Creating a virtual life coach to support ADHD students' life structure

Prepared by:
Daan den Otter
daan.denotter@student.hu.nl
1665029

January 28th, 2021

Graduation assignment
MA Data-driven Design
University of Applied Sciences Utrecht
Supervisor: Arjen Suijker

ABSTRACT

Entering college reduces students' life structure, which was formerly provided by their parents or teacher. This asks for more self-regulation of the individual, something that is extra difficult for ADHD patients. This study aims to create a virtual life coach (VLC) that supports a weekly structure for ADHD students as an addition to the current ADHD coaching treatment. The VLC is a mobile application (app) that gathers data from interacting with the user to provide better service. The VLC schedules the user's day by using time blocks and keeps the user on track by sending messages. The users reflect on their day by rating their mood, upon which the system can learn to provide better schedules. To substantiate the research results, a prototype of the VLC is created using a co-design approach. Therefore stakeholders were involved as much as possible. The iterations in the design process of the prototype gained insights into how such technology could be part of ADHD treatment.

Keywords: ADHD treatment; ADHD students; Technology for ADHD; Virtual life coach;

1. INTRODUCTION

The number of Attention Deficit Hyperactivity Disorder (ADHD) substance users in the Netherlands has more than quadrupled over the past two decades (GIP / Zorginstituut Nederland, 2021). The most recent prevalence in 2020 shows that 221.633 people (compared to 48.436 in 2003) got ADHD substances to help them control their symptoms. ADHD is characterized by hyperactivity, concentration problems, and impulsivity (Fabio et al., 2015). The worldwide prevalence of ADHD is 5.29%. The estimated ADHD diagnosis in the Netherlands is at 2,9% for children and 2,1% for adults (Tuithof et al., 2010). Treatment can start right after the diagnosis takes place.

The most used drug for treating ADHD is methylphenidate (Ritalin). The medication can cause various side effects, such as loss of appetite, difficulty sleeping, sadness, and nervousness (Efron et al., 1997). Besides, there is an increasing misuse of ADHD stimulants among high school and college students and athletes (Lakhan & Kirchgessner, 2012; van der Heijde et al., 2020). Therefore, Van der Heijde et al. (2020) recommend paying more attention to, among other things, lifestyle improvement, more effective study methods, and stress management.

The latest diagnosis model DSM-V expanded the ADHD definition and made more accurate recognition of the disorder possible, explaining an increased number of people diagnosed with ADHD, resulting in an increased number of substances (American Psychiatric Association, 2013). DSM-V also made it easier for people to be diagnosed with ADHD at a later age. Therefore, young adults that enter college are now easier getting diagnosed, while back in the days, this was mostly done while in primary school.

Entering college reduces students' life structure, formerly given by their high school and family (Meaux et al., 2009). The lack of structure is an extra burden for an ADHD student because it creates more possibilities for distractions (Farrell, 2003). While students have to attend their classes and do their studying, they also have many opportunities to participate in non-academic activities, distracting them from obtaining their goals (Knouse & Fleming, 2016). Together, this creates an information overload and can feel overwhelming, confusing, and frustrating, making it harder to stay attentive (Jones et al., 1997). To maintain their structure, more self-regulation is asked from the individual, something extra difficult for

someone with ADHD as they experience impairment of their executive functions (Barkley, 2013).

Psychological treatment lets the patient deal with the disorder's limitations, which takes time. Diagnosed children and adolescents already had the time to practice, but the inconsistent lifestyle of college students makes it difficult to maintain structure in their week (Knouse & Fleming, 2016). This prevents this group from dealing with the disorder seriously, and therefore there needs to be a more accessible solution for this specific age group.

Personalized and productive ADHD treatment to learn how to structure their life in a more fulfilling way is time-consuming, and it takes perseverance to implement those new habits (GGZ, 2019). This would create a threshold, especially if this were not learned at a young age. Moreover, a way to make the learning process more accessible and sustainable has not been developed yet. Technological developments in healthcare and life coaching have led to a renewed interest in ADHD treatment.

Technology that tries to change the user's behavior is called persuasive technology (Oinas-Kukkonen & Harjumaa, 2009). Such technologies can be applied in many areas, such as education, health, and sustainability (Loock et al., 2013; Oinas-Kukkonen & Harjumaa, 2009; Soror & Davis, 2014). A mobile application (app) is an example of this. They benefit from the data gathered to improve their service. In this way, the app can develop a personal relationship with the user (Fortin et al., 2012). Clinicians specializing in ADHD see potential in an application to engage and motivate people with ADHD (Powell et al., 2017).

Persuasive mobile applications are also used to take over the role of a life coach. Preliminary research shows the potential of helping people improve their lifestyles by gathering data with a virtual life coach (VLC; Mason-Robbie, 2021). To illustrate, Cazier & Green (2016) introduced a virtual life coach that helps with the user's finance, health, and well-being. The European Commission (2017) also expressed its belief in VLCs by announcing a program where they specifically called for *"(...) Radically new solutions for a personalized 'virtual coach'"*. However, although there have been studies about the potential of VLCs and persuasive technology to help specific groups, there has not been any research on whether a VLC could help students diagnosed with ADHD. (Mason-Robbie, 2021; Păsărelu et al., 2020; Simons et al., 2016)

Therefore, this paper promotes the concept of a data-driven virtual life coach to help ADHD students create and maintain a unique structure of their week. The proposed VLC aims to cause an improvement in the student's lifestyle which eventually leads to better symptom control. The VLC should plan out the student's day, considering as many life

aspects as possible by gathering their data. Thereby, the VLC gives the student tips on managing the student's life and encourages the student to maintain the given structure. The application will ask the user for feedback to measure the effectiveness of the given structure upon which the VLC will improve its planning.

The application will be part of psychological ADHD treatment that could be used as an alternative and an addition to medicinal treatment. This research focuses on ADHD students because of their inconsistent lifestyle causing a sudden lack of structure. Thus, the following research question is proposed:

RQ: *How can a data-driven virtual life coach be part of ADHD treatment by providing life structure to college students with ADHD?*

The sub-questions asked to answer the main question are; 1) What features will benefit the students' structure?; 2) What role can a data-driven VLC play in ADHD treatment to mediate the students' behavior?; 3) What metrics from the interaction with the user can benefit the system to optimize the ADHD students' structure?

2. THEORETICAL FRAMEWORK

2.1 Attention Deficit Hyperactivity Disorder

Attention Deficit Hyperactivity Disorder (ADHD) is a common psychiatric disorder with restless, impulsive, and unconcentrated behavior symptoms (Fabio et al., 2015). In the Netherlands, ADHD symptoms are classified under three categories; 1) overactive child/hyperkinetic syndrome, 2) memory/concentration/orientation disorders, and 3) other concerns about a child's behavior (Prins & van Dijk, 2015a). While these categories may suggest that ADHD is a children's disorder, two-thirds of ADHD cases persist in adulthood (Wender et al., 2001). The worldwide prevalence of ADHD was estimated at 5.29% (Polanczyk et al., 2007). Tuithof et al. (2010) estimated the prevalence of ADHD diagnoses in the Netherlands is at 2.9% for children and 2,1% for adults. In the Netherlands, the annual prevalence of newly reported ADHD symptoms (a clustering of the three categories) more than doubled between 2002 and 2011 (Prins & van Dijk, 2015b).

People who suffer from ADHD experience problems conducting normal daily activities (Barkley & Murphy, 2011). ADHD is associated with a reduced quality of life (QoL) for all age groups (Brod et al., 2005). The QoL includes academic performance, behavior at school, peer relations, and family conduct (Hakkaart-van Roijen et al., 2007). ADHD in adulthood is related to a less educated and lower-income (Fayyad et al., 2007; Tuithof et al., 2014). Also, adults with ADHD suffer more from a disorder of mood, anxiety, or substances than adults without ADHD (Tuithof et al., 2014). ADHD is associated with other psychiatric disorders such as behavioral disorders, dyslexia, depression, anxiety, addiction, and sleeping problems in two-thirds of children and adults (Elia et al., 2008; Goodman & Thase, 2009). Adults with ADHD have average comorbidity of three other diagnosed disorders (Biederman et al., 1993; Fayyad et al., 2007).

The impact that ADHD has on someone's life functioning underscores the importance of good treatment. People who have ADHD-symptomatic complaints are referred to psychiatry. There they are diagnosed with a DSM classification of psychiatric illnesses. Since 2014, the fifth version of this model, DSM-V (American Psychiatric Association, 2013), has been used in the Netherlands. Since then, the test could also diagnose adults.

2.2 ADHD treatment

After someone is diagnosed with ADHD, the patient is referred to a specialist to undergo treatment. In the Netherlands, this could be the government agency of mental health care (GGZ), but they could also go to other ADHD centers (GGZ, 2019). A treatment plan is

created where ADHD standards are described (GGZ, 2019). However, they distinguished four elements: psychoeducation, ADHD coaching, medication, and cognitive behavioral therapy.

Psychoeducation educates patients and possibly parents and teachers about ADHD and its symptoms. This is done by a professional or by giving the information through a website. Medicational treatment starts with methylphenidate (better known as Ritalin or Concerta) or dexamfetamine, based on the patient's preferences. The medication helps patients for two to four hours after being taken in. However, it could have various side effects, such as loss of appetite, difficulty sleeping, sadness, and nervousness (Efron et al., 1997). ADHD coaching is a training program done by a therapist to reduce ADHD symptoms. It focuses mainly on planning and organization. If patients suffer from their symptoms, they will get a more intense therapy done by a psychologist: CBT. It focuses on thinking patterns to improve skills and increase motivation, besides planning and organization (GGZ, 2019). These interventions positively affect ADHD symptom reduction (Young et al., 2020). Consistently applying and repeating skills such as planning and organizing are determined for the success of the therapy (Ramsay et al., 2016). However, usually, intervention periods are temporary.

GGZ (2019) standards state that ADHD care should generally focus on self-regulation. They emphasize that it is essential to centralize the possibilities and preferences of patients. By doing this, patients will learn, among others, to recognize when they should take a rest, spend more time on one's actions and learn how to use a to-do list. Patients benefit from tools that can help with giving warnings for taking medication or mobile applications that help schedule so that people learn to make more use of their strengths. The statement of the GGZ about the focus on self-regulation corresponds to the work of Brown et al. (2019), where various unmatched needs for adults with ADHD are described. While having medication, they still experience impairments throughout the day or when the medication has worn off. Therefore, Brown et al. (2019) say that supporting activities for an optimized treatment is essential throughout the day.

2.3 Self-regulation

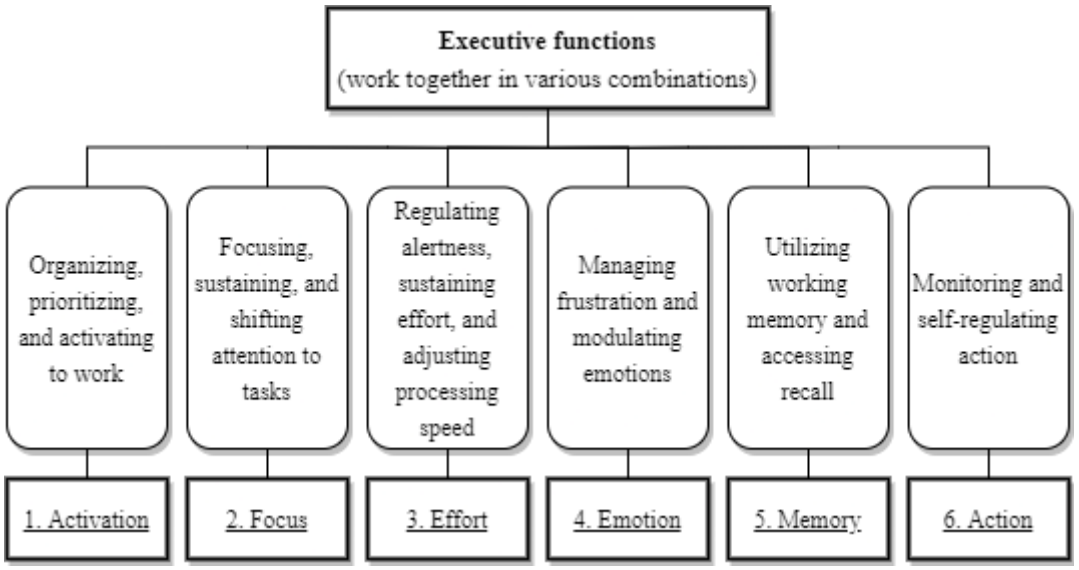
Self-regulation is provided by the executive functions (EFs) in the brain, which are "*neuropsychological processes needed to sustain problem-solving toward a goal"* (Miyake et al., 2000). In other words, EFs provide the self-regulation of a person's day-to-day behavior (Vohs & Baumeister, 2011). This includes organization and planning, starting and achieving

(short-term) goals, and self-monitoring (Barkley, 2015). ADHD patients often struggle with their self-regulation. Therefore, it is often seen as a deficit (Barkley, 2015; Brown, 2013).

Figure 1 shows the EFs model of Brown (2001), which includes six clusters with corresponding cognitive functions that affect a person's self-regulation. These factors are; 1) activation, 2) focus, 3) effort, 4) emotion, 5) memory, and 6) action. While the clusters in Brown's EF model work together in various combinations, they show a person's steps when doing daily activities.

Figure 1

Executive functions impaired in ADHD.



Note. Adapted from *Brown attention deficit disorder scales for children and adolescents (2nd ed.)*, by Brown (2001).

Over the years, Barkley developed a similar EF model that measures multiple components of EF with 89 items. The components include five domains used in daily life (Barkley, 2011); 1) self-management to time, 2) self-organization/problem solving, 3) self-restraint, 4) self-motivation, and 5) self-regulation of emotion.

Self-regulatory skills are crucial for college students as they become more self-reliant to achieve academic success. The inability to set clear goals is associated with the course,- and college dropout rates (Morisano et al., 2010). Dorr & Armstrong (2019) reported that ADHD college students' experienced difficulties in planning, organization, and self-motivation. Students with ADHD deal with an irregular schedule, structure organization, and many side activities, difficulties that were mainly managed by their parents before

college (Meaux et al., 2009). Teaching skills that help with executive functioning will decrease academic impairment in in-risk college students (Stevens et al., 2019). Helping college students with ADHD with organizational skills can improve their academic impairments (Bikic et al., 2017; LaCount et al., 2018).

Organizational, time-management, and planning (OTMP) skills are most directly related to the EFs of college students and the demands of college. Therefore, Hartung et al. (2020) came up with a particular intervention focusing on OTMP skills for ADHD college students who struggle with these impairments, considering the lack of time. The results were promising as significant improvements in inattention, total ADHD symptoms, self-concept impairment, and OTMP skills. Helping ADHD students with OTMP can meet their needs for extra support activities throughout the day (Brown et al., 2019). ADHD students prefer to organize their day technologically, above conventional planning, as it can grab the user's attention in a good way by using visuals, audio, and especially reminders and notifications (Shrieber & Seifert, 2009).

In an academic guide that helps students with learning disabilities or ADHD with their college transition, Conor (2012) emphasizes using time management to block time in their calendar for study. Allocating extensive periods in a calendar to a specific task or activity is a method called (Adaptive) Time Blocking. The method gained more popularity since productivity expert Cal Newport's "Deep Work" (Newport, 2016). It could be carried out in many ways, such as scheduling every hour for different activities or a few hours of the day for a specific task. Time blocking could help ADHD patients since they have trouble to oversee the perception of time (Fontes et al., 2020).

Students show increased motivation if activities are done within a personal rhythm (Indreica et al., 2011). Therefore, students must be mindful of their maximum hours of effort. Here, the ultradian rhythm and circadian rhythm are significant components (Nadinloyi et al., 2013). The ultradian rhythm is a body's personal cycle of alterations between activities and breaks. The circadian rhythm is the 24-hour cycle that alternates between light and dark. The body adjusts to these rhythms to eat, sleep, do activities, and rest. Therefore, effective time management for academic achievement requires getting the most out of the student´s personal rhythm.

2.4 Designing technology for ADHD

In a review of 15 recent studies focussed on technology-based interventions for ADHD patients, Guan Lim et al. (2020) concluded that technology has the potential for

individualization of ADHD treatment. The interventional components look promising, although there is not enough evidence about the effectiveness of the interventions. In the latest, most relevant review of ADHD mobile applications (apps), there were 109 apps available (Păsărelu et al., 2020). The purpose of most ADHD apps is treatment (78%, n=85) and 33 apps (30.3%) focussed on adults. Noticeably, only 16% of apps describe the theory they draw on, but they only reference professionals involved in creating the app (Păsărelu et al., 2020).

To see what ADHD patients are looking for in an app, Simons et al. (2016) conducted a qualitative study. They strongly suggest that young people and adults with ADHD are looking for a more personalized, responsive approach to ADHD treatment that can support long-term. According to their findings, users' needs should drive an ADHD app. Participants saw the potential to monitor symptoms easily and see patterns or unusual behavior. They named it "supporting greater self-management," increasing their knowledge, self-awareness, and confidence. Simons et al. (2016) described an ideal app with four primary functions: 1) organizational aid, 2) a coach/supporter/motivator, 3) reliable, trustworthy, and tailored information, and 4) monitoring and tracking side effects and symptoms.

Powell et al. (2017) assessed ten different apps for children and young people with ADHD and clinicians. They aimed to discover what they would like to see in ADHD apps and gather valuable ideas for new apps. They found that an app must 1) be reliable, 2) be relatable, 3) be visually attractive without being visually "busy", 4) target symptoms or specific needs, 5) provide rewards, 6) be able to interact with the user. In the research, clinicians said apps could also be helpful to monitor ADHD symptoms, diet, and mood. The apps Powell et al. (2017) analyzed failed to meet these criteria in their research.

One year later, Powell et al. (2018) developed specific guidelines for designing technological interventions for children and young people aged 8 to 11 years to self-manage their ADHD. The guidelines create a tool to maximize the impact of developments for this population. They identified seven key themes: 1) positive, rewarding feedback, 2) downloadable gaming resources, 3) personalizable and adaptable components, 4) psychoeducation component, 5) integration of self-management strategies, 6) goal setting, and 7) context (personal and environmental).

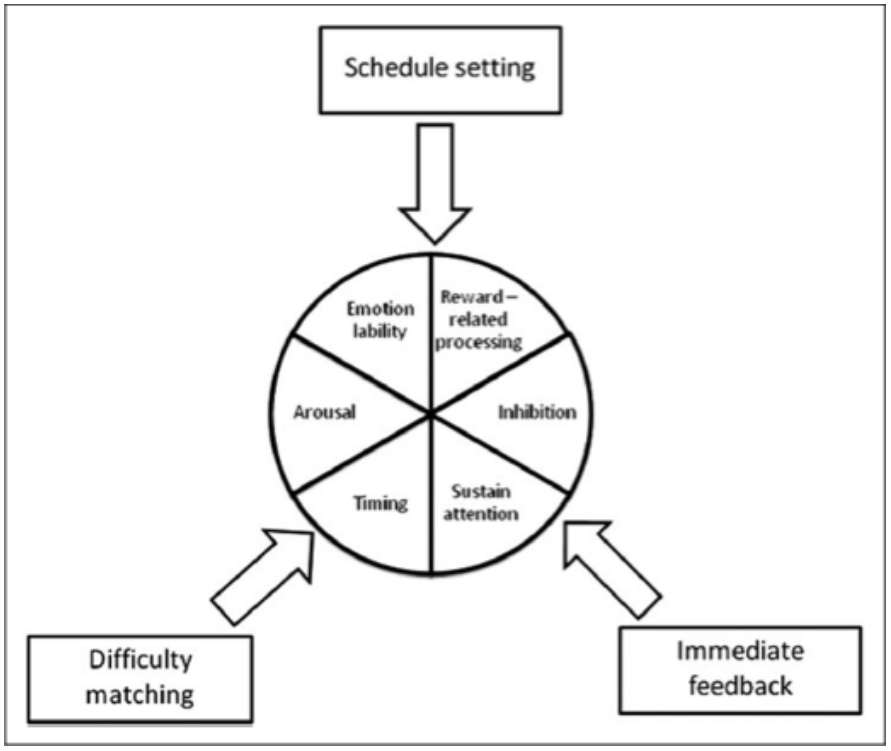
Powell et al. (2018) also recommend using a co-design approach when designing complex interventions. Co-design means that the process must involve key stakeholders (Boyd et al., 2010). Prioritizing the patient increases the engagement with the intervention

and the likelihood of acceptance. They refer to a health service co-design toolkit as a guide for using this method (Boyd et al., 2010).

Benyakorn et al. (2016) created a model to evaluate ADHD intervention technology, called the "tech model". The model uses the Research Domain Criteria (RDoC) framework to cluster the ADHD technology. RDoC is a collection of research findings related to mental health. They follow Baroni and Castellanos' RDoC structure for ADHD (Baroni & Castellanos, 2015). They cluster ADHD within six domains: 1) reward-related processing; 2) inhibition; 3) sustain attention; 4) timing; 5) arousal; and 6) emotional lability. On top of that, they propose that ADHD technology should include three components: 1) the technology must set specific goals and schedules after an initial assessment, 2) the technology must match the user's skill level to improve concentration and engagement, and 3) the technology should give immediate feedback about the performance of the user to encourage the user to complete a task, they suggest that immediate positive reinforcement leads to early correction when the user is distracted. Therefore, the technology must track the user's progress and present it understandably.

Figure 2

The "Tech model" is used to evaluate ADHD intervention technology.



Note. Adapted from *Current State and Model for Development of Technology-Based Care for Attention Deficit Hyperactivity Disorder*, by Benyakorn et al. (2016).

2.5 Virtual life coach

Zidaru et al. (2021) found that patients and clinicians have a positive attitude towards data-driven approaches to mental health. One of the benefits of using technology is gathering data and improving the product or service. Gathering data gives a better understanding of the users and can make the product or service more personalized. A more customized product collects even more data. This constant loop is called the data-driven feedback loop (Smits et al., 2020).

While preliminary research shows a progression in the development of ADHD mobile applications (Păsărelu et al., 2020), no apps could take on the role of a data-driven life coach. Life coaching is a behavioral change approach that motivates to reach goals and focuses on well-being and personal functioning (Grant, 2003). ADHD coaching interventions that patients have with therapists are temporary, while the user can take a life coach in an app everywhere and forever. A virtual life coach (VLC) creates a sustainable way to maintain day-to-day activities (Mason-Robbie, 2021).

Different approaches to deploying a virtual life coach have already been made. Gabrielli et al. (2020) created a chatbot-based self-help intervention for adolescents to promote well-being. The virtual life coach showed potential as 76% (n=16) found it helpful, and 95% (n=20) would recommend it to a friend. Hill et al. (2020) developed a virtual coaching tool for breast cancer survivors. The app helps users achieve and maintain personalized healthy nutrition, activity regimens, and mindfulness in-between doctor visits. ‘Fabulous’ is an example of an evidence-based app that focuses on self-improvement and behavior change, which could be considered a VLC. The application has different exercises to make small changes in one’s life. The app tries to create tiny habits to achieve long-term results.

2.6 Persuasive technology

VLCs can help ADHD students by serving as a backbone of the student’s life structure. However, the application needs to use persuasive technology to change the user’s attitude or behavior. Persuasive technology is a concept defined by Fogg et al. (2003) and is used in electronic health care (Silva et al., 2019). It strives to change the behaviors or attitudes of users. It implicates voluntary change as the “ persuader “ intends to be transparent. According to (Fogg, 2009), designers must understand the mechanics of influence on behavior. Otherwise, the designers assume that a solution works or do not understand why a solution

works. The model that Fogg (2003) created has three components:1) the person's inherent motivation; 2) their ability; and 3) an appropriate trigger or prompt.

Oinas-Kukkonen & Hurjumaa (2009) created the persuasive system design (PSD) model to expand on the Fogg model. Since Fogg's model does not provide practical solutions, PSD compiles the principles of Fogg's model into four applicable design principles and 28 elements.

Another example of a method used to change health-related behavior is the Self-Regulation Theory of Soror and Davis (2014). An app can motivate users to obtain their goals through feedback, such as notifications and reminders. Based on the gathered data, the app can find the ideal personalized approach for the student. Soror and Davis (2014) propose strong potential when designing the app to 1) monitor and provide feedback about the user's progress, 2) motivate users to change behavior and present their strategies to implement for them to accomplish the desired changes, and 3) facilitate the execution of selected strategies.

3. METHODOLOGY

This research aimed to develop a prototype of a data-driven concept using iterative design. This includes: 1) exploring the field of the subject, 2) exploring the technical side of the prototype, which includes creating a dataset, and 3) creating a workable designed prototype. For the research and development of the prototype, the following research question is answered: *How can a data-driven virtual life coach be part of ADHD treatment by providing life structure to college students with ADHD?*

3.1 Data-driven concept

The data-driven virtual life coach (VLC) will help ADHD students create structure in their inconsistent lives. The application uses the time-blocking method to start with a basic framework of their week based on their calendar and preferences. The student can set goals to help them build their routine. It takes data of the user's behavior and feedback to optimize the student's schedule by learning and anticipating their personal cycles. User behavioral data is described as how the user interacts with the system and deals with the proposed plan. User feedback data is described as ratings the user gives about their mood during the day. The app stimulates the user to stick to their schedule and obtain their goals by sending tips and motivational messages notifications. The students can monitor their behavior by seeing an overview of time spent on activities, goals, and mood. They can also share this data with their clinician. The VLC will learn from the users' interactions and improve the service every time the student uses the app. Therefore, the data-driven feedback loop (Smits et al., 2020) plays a critical part in the process since it collects data from the user to create a better, more personalized schedule. The goal of the VLC is to form the foundation of the ADHD student's days, which will help them focus better and have the feeling of owning their hours of the day again. The persuasive system design model was implemented based on Fogg's persuasive technology model (Fogg et al., 2003; Oinas-Kukkonen & Harjumaa, 2009).

The VLC concept fulfills the four primary functions of the ideal ADHD application described in the work of Simons et al. (2016). Since the app is a (virtual) coach that helps organize users' day, tracks and monitors users' behavior, and is reliable and trustworthy. The VLC uses the three elements of Benyakorn et. al (2016) Tech model, by constantly learning the user's behavior and adapting accordingly (difficulty matching), sending messages during the day anticipating their actions (immediate feedback), and helping the user to set, plan and achieve their goals (schedule setting).

3.2. Engaging with stakeholders

Engaging is a way of co-design to recognize the patient's needs (Boyd et al., 2010). The stakeholders are ADHD students (aged 18-25) and ADHD clinicians (psychologists and psychiatrists). By engaging with the stakeholders early in the process, critical decisions were made for the rest of the project. The goal was to establish and maintain relationships to improve the service. The addressed stakeholders formed the target group of three ADHD students and two ADHD clinicians involved in every process. Other stakeholders were also approached (two ADHD students and one ADHD clinician). However, they were not involved in the whole process.

In the first step of engaging with the stakeholders, semi-constructed interviews were conducted where the concept of the data-driven application was proposed (Baarda et al., 2012). Three clinicians and three ADHD students were interviewed. Besides doing interviews, students also did a case study to show their current planning method (Mcleod, 2007). The interviews formed the base of the relationships between researcher and target audience.

3.2.1 Expert interviews

In total, three experts involved in ADHD treatment were interviewed. In one interview, two experts were questioned at the same time. These interviews' goal was to understand better how a virtual life coach could play a role in treatment. The experts gave interesting insights about how different each ADHD student is and what techniques they use to start with and work most of the time. They always stress the importance of routine and structure to the students. However, when the patients are done with therapy, it is up to them to maintain those techniques.

The patients learn such techniques themselves with the ADHD coaching interventions. The interventions teach the patients to deal with their symptoms. However, by only seeing the patient once a week, the therapists have to catch up about the course of the patient's week. Therefore the insights could be biased for what the patients remember at that moment and how the patients feel emotionally. There is always a gap between what the patient is telling them and what they experienced. Better insights about how the patients think are desired.

They used time blocks to make the schedule easy and understandable to create a routine. When a schedule is too packed with specific short tasks, it would be perceived as information overload. They also used a brief overview of the biggest tasks in the morning,

afternoon, and evening. The most important part of making the schedule understandable is visually attractive and legible. This will motivate the patient to be encouraged to keep ongoing.

The therapists also expected that reflection would be a good way for the students to become more mindful of their hours. Something that they try to do themselves the interventions once a week.

3.2.2 User interviews and case studies

The goal was to understand the different life components where patients struggle with their symptoms. Three ADHD students were interviewed, which gave good insights into what the ADHD students tried to deal with their symptoms and what worked and didn't. It was great to start relationships with people interested in helping the project further.

The most notable thing that became clear was that every student experienced ADHD differently. This made me look for similarities between the different ADHD students. The most crucial similarity was how much ADHD students were already trying to deal with their symptoms. One respondent said: *"If I want to get something done, I have to think about it very carefully. I must have a good plan for that. Do I have to work systematically? Yes, and I can go a long way in that. I should find some kind of balance in it."*

The students already had experience using applications or methods they had heard of. However, most of these were not very sustainable. Sometimes it took too much time to prepare or execute the technique. Sometimes an app did not work correctly, and they eventually stopped using it. Reasons could be that the application was visually not appealing, had a lousy interface, or did just not live up to the expectations.

The case studies were planned to gain insights into how students would schedule their next study day. It showed that they did not have a customary routine. One student showed something similar to time blocking. Another student would tell himself to focus on one particular task or activity for a whole day, or until the task is finished. The last student did not plan their day and would just start with the first thing he thought had priority. All students had trouble with the time it takes to schedule their day and the chance of events happening throughout the day, causing the schedule to be invalid.

3.3 Iteration 1

3.3.1 Process

A proof-of-concept prototype was created to test it using the Wizard of Oz method in the first iteration (Harwood, 2018). A day planner template was made in Google Spreadsheets to function as the first version of the prototype. Three students from the stakeholder group were asked to keep track of their activities on a specific day. They filled in the day planner accordingly, and at the end of the day, they reflected on their day by giving a rating of their mood out of five stars with a brief elaboration.

The spreadsheets were given to two ADHD therapists, which they used as input to schedule a new plan using the adaptive time blocking method for a new (preferred) day. Their reasoning was questioned and elaborated to form the core of the algorithm.

The students used their spreadsheet on their smartphones and laptop during the scheduled day. After every block ended, they were sent messages to notify and encourage the student to go on. The students could interact by responding to the messages if they wanted to extend their time block or were delayed by sending “1” or “2” on specific messages. Here, insights were gained about how the system could interact with learning from the student’s behavior. The students reflect on their day the same way as the first time. The following day interviews took place to understand how the students experienced that day.

3.3.2 Results

Generally, the students and therapists were positively surprised and excited about the concept. The students said they could control their symptoms because they felt like they were more in a rhythm, and the time blocks created better periods to focus. This lowered the ADHD symptoms and made the student more relaxed throughout the day. Therefore, the proof-of-concept showed potential for further development. While using the day planner, the respondents liked how little effort it took them to have a scheduled day and trusted the planned hours to make the best out of their time. Therefore, this showed that the system must take the lead to guide the user through the day.

The users positively received the notifications. They kept the user sharp and reminded the user what time block he was in the schedule. Collecting data points like knowing when the user wants to extend his time block or knowing what moments the user is more likely to be distracted are very valuable for the system to learn behavioral patterns in the user’s personal cycle. A liked feature was that the VLC helped them when their day did not go

according to the schedule. They suggested how such a feature could be implemented in the application, resulting in a “panic” button in the second iteration.

While the function of reflecting the day was built to gather valuable user data to help the system learn behavioral patterns, it also positively impacted the user. They responded by being more mindful of their day, unlike other days where the day would move on rapidly. Furthermore, the first data was collected to use for the algorithm.

3.4 Iteration 2

3.4.1 Process

In the second iteration, the technical and visual parts of the prototype were divided. For the technical aspect, the algorithm was developed based on the thinking process of the therapists in iteration one. A rule-based expert system was chosen because the scheduling happened based on multiple trade-offs. There was not enough data available to use a machine learning algorithm. The first version of this system was written on paper to have quick improvements. The algorithm was then used and tested in a co-creation session with the therapists to ensure that it matched with their way of scheduling.

The first version of the visible part of the eventual prototype consisted of clickable wireframes. Wireframes give a good understanding of the structure and elements of the prototype. Adobe XD was used as the design tool to design the prototype. The wireframes were usability tested upon the target audience via a video call. Each respondent received the link to the prototype and was asked to navigate through the app. They were asked questions that mainly concerned the onboarding content, the application structure, and the overview of the day planning.

3.4.2 Results

The second iteration created the non-digital working algorithm that the therapists approved. The algorithm was not tested on the ADHD students in this iteration, considering the limited time of the project. Since the algorithm had to follow the same decision process as the therapists, they were involved. It gave a great understanding of how the system should function, which was needed before coding the algorithm.

In the iteration, a usability test was conducted to test the wireframes. The overall structure of the prototype was well perceived. Much feedback was collected to gain more insights into how elements were used. For instance, a panic button was added for the next

iteration, and an onboarding screen was created to emphasize the importance of reading it carefully.

3.5 Iteration 3

3.5.1 Process

In the last iteration, the prototype's technical and visual parts got together again. The visual aspect is essential for an ADHD student to determine the effectiveness of an application. Therefore, the students tested the algorithm through the high-fidelity prototype. The rule-based expert system from the co-creation session from the second iteration was digitized in Python with Jupyter Notebook. The data from the spreadsheets in the first iteration served as input. The data was cleaned, and an algorithm was created that worked for every respondent.

The system outputs a new schedule for the respondents upon which it was used to design different personalized visual prototypes. The wireframes were converted to a first version of the high fidelity prototype using colors and illustrations to give the final product a better look and feel. Two respondents used the high fidelity prototype with a personalized schedule for a whole day to get a complete experience. Unfortunately, it was not possible to test the prototype with more ADHD students. Therefore, only their opinion was asked to gain insight about the appearance.

3.5.2 Results

In general, the appearance of the prototype was according to the expectations. The prototype showed the importance of being adaptive to the user's day. While the time blocks could easily be adjusted in the first iteration, this could not be done in the high fidelity prototype. It was causing one student to stop following the schedule accordingly. The other respondent had a more positive experience. The colored time blocks were clear and gave a good overview of the completion of hours in the day. The respondent also commented that a quick(er) way to see his planning is desirable. For instance, when the user executes the schedule, the time blocks are automatically opened as start screens. The summary of the user's morning, afternoon, and evening was an excellent addition to create a more straightforward overview.

3.6 Data management plan

All data mentioned in the research was anonymized and did not contain any personal information of participants. Therefore, the study follows the General Data Protection Regulation (GDPR) law (2019).

All data were collected during this research, and all participants were informed about the data process. The interviews could still contain some sensitive data, which will be deleted after completing the project. The researcher secured the data on his hard disk, except for the collected data with Google Spreadsheets. The clinicians involved did not know any personal information about the respondents, except for the voluntarily given data in the spreadsheet.

4. RESULTS

This paper explored the potential of a virtual life coach that helps structure the week of students with ADHD through the following research question: “How can a data-driven virtual life coach be part of ADHD treatment by giving life structure to college students with ADHD?” The following questions will answer the research question.

5.1. What kind of features will benefit the students’ structure?

Research has shown that time blocking is an effective method for academic achievement. The interviews with the therapists also indicated that they use this method to help ADHD students create more overview of their day. Besides, time blocks must be visually different to distinguish. Therefore, colors must be used to visually draw attention to the specific time blocks.

The interviews with the students showed that they are very willing to teach themselves time management methods that work. Although often techniques are not sustainable. The biggest bottleneck is that those methods take too much time and are often skipped. Therefore, a feature must be that the system must do as much as possible for the student, reducing the student's time to conduct. The system must guide the student.

Research showed the lack of self-motivation ADHD patients could experience. This could unwillingly make the app unsustainable. For that reason, the system must act pro-actively. In the first iteration, notifications were sent to the students to keep track of their schedules and encourage them to move on. These messages were very much loved. The interaction made the users be in the present moment. If the students were lost during the day, they could interact with the system to make changes in the planning and start over.

Reflecting on one’s day will benefit the system for gathering data insights about how well it performed. It is also a moment for the student to look back at their spent hours and be mindful of their feelings. With the ability to let the users track and monitor themselves, insights are gained for both sights about behavior. For instance, an ADHD student usually might not notice his mood reduced over some time. By keeping track of their mood, the student could be motivated to make behavioral changes. Thereby, the system also sees the patterns of the reduced mood upon which it could suggest and implement changes in the daily schedule. The student will be more open to it because one has insights into seeing the same patterns.

5.2. What role can a data-driven VLC play in ADHD treatment to mediate the students' behavior?

Two things became clear from the interviews with the therapists: 1) their interventions are always a snapshot, for example, they see the patient once a week, and the student has to tell what they have experienced, usually based on how they feel that moment feels. It is often difficult for therapists to understand how a student has been doing the rest of the days. There seems to be an opportunity here by having the tracked data monitored by the therapists to better understand and help with progression. 2) interventions are temporary. The students are not in therapy forever. As a result, the therapists cannot help maintain the structure after the period. An app can fulfill this role if it has become a permanent force in students' lives.

For these reasons, the app can be used to extend ADHD coaching. The app can be used during and after the coaching program. In this way, the user learns to become well acquainted with the app during the process to see it as a habit after coaching.

In addition, the app supports the user by motivating him to change his behavior and by providing more insight into his hours. Something students are taught to do themselves in ADHD coaching.

5.3. What metrics from the interaction with the user can benefit the system to optimize the ADHD students' structure?

It turned out from the first iteration that the interaction between the system and user through the notifications throughout the day is full of information about how a user experiences its day. This allows the system to recognize the personal cycle of one's day. This means that the system can schedule better time blocks, which the student again tries out. Therefore, the system makes use of the data-driven feedback loop.

Knowing when someone does not comply with his schedule, such as when someone continues studying longer, stops earlier, or oversleeps, are valuable data to predict the user's behavior. From the first iteration, it became clear that the therapists look very closely at where things went wrong when they scheduled a day. If a student has continued too long, he indicates that time is distracted. That means the student might have overestimated herself. The next time, the system could foresee this coming, upon which it can suggest taking a break.

For now, the prototype was designed only to retrieve data about the user's mood. This decision was made following the therapists' advice and was valuable to understand how the

user experienced their day. However, insights were gained that productivity could also indicate the performance of the user.

5. CONCLUSION & DISCUSSION

Students with ADHD experience impairment in their executive functions (EFs) providing their self-regulation (Brown, 2013). Therefore they have difficulty with their organizational, time-management, and planning (OTMP) skills (LaCount et al., 2018). Those skills are crucial in the life of a college student (Stevens et al., 2019). A virtual life coach (VLC) can help students deal with these symptoms. Using persuasive technology, the VLC could change little behaviors to help the students deal with their symptoms. By doing this, the VLC aims to be a backbone in the inconsistent lifestyle of ADHD students.

Currently, there already are mobile applications made for people with ADHD. However, according to the latest ADHD intervention app review, only 10% is based on proven theory (Păsărelu et al., 2020). Besides, the ideal application according to ADHD stakeholders has not been developed yet (Simons et al., 2016). Simons et al. (2016) found that the perfect app should be a coach that functions as an organizational aid and can motivate the user. The app should also be reliable and trustworthy, and the user must be able to monitor and track their behavior.

Therefore, this research aims to create a data-driven virtual life coach helping ADHD students to structure their day. The VLC uses time blocks to schedule the student's day based on their personal rhythm. This study is based on the following research question: *How can a data-driven virtual life coach be part of ADHD treatment by providing life structure to college students with ADHD?* Three sub-questions were asked to answer the research question. 1) What features will benefit the students' structure? 2) What role can a data-driven VLC play in ADHD treatment to mediate the students' behavior? And 3) What metrics from the interaction with the user can benefit the system to optimize the ADHD students' structure?

A high-fidelity prototype was designed as a substantiation to the answers. The prototype consists of a visual and technical component. An iterative design process used a co-design approach from the start (Boyd et al., 2010). In the first iteration, a proof-of-concept was tested in which minor technical limitations played a role. The proof-of-concept showed potential in using a VLC in the daily life of an ADHD student. Therapists and ADHD students were excited about the concept. The students were more relaxed and could better control their ADHD symptoms during the day. However, the subsequent prototypes had more technical limitations. For instance, the algorithm could only schedule the student's day

beforehand and not change the user's schedule based on unannounced daily events. Besides, the high-fidelity prototype was not easily attainable on all the user's screens, causing the user to keep less eye on it. Both of these limitations are crucial aspects if a VLC wants to give structure in the life of an ADHD student.

Besides technical limitations, this research also dealt with limitations with the involvement of stakeholders. Making appointments with ADHD students was considered a challenge. Multiple times a student did not show up, did not keep to agreements of a feedback session, or took days to reply. When two more ADHD students joined the process to gain more insights, the same problems occurred. Although you cannot blame the students for their ADHD symptoms, this limited the research results. Apart from the ADHD students, there was a COVID-outbreak in the therapists' clinic, causing the therapists to not participate for almost two weeks.

The students involved in the research were all friend-related to the researcher who had positive and negative effects. On the one hand, the students could speak freely about a sensitive subject. The bond of trust caused more open conversations between the researcher and the student. However, because of the friend-relationship, it could be the case that the students wanted to do the researcher a favor as a friend, which means that the results could not be completely valid.

The research explored the field of virtual life coaches and giving structure to ADHD students' lives. It has also gained interesting insights to build upon for further study. Before the concept could be developed, more research has to be done on how the VLC will learn from the given metrics from this paper. Therefore, much data from ADHD students need to be collected first.

5. BIBLIOGRAPHY

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*. American Psychiatric Pub.

Baarda, D. B., Goede, M. P. M., & van der Hulst, M. (2012). *Basisboek interviewen: handleiding voor het voorbereiden en afnemen van interviews*. Noordhoff Uitgevers bv.

Barkley, R. A. (2011). *Barkley Deficits in Executive Functioning Scale (BDEFS)*. Guilford Press.

Barkley, R. A. (2013). ADHD, Executive Functioning, Self-Regulation. In *PsycEXTRA Dataset*. https://doi.org/10.1037/e546532013-002

Barkley, R. A. (2015). Executive functioning and self-regulation viewed as an extended phenotype: Implications of the theory for ADHD and its treatment. *Attention-Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment., 4th Ed.*, *4*, 405–434.

Barkley, R. A., & Murphy, K. R. (2011). The nature of executive function (EF) deficits in daily life activities in adults with ADHD and their relationship to performance on EF tests. *Journal of Psychopathology and Behavioral Assessment*, *33*(2), 137–158.

Baroni, A., & Castellanos, F. X. (2015). Neuroanatomic and cognitive abnormalities in attention-deficit/hyperactivity disorder in the era of “high definition” neuroimaging. *Current Opinion in Neurobiology*, *30*, 1–8.

Benyakorn, S., Riley, S. J., Calub, C. A., & Schweitzer, J. B. (2016). Current State and Model for Development of Technology-Based Care for Attention Deficit Hyperactivity Disorder. *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association*, *22*(9), 761–768.

Biederman, J., Faraone, S. V., Spencer, T., Wilens, T., Norman, D., Lapey, K. A., Mick, E., Lehman, B. K., & Doyle, A. (1993). Patterns of psychiatric comorbidity, cognition, and

psychosocial functioning in adults with attention deficit hyperactivity disorder. *The American Journal of Psychiatry*, *150*(12), 1792–1798.

Bikic, A., Reichow, B., McCauley, S. A., Ibrahim, K., & Sukhodolsky, D. G. (2017). Meta-analysis of organizational skills interventions for children and adolescents with Attention-Deficit/Hyperactivity Disorder. *Clinical Psychology Review*, *52*, 108–123.

Boyd, H., McKernon, S., & Old, A. (2010). *Health service co-design: working with patients to improve healthcare services: guide and toolkit*. Waitemata District Health Board.

Brod, M., Perwien, A., Adler, L., Spencer, T., & Johnston, J. (2005). Conceptualization and assessment of quality of life for adults with attention-deficit/hyperactivity disorder. *Primary Psychiatry*, *12*(6), 58–64.

Brown, T. E. (2001). *Brown attention deficit disorder scales for children and adolescents (2nd ed.)*. TX: The Psychological Corporation.

Brown, T. E. (2013). *A new understanding of ADHD in children and adults: Executive function impairments*. Routledge.

Brown, T. E., Romero, B., Sarocco, P., Atkins, N., Schwartz, E. J., & Rhoten, S. (2019). The Patient Perspective: Unmet Treatment Needs in Adults With Attention-Deficit/Hyperactivity Disorder. *The Primary Care Companion to CNS Disorders*, *21*(3), 0–0.

Cazier, J. A., & Green, J. A. (2016). Life Coach: Using Big Data and Analytics to Facilitate the Attainment of Life Goals. In *2016 49th Hawaii International Conference on System Sciences (HICSS)*. https://doi.org/10.1109/hicss.2016.129

Connor, D. J. (2012). Helping Students with Disabilities Transition to College: 21 Tips for Students with LD and/or ADD/ADHD. *TEACHING Exceptional Children*, *44*(5), 16–25.

Dorr, M. M., & Armstrong, K. J. (2019). Executive Functioning and Impairment in Emerging Adult College Students With ADHD Symptoms. *Journal of Attention Disorders*, *23*(14),

1759–1765.

Efron, D., Jarman, F., & Barker, M. (1997). Side effects of methylphenidate and dexamphetamine in children with attention deficit hyperactivity disorder: a double-blind, crossover trial. *Pediatrics*, *100*(4), 662–666.

Elia, J., Ambrosini, P., & Berrettini, W. (2008). ADHD characteristics: I. Concurrent co-morbidity patterns in children & adolescents. *Child and Adolescent Psychiatry and Mental Health*, *2*(1), 15.

European Commission. (2017, August 11). *Personalised coaching for well-being and care of people as they age*. CORDIS. https://cordis.europa.eu/programme/id/H2020_SC1-PM-15-2017

Fabio, R. A., Castriciano, C., & Rondanini, A. (2015). ADHD: Auditory and Visual Stimuli in Automatic and Controlled Processes. *Journal of Attention Disorders*, *19*(9), 771–778.

Farrell, E. F. (2003, September 26). Paying Attention to Students Who Can't. *The Chronicle of Higher Education*, *A50-A51*(26).

Fayyad, J., De Graaf, R., Kessler, R., Alonso, J., Angermeyer, M., Demyttenaere, K., De Girolamo, G., Haro, J. M., Karam, E. G., Lara, C., Lépine, J.-P., Ormel, J., Posada-Villa, J., Zaslavsky, A. M., & Jin, R. (2007). Cross-national prevalence and correlates of adult attention-deficit hyperactivity disorder. *The British Journal of Psychiatry: The Journal of Mental Science*, *190*, 402–409.

Fogg, B. J. (2009). A behavior model for persuasive design. *Proceedings of the 4th International Conference on Persuasive Technology*, 1–7.

Fogg, B. J., B. J. (Stanford University Fogg, Stanford CA U.S.A.), Fogg, G. E., & Zimbardo, P. G. (2003). *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann.

Fontes, R. M., Marinho, V., Carvalho, V., Rocha, K., Magalhães, F., Moura, I., Ribeiro, P.,

Velasques, B., Cagy, M., Gupta, D. S., Bastos, V. H., Teles, A. S., & Teixeira, S. (2020). Time estimation exposure modifies cognitive aspects and cortical activity of attention deficit hyperactivity disorder adults. *The International Journal of Neuroscience*, *130*(10), 999–1014.

Fortin, A. H., Dwamena, F. C., Frankel, R. M., & Smith, R. C. (2012). Chapter 2. Data-Gathering and Relationship-Building Skills. In *Smith's Patient-Centered Interviewing: An Evidence-Based Method, 3e*. The McGraw-Hill Companies.

Gabrielli, S., Rizzi, S., Carbone, S., & Donisi, V. (2020). A Chatbot-Based Coaching Intervention for Adolescents to Promote Life Skills: Pilot Study. *JMIR Human Factors*, *7*(1), e16762.

GGZ. (2019). *ADHD*. Geestelijke gezondheidszorg. https://www.ggzstandaarden.nl/zorgstandaarden/adhd/

GIP / Zorginstituut Nederland. (2021, May 19). *Het aantal gebruikers van ADHD-middelen, 2003 - 2020*. https://www.gipdatabank.nl/databank?infotype=g&label=00-totaal&tabel=85_adh&geg=gebr&item=bijlage

Goodman, D. W., & Thase, M. E. (2009). Recognizing ADHD in adults with comorbid mood disorders: implications for identification and management. *Postgraduate Medicine*, *121*(5), 20–30.

Grant, A. M. (2003). The impact of life coaching on goal attainment, metacognition and mental health. *Social Behavior and Personality An International Journal*, *31*(3), 253–263.

Guan Lim, C., Lim-Ashworth, N. S. J., & Fung, D. S. S. (2020). Updates in technology-based interventions for attention deficit hyperactivity disorder. *Current Opinion in Psychiatry*, *33*(6), 577–585.

Hakkaart-van Roijen, L., Zwirs, B. W. C., Bouwmans, C., Tan, S. S., Schulpen, T. W. J., Vlasveld, L., & Buitelaar, J. K. (2007). Societal costs and quality of life of children suffering from attention deficient hyperactivity disorder (ADHD). *European Child & Adolescent Psychiatry*, *16*(5), 316–326.

Hartung, C. M., Canu, W. H., Serrano, J. W., Vasko, J. M., & Flory, K. (2020). A New Organizational and Study Skills Intervention for College Students with ADHD. *Cognitive and Behavioral Practice*. https://doi.org/10.1016/j.cbpra.2020.09.005

Harwood, F. (2018, August 30). *Wizard of Oz testing – a method of testing a system that does not yet exist. - Usability Testing & Market Research by SimpleUsability Behavioural Research Consultancy*. Usability Testing & Market Research by SimpleUsability Behavioural Research Consultancy. https://www.simpleusability.com/inspiration/2018/08/wizard-of-oz-testing-a-method-of-testing-a-system-that-does-not-yet-exist/

Hill, C. K., Luu, T., & Bourdeanu, L. (2020). Abstract P1-17-15: OWL: Own your wellness and living platform -An artificial intelligence virtual well - being supporting coach for breast cancer survivors. *Cancer Research*, *80*(4 Supplement), P1–P17 – 15–P1 – 17–15.

Indreica, E.-S., Cazan, A.-M., & Truta, C. (2011). Effects of learning styles and time management on academic achievement. *Procedia - Social and Behavioral Sciences*, *30*, 1096–1102.

Jones, G. C., Kalivoda, K. S., & Higbee, J. L. (1997). College Students with Attention Deficit Disorder. *Journal of Student Affairs Research and Practice*, *34*(4), 261–273.

Knouse, L. E., & Fleming, A. P. (2016). Applying Cognitive-Behavioral Therapy for ADHD to Emerging Adults. *Cognitive and Behavioral Practice*, *23*(3), 300–315.

LaCount, P. A., Hartung, C. M., Shelton, C. R., & Stevens, A. E. (2018). Efficacy of an Organizational Skills Intervention for College Students With ADHD Symptomatology

and Academic Difficulties. *Journal of Attention Disorders*, *22*(4), 356–367.

Lakhan, S. E., & Kirchgessner, A. (2012). Prescription stimulants in individuals with and without attention deficit hyperactivity disorder: misuse, cognitive impact, and adverse effects. *Brain and Behavior*, *2*(5), 661–677.

Loock, C.-M., Staake, T., & Thiesse, F. (2013). Motivating Energy-Efficient Behavior With Green Is: An Investigation of Goal Setting and the Role of Defaults. *The Mississippi Quarterly*, *37*(4), 1313–1332.

Mason-Robbie, V. (2021). Experience of Using a Virtual Life Coach: A Case Study of Novice Users. *Postdigital Humans: Transitions, Transformations and Transcendence*, 35–52.

Mcleod, S. (2007, February 5). *Case Study Method*. https://www.simplypsychology.org/case-study.html

Meaux, J. B., Green, A., & Broussard, L. (2009). ADHD in the college student: a block in the road. In *Journal of Psychiatric and Mental Health Nursing* (Vol. 16, Issue 3, pp. 248–256). https://doi.org/10.1111/j.1365-2850.2008.01349.x

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis. *Cognitive Psychology*, *41*(1), 49–100.

Morisano, D., Hirsh, J. B., Peterson, J. B., Pihl, R. O., & Shore, B. M. (2010). Setting, elaborating, and reflecting on personal goals improves academic performance. *The Journal of Applied Psychology*, *95*(2), 255–264.

Nadinloyi, K. B., Hajloo, N., Garamaleki, N. S., & Sadeghi, H. (2013). The Study Efficacy of Time Management Training on Increase Academic Time Management of Students. *Procedia - Social and Behavioral Sciences*, *84*, 134–138.

Newport, C. (2016). *Deep Work: Rules for Focused Success in a Distracted World*. Hachette UK.

Oinas-Kukkonen, H., & Harjumaa, M. (2009). Persuasive Systems Design: Key Issues, Process Model, and System Features. In *Communications of the Association for Information Systems* (Vol. 24). https://doi.org/10.17705/1cais.02428

Păsărelu, C. R., Andersson, G., & Dobrean, A. (2020). Attention-deficit/ hyperactivity disorder mobile apps: A systematic review. *International Journal of Medical Informatics*, *138*, 104133.

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. *The American Journal of Psychiatry*, *164*(6), 942–948.

Powell, L., Parker, J., Harpin, V., & Mawson, S. (2018). Guideline development for technological interventions for children and young people to self-manage ADHD: A realist evaluation. *Journal of Medical Internet Research*. http://dx.doi.org/

Powell, L., Parker, J., Robertson, N., & Harpin, V. (2017). Attention Deficit Hyperactivity Disorder: Is There an App for That? Suitability Assessment of Apps for Children and Young People With ADHD. *JMIR Mhealth and Uhealth*, *5*(10), e145.

Prins, M., & van Dijk, L. (2015a). *HELFT VAN KINDEREN EN EEN DERDE VAN VOLWASSENEN MET ADHD KRIJGT ADHD-MEDICATIE VIA HUISARTS*. https://www.nivel.nl/sites/default/files/bestanden/factsheet_ADHD_medicatie_via_huisarts.pdf

Prins, M., & van Dijk, L. (2015b). *KINDEREN EN VOLWASSENEN MET ADHD BINNEN DE HUISARTSENPRAKTIJK: TRENDS IN JAARPREVALENTIES EN VERWIJZINGEN*. https://www.nivel.nl/sites/default/files/bestanden/factsheet_ADHD_binnen_huisartsenpr

aktijk.pdf

Ramsay, J. R., Russell Ramsay, J., & Rostain, A. L. (2016). Adult attention-deficit/hyperactivity disorder as an implementation problem: Clinical significance, underlying mechanisms, and psychosocial treatment. In *Practice Innovations* (Vol. 1, Issue 1, pp. 36–52). https://doi.org/10.1037/pri0000016

Shrieber, B., & Seifert, T. (2009). *College Students with Learning Disabilities and/or ADHD Use of a Handheld Computer Compared to Conventional Planners*. http://dx.doi.org/

Silva, M. E., Graham, F., Levack, W., & Hay-Smith, J. (2019). Parent-focused eHealth: A scoping review protocol. *New Zealand Journal of Physiotherapy*, *47*(1), 36–48.

Simons, L., Valentine, A. Z., Falconer, C. J., Groom, M., Daley, D., Craven, M. P., Young, Z., Hall, C., & Hollis, C. (2016). Developing mHealth Remote Monitoring Technology for Attention Deficit Hyperactivity Disorder: A Qualitative Study Eliciting User Priorities and Needs. *JMIR mHealth and uHealth*, *4*(1), e5009.

Smits, A., Van Turnhout, K., Hekman, E., & Nguyen, D. (2020). Data-driven design. In *Proceedings of the 22nd International Conference on Engineering and Product Design Education*. https://doi.org/10.35199/epde.2020.10

Soror, A., & Davis, F. (2014). Using Self-Regulation Theory to Inform Technology-Based Behavior Change Interventions. In *2014 47th Hawaii International Conference on System Sciences*. https://doi.org/10.1109/hicss.2014.373

Stevens, A. E., Hartung, C. M., Shelton, C. R., LaCount, P. A., & Heaney, A. (2019). The Effects of a Brief Organization, Time Management, and Planning Intervention for At-Risk College Freshmen. In *Evidence-Based Practice in Child and Adolescent Mental Health* (Vol. 4, Issue 2, pp. 202–218). https://doi.org/10.1080/23794925.2018.1551093

Tuithof, M., ten Have, M., van Dorsselaer, S., & de Graaf, R. (2010). *ADHD, gedragsstoornissen en antisociale persoonlijkheidsstoornis. Vóórkomen en gevolgen in*

de algemene bevolking: resultaten van NEMESIS-2. Trimbos-instituut.

Tuithof, M., Ten Have, M., Van Dorsselaer, S., & De Graaf, R. (2014). Prevalentie, persistentie en gevolgen van ADHD in de Nederlandse volwassen bevolking. *Tijdschrift Voor Psychiatrie*, *56*, 10–19.

van der Heijde, C., van den Berk, C., & Vonk, P. (2020). Ervaringen en visies van professionals over gebruik en misbruik van methylfenidaat door studenten in het hoger onderwijs. *TSG - Tijdschrift voor gezondheidswetenschappen*, *98*(1), 1–8.

Vohs, K. D., & Baumeister, R. F. (2011). *Handbook of Self-Regulation, Second Edition: Research, Theory, and Applications*. Guilford Press.

Wender, P. H., Wolf, L. E., & Wasserstein, J. (2001). Adults with ADHD. An overview. *Annals of the New York Academy of Sciences*, *931*, 1–16.

Young, Z., Moghaddam, N., & Tickle, A. (2020). The Efficacy of Cognitive Behavioral Therapy for Adults With ADHD: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Journal of Attention Disorders*, *24*(6), 875–888.