST). The three layers form the online learning stack and are meant to be used together; each layer is necessary

but not sufficient for an optimally inclusive online learning experience. Ensuring accessibility in each layer is necessary to ensure ‘full-stack accessibility’ in online learning. We used this TCP framework to organize and interpret our findings.

Findings

About ADHD

ADHD is a neurodevelopmental disorder that typically manifests early in development (Khan et al. 2). Parts of the ADHD brain develop more slowly than a neurotypical brain, resulting in a spectrum of ADHD conditions from mild to severe (Novotney). The Diagnostic and Statistical Manual of Mental Disorders (DSM) classifies ADHD into three types, marked by (1) inattention, (2) hyperactivity/impulsivity, and (3) a combination of both. Combined type is the most common form of ADHD, while hyperactive/impulsive is the least common.

In most cases, ADHD is comorbid with other learning or psychiatric conditions, making it difficult to differentiate ADHD (Rommelse et al. 282). Many students with significant cognitive disabilities might also have co-occurring motor and sensory impairments that impact their ability to learn (Erickson and Geist 87). A diagnosis of ADHD is highly correlated with lower levels of academic success, including lower rates of high school and college completion, and those with ADHD symptoms tend to experience behavioural difficulties and obstacles in their work and personal lives (Hoben & Hesson 40). ADHD is marked by a delay in the normal developmental unfolding of cortical executive function.

Executive function is the ability to perform goal-directed tasks using organizational skills and the ability to plan, sustain attention, and control impulsivity (Rigoni et al. 875). All persons with ADHD, regardless of subtype or severity, are characterized by an impairment of executive function (Brown 38). Students with ADHD perform more poorly on measures of executive

function than those without ADHD (Brown 37). This could impact their school performance, among other things. However, they can excel in academic settings if supported with appropriate interventions (Brown 39; Levy and Hay 43).

Interventions Used with ADHD

There are two primary forms of interventions used to manage ADHD: medical, and behavioural. Traditionally, stimulant medication has been the main intervention for ADHD, and it still plays a major part in managing the condition with or without other forms of intervention. Over two-thirds of children and teens who have been diagnosed with ADHD take medication to manage it (CDC). But medication is found to be minimally effective in increasing academic achievement or improving peer relationships (Chronis, Jones, & Raggi 6), which tend to respond better to behavioural interventions (Clay 45).

Behavioural intervention from parents and teachers is another form of support for ADHD. While most of such interventions require physical co-presence, it is possible to use them in an online context with synchronous meeting tools and pedagogical processes (Andersen and Sorensen). A combination of medical and behavioural interventions is found to be optimally effective (Barbaresi et al. S36; Wolraich et al. 1740).

Strategies for Teaching and Learning

Several strategies have been reported for supporting learning with ADHD, some of them for use by teachers as behavioural interventions and some of them by students as measures for self-monitoring or self-regulation. We examined the strategies through the TCP framework lens. Table 1 lists the strategies under technology, content, or pedagogy based on which layer each of the strategies is predominantly associated. These are each discussed further below.

Table 1: Online learning strategies for ADHD

Technology	Content	Pedagogy
Accessible authoring tools with dictation support	Structure & overview templates for creating content	Frequent feedback and positive attention
Assistive tools like text-to-speech with highlighting	Assessment artifact creation and submission templates	Multimodal options for task completion
Speech-to-text programs to help with writing	Templates for comprehension of content	Motivation through awards and game-based learning
Self-monitoring aids	Templates for communication	Peer tutoring
Reminder programs and intelligent agents		Shielding from distractions to improve focus
Virtual reality		Multimodal communication
		Information chunking
		Means for collaboration and knowledge-building

Technologies used most in special education are computer-based and web-based (Liu, Wu, and Chen 3620). The options to support students with ADHD through technology are ever-increasing. However, finding the right tool to address a student's specific needs could get challenging given the variance in the characteristics of ADHD across different students (Mosher et al., 2020, p. 2). These characteristics may affect the way each of them responds to specific technologies.

Digital technologies offer possibilities for multimodal expression/communication amongst students and teachers. Some technologies focus on aiding students with ADHD for production and dissemination of information such as accessible authoring tools with dictation support or speech-to-text programs, and accessible information consumption with text-to-speech and highlighting tools (Sorensen and Andersen 49). Assistive tools for reading difficulty use various combinations of instructional strategies to grab learners' attention and focus (Thapliyal & Ahuja, 2021, p. 2). Mobile devices such as iPad and iPhone allow students to store learning material including textbooks in apps like the iBooks. This technology allows the use of strategies like highlighting and note-taking for boosting reading comprehension, which are critical for students with low attention.

Some technological tools help students with self-monitoring their progress with learning or task completion (Blotnick-Gallant et al. 5). Reminder systems and intelligent agents help with remembering recurring tasks such as completing assignments for self-regulation (Rigoni et al., 2020, p. 882). Teachers use these strategies in their classrooms, to provide their students with ADHD with optimal interventions to enhance both their learning and behavioural functioning at school (Blotnick-Gallant et al. 16). Virtual reality environments can help foster rapid interaction and real-time feedback, keep students active by performing activities on their own or in collaboration with other students, and allow teachers to have tools to measure student performance and provide feedback (Cardona-Reyes et al. 3787).

Well-designed technology strategies have the potential to provide visibility to what students can do and what they know. When things go well, the self-esteem of the student improves; when they do not, there is an opportunity for teacher insight into what to improve to provide adequate support (Sorensen and Andersen 57).

In terms of content, both consistency and structure are important for students with ADHD (Sorensen 50). Teachers must focus on maintaining consistency in their communication and learning material. An effective strategy for this is to provide templates with appropriate structure to the students for creating content, artifacts and submissions for assessment, note-taking for comprehension, or communicating (Cinquin 165).

It could get difficult for students with ADHD to simultaneously work on content and structure. Templates serve to scaffold their learning process. Writing templates can offer the student a frame for the task at hand. These could be created by teachers using popular software such as MS PowerPoint or MS Word.

From a pedagogy perspective, several strategies are reported to promote consumption and production of information by the learner as well as engagement with the learning process. To make consumption of learning material easier, teachers are encouraged to use multi-modal representation and communication (Sorensen 53). This helps with providing choices to the students to engage through the mode that best suits them. Providing students flexibility for task completion such as allowing multiple modes for task completion (oral as well as written) facilitates submissions. Communication can be facilitated through building in means for collaboration and knowledge-building (Sorensen & Andersen 46).

Engagement with the learning material is enhanced through information chunking, which refers to dividing content or assignments into smaller parts or modifying them to reduce the length of tasks to enable students to complete each piece without losing their attention. Research indicates that frequent feedback, positive attention, and rewards motivate students with ADHD to remain engaged and respond better (Rigoni et al., 2020, p. 882). Awards and game-based

learning may also help with this. However, the environment must be constructed to shield students from distraction (Sorensen 53).

Peer tutoring is another useful pedagogical strategy that draws upon other students. Peer tutors are sometimes enrolled into the same course as the student. They help students interpret the course material and assist them in understanding what is expected of them in that course. How the peer tutor works with the student to help them be successful in the course depends on the level of accommodation that student needs (Blotnicky-Gallant et al. 15).

Some strategies could require additional preparation time, such as providing advanced organizers for content and customizing learning materials for the student. When teachers use these strategies in their classrooms, their students with ADHD are provided with optimal interventions that may enhance both their learning and behavioural functioning at school (Blotnicky-Gallant et al. 16). It is important, therefore, to ensure that teachers have appropriate training and support for the time required to implement such evidence-based strategies.

Discussion

Technology emerged as a strong factor in providing behavioural interventions to students with ADHD in online learning both directly as a modality-interchange tool and indirectly as a vehicle for supporting content creation and consumption using templates. The pedagogical processes that support students with ADHD align with UDL principles (REF), enabling multiple modes of content and communication, and multiple means of action, expression, and engagement. This suggests that the practice of inclusive education based on UDL principles would greatly benefit students with ADHD in the class, both for students who declared their disability and for those who did not.

Regarding the usefulness of the TCP framework for categorizing the strategies, it is evident from Table 1 that some strategies based on mindfulness (Xue et al. 1), humour (Erdoğdu & Çakıroğlu 3), and exercise (Ng et al. 124) that have a positive effect on learning do not fit into it directly. Humour could be applied to some extent to pedagogy, especially to teacher-to-student and student-to-student communication. Erdoğdu and Çakıroğlu (3) posit three dimensions of student engagement: behavioural, emotional, and cognitive. When humour is infused into a learning activity, it creates a positive emotional atmosphere. This can increase motivation and engagement. Thus, using humour brings students and teachers closer (Mayer & Estrella, 14).

The three layers, technology, content, and pedagogy, also intersect with one another (see Fig 1). This affords us to consider if any of the strategies might lie in the cusp of two layers, or at the intersection of all three layers. Considering the case of a text reader that highlights and reads out text loud. While this is a technology, it also improves engagement. It is arguable whether the strategy that engages the student using a text reader to consume learning content would fall under technology, or at the intersection of technology and pedagogy or at the intersection of all three layers in the centre. We would argue that it falls only under technology as the increased engagement is not on account of anything the teacher did or designed into the content but because of the technology. More work needs to be done to examine strategies from this angle.

Further, much more work is needed to examine the effectiveness of strategies and combinations of strategies. Many of the strategies considered in the reviewed literature were suggested based on findings (e.g., Rigoni et al. 881) or reported based on teacher use (Blotnicky-Gallant et al. 9). Other strategies or approaches were explored in research, but effectiveness of the strategies was not measured (e.g., Sorensen & Andersen, 47-48). Given the range of experience for learners with ADHD, it is important evidence for strategy effectiveness includes

studies both with high internal validity and those with high external validity. A combination of between group and within-subject designs is important to provide evidence for strategy effectiveness in the population of learners with ADHD (Fabiano et al. 130).

Conclusions

Through this research, we derived insights about the accessibility needs of students with ADHD and ways to support them in an online learning environment. We drew our data for this research only from secondary research and did not gather empirical data. Conducting primary research with students with a range of cognitive needs is an important future goal. It would also be useful to examine other cognitive conditions such as learning disabilities, autism spectrum, and developmental disabilities. Supporting students with cognitive disabilities who require specialized attention from teachers and specialists during these pandemic times is vital to ensure they are not left behind.

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