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Computer gamification: Addressing symptoms of inattentive ADHD in children

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COMPUTER GAMIFICATION:

ADDRESSING SYMPTOMS OF INATTENTIVE ADHD IN CHILDREN

by

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ABSTRACT

Computer gamification has the potential to help meet the educational needs of children with Inattentive Attention Deficit/Hyperactivity disorder (ADHD). The elements of computer gamification are mapped to distinct kinds of interventions for Inattentive ADHD and show certain types of computer gamified learning are better than others for those who experience Inattentive ADHD.

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1. INTRODUCTION

More than seven percent of children worldwide have Attention-Deficit/Hyperactivity disorder (ADHD) (Boon, 2020). A significant subset suffers from short-term and long-term learning difficulties created from living with Inattentive ADHD. Inattentive ADHD sufferers typically perform poorer academically than their peers, as reflected in lower scores and increased likelihood of repeating a grade (Colomer et al., 2017). Consequently, as adults, they have reduced lifetime earnings, are typically employed in part-time rather than full-time work that requires minimal training, and require more government aid than their peers (Christiansen, 2021). Proper diagnosis and treatment during childhood can improve their academic and professional success.

Existing interventions (e.g. Cognitive Behavioral Therapy (Alqithami, 2021), self-management (Harrison et al., 2020), behavioral parent and teacher training (van der Oord & Tripp, 2020), and neurofeedback (Baumeister et al., 2019) help Inattentive ADHD sufferers, but they do not completely address their needs. One promising approach is the utilization of computer gamification, specifically the components and elements, to help children improve their chances for success. This thesis identifies aspects of computer gamification components and elements that improve Inattentive ADHD children's academic performance and theorizes on the causal link between computer gamification components and Inattentive ADHD sufferers' academic performance.

The thesis proceeds as follows: Section 2 explores Inattentive ADHD in children, including barriers to success and interventions. Section 3 explains how computer gamification works with Inattentive ADHD symptoms. Section 4 concludes this synthesis.

2. INATTENTIVE ADHD IN CHILDREN

Children with Inattentive ADHD have numerous symptoms that can hinder their ability to learn and complete tasks. Each child's symptoms vary in severity of manifestation and subtype, and understanding the symptoms and subtypes is important for determining appropriate interventions. Ahamdi et al (2014, p. 197) described the experiences of symptoms for these children as the following:

inattention and disorganization characteristics are involved in inability to maintain tasks, seeming not to listen and losing things, and the hyperactivity-impulsivity characteristic involves in [sic] over activity, fidgeting, inability to stay seated, disrupting other's activities and inability to wait more than what is expected for their age.

Inattentive ADHD sufferers' inability to concentrate creates ancillary behavioral issues that impact their ability to engage in successful living. They are unable to perform detailed planning, and have difficulty organizing and holding conversations (Stanford's Children Health, n.d.). These combined issues make learning and completing tasks difficult. Assignments at school and other daily responsibilities may be left incomplete or have many errors ("University of Michigan Medicine, n.d.). Poor performance can lead to academic issues.

As a result, expected social interactions, behavior patterns, and educational progression are not displayed in many children who live with this disorder (Moore et al., 2017). This atypical development causes Inattentive ADHD sufferers to struggle in daily

living. Identifying and addressing these issues can improve the outcome for children with Inattentive ADHD.

2.1. ADHD SYMPTOMS

Children with Inattentive ADHD may be distractible, disorganized, inattentive, unfocused, have an aversion to mentally exhausting tasks, and have issues at home and school (Centers for Disease Control and Prevention, n.d-b). These symptoms can cause secondary symptoms of low self-esteem, social difficulties, stress, anxiety, hostility, difficulties in problem solving, decision making, task switching (Farcas & Szamosközi, 2016), extrinsic and intrinsic motivation, engagement, feelings of achievement, persistence, and performance.

Children are diagnosed with Inattentive ADHD if they are detected to have at least six symptoms over a period of six months at a level atypical of their age (Centers for Disease Control and Prevention, n.d-b). Symptoms must also have occurred before twelve years of age in at least two environments (e.g. school and home) (Centers for Disease Control and Prevention, n.d-b). There is no single test available for the purpose of diagnosing Inattentive ADHD (Sinfield, 2017). Instead, "a comprehensive evaluation is necessary to establish a diagnosis, rule out other causes, and determine the presence or absence of co-existing conditions" (Children and Adults with Attention-Deficit/Hyperactivity Disorder [CHADD], n.d.). This process "requires time and effort and should include a careful history and a clinical assessment of the individual's academic, social, and emotional functioning and developmental level" (CHADD, n.d).

Currently, the American Psychiatric Association's Diagnostic and Statistical Manual-Fifth Edition (Sinfield, 2021) suggested there are three subtypes of ADHD with two having the presence of inattentiveness (Boon, 2020). Inattention exists in the majority of children with ADHD (Øie et al., 2014). Some studies have determined around 97% of children with ADHD exhibit inattentiveness (İPÇİ, 2020). This paper focuses on those two subtypes and refers to them as one--Inattentive ADHD.

2.2. BARRIERS

Inattentive ADHD, a neurodevelopmental disorder (Sinfield, 2021), results in altered brain function (Boon, 2020). Inattentive ADHD sufferers have differences in their brain structures that alter their ability to process information. Children with Inattentive ADHD frequently have poor executive functioning, which includes working memory impairments (Dovis, 2015, p. 575). Executive function and its related components, such as motivation and adaptability, are linked to the symptoms of Inattentive ADHD.

However, it does not impact intellect, only development (Sinfield, 2021). Lower levels of dopamine, "the feel good hormone" (Denny, 2016, p.16) and neurotransmitter (Sinfield, 2021), are found in Inattentive ADHD sufferers (Sinfield, 2020). Furthermore, Structural Magnetic Resonance Imaging has shown the basal ganglia, thalamus, cerebellum, corpus callosum, and the gray and white areas of the cerebral cortex are impacted by ADHD (Boon, 2020). These areas are responsible for "mental processing, attention, motivational and movement regulation, and the behavioral characteristics routinely observed in ADHD" (Boone, 2020, p. 540). The amygdala (Sinfield, 2021) and hippocampus (2021), which influence emotions, are reduced in size (2021) in children

with Inattentive ADHD. These differences in the brains of children with ADHD result in their learning difficulties.

     Problems in executive function are connected to many of the learning barriers encountered by children with ADHD. Motivation (Colomer et al., 2017), persistence (Colomer et al., 2017), attention (Colomer et al., 2017), learning (Holmes et al., 2020), and memory (2020) are elements of executive functioning. Moreover, impairments in working memory have been linked to the academic struggles of children with ADHD. Working memory is essential to managing attentiveness and effectively absorbing information when engaged in the learning process (Martinussen & Major, 2011). Additionally, Inattentive ADHD is linked to difficulties with "mathematical problem-solving, reading and language comprehension, and written expression" (Martinussen & Major, 2011, p. 69). Executive functions, such as planning, and verbal fluency are found to be diminished with inattentive ADHD, which has been termed executive dysfunction (Ahmadi et al., 2014). They are also easily distracted by their inability to ignore stimuli (diminished response inhibition) (Ahmadi et al., 2014).

     Furthermore, children with inattentive ADHD need greater and immediate rewards (Dovis, 2015, p. 575), which has been attributed in part to lower levels of dopamine (Hulsbosch et al., 2021). When rewards are reduced or no longer offered, they will not complete tasks with the same level of accuracy. They respond similarly to punishment (Bunford et al., 2021). Additionally, they become steadfast in their reaction if they are no longer receiving rewards (extinction) or are punished for behavior after being given rewards, also known as reverse learning (2021).

Their mental processing speeds may be slower than others, both in terms of perception and psychomotor activity. Thus, they are often unable to keep pace in class and learning can become cognitively exhausting for them (Kibby, 2019). Also, their slower processing speed negatively impacts reading comprehension (Wrońska et al., 2015). They tend to be easily distracted which results in them having a lower attention to detail and "often have significant difficulty paying attention over prolonged periods of time when engaged in effortful, boring tasks" (Fosco & Hawk, 2017, p.155), which results in struggles with motivation and engagement to complete tasks. Furthermore, children with inattentive ADHD are typically unable to approach problems in multiple ways, and solve problems only using one approach- even when the approach is inappropriate. Likewise, they are unable to view a situation from multiple perspectives (Mohammadzadeh et al., 2020. p. 29) and have reduced ability to plan into the future and to self-regulate (Ahmadi et al., 2014).

The above cognitive differences in inattentive ADHD sufferers means math, reading, writing, and spelling are some of the academic areas impacted by ADHD symptoms. Inattentive ADHD is likewise linked to major deficits in "social, academic, and executive functioning" (Boon, 2020, p. 534). Motivation and emotional processing are also diminished (Boon, 2020, p. 534).

A second subgroup of inattentive ADHD sufferers exhibits a form of ADHD where they have symptoms of hyperactivity and impulsivity. These additional symptoms complicate the lives of inattentive ADHD sufferers and further impede their learning progress. The constant motion and actions without thought exhibited by this particular subgroup of sufferers can be disruptive in classroom and social environments (University

of Michigan Medicine. of (n.d.)). These interferences in turn can impede learning and completing tasks. Meetings, social outings, and other events that require patiently sitting for prolonged periods are difficult with these symptoms (n.d.). Taking part in disallowed activities at school is a consequence of the accompanying behavior (n.d).

A portion of Inattentive ADHD sufferers exhibit symptoms of other learning disorders including dyslexia (Czamara, 2013)- occurs in 8% to 17% (Olivardia, n.d) of inattentive ADHD sufferers, dysgraphia (a writing impairment)- occurs with 56% of children with inattentive ADHD (Mayes et al., 2018), and dyscalculia (math learning disability) (Frye, n.d.)- 11%.

Some children with inattentive ADHD have also "been shown to have aggressive and withdrawn behaviors stemming from lack of self-esteem and frustration over poor school performance" (Wei et al., 2014, p.206). Additionally, the coexistence of learning disabilities and ADHD is linked to increased inattentiveness and reduced memory (2014). Reading, social, and behavioral impairments are intensified by children having Inattentive ADHD and another condition (2014).

Numerous studies have investigated the causes of symptoms in ADHD. Some of the major differences in brain function of ADHD sufferers compared to their peers have been identified (e.g., Ahmadi et al., 2020, Mohammadzadeh, et al., 2020, Boone, 2020), and their impact and interventions have been addressed as well. As many ADHD symptoms persist into adulthood, it is important for educators to identify and reduce these barriers as early as possible. These cognitive, social, emotional, and behavioral symptoms can result in less successful personal and academic outcomes for Inattentive Attention-Deficit/ Hyperactivity disorder sufferers.

2.3. INTERVENTIONS

Interventions to improve academic performance in children with inattentive ADHD can be divided into the following types: behavioral, cognitive, social, emotional, and environmental.

2.3.1. Behavioral Interventions. Behavioral interventions involve either teaching such children acceptable behaviors or recognizing inattentive ADHD sufferers' specific behavioral limitations. For example, lessons are deliberately kept short and interspersed with frequent periods where such children can move around. Movement is deliberately incorporated as part of the learning process (e.g., emphasizing using the fingers for counting). "Daily yoga and mindfulness activities can improve self-regulation, confidence, problem-solving, focus, and empathy" (Buck, 2017, p. 12).

2.3.2. Cognitive Interventions. Cognitive interventions involve restructuring the environment and developing cognitive skills to provide fewer distractions (Burns & Martin, 2014). This includes internal and external controls for improving attention. External controls alter surroundings, such as providing such children headphones for noise reduction (2014) and thoughtful placement of wall art to reduce visual disruptions (2014). Internal controls focus on self-regulation to improve "motivation and sustained attention" (Burns & Martin, 2014, p, 234), which includes rewards and other reinforcements (2014). Identifying and working through problems is another beneficial intervention (2014). Young and Brahams's Five-Stages of Problem Solving recommended determining what the problem is, creating a list of remedies for the problem, comparing the options, addressing the problem with the best option, and determining if outcome was as expected (Burns & Martin, 2014, p. 234).

2.3.3. Social Interventions. Social interventions involve reducing teacher student interaction in favor of peer-to-peer interaction. Thus, a child with inattentive ADHD learns through group work or a group discussion or via peer tutoring (Moore et al., 2017). By including the inattentive ADHD sufferers in group activities, they are able to feel included (2017). Additionally, pairing children together based on compatibility encourages beneficial interactions that can improve academic and social skills (2017). On a cautionary note, educators must maintain a balance between the needs of both students involved in peer tutoring to avoid negative feelings (Little, 2018). Peer-Assisted Learning Strategies is a method of training these students to better assist each other in appropriate ways (2018).

2.3.4. Emotional Interventions. Emotional interventions focus on helping an inattentive ADHD sufferer manage emotions. Such interventions include anger-management training, interventions to build up their self esteem, and self-regulation techniques (Burns & Martin, 2014, p.233). Additionally, teaching methods to reduce stress, such as yoga and deep breathing, to children with ADHD will help them adjust to uncomfortable situations (2014).

2.3.5. Environmental Interventions. Environmental interventions can further improve educational outcomes for children with Inattentive ADHD through alterations in environment. Offering items, such as fidget spinners or Pop Its, to keep their hands occupied during instruction can help some children concentrate (Betker, 2017). Additionally, permitting children to be in motion at times (2017) and providing chairs that allow for movement (2017) further helps sooth ADHD sufferers. Ensuring children

with Inattentive ADHD have clear guidelines for daily activities is also important because it provides organization they might not otherwise have (2017).

Medication is another intervention of Inattentive ADHD. It is used to treat symptoms, aid in participating in daily activities in different settings, and improve other intervention outcomes (Ryan et al., 2011) of children with Inattentive ADHD. According to the Center for Disease Control's website, sixty-nine percent of children ages 6-11 are prescribed medication. Despite its wide usage, medication is not addressed in this paper due to the controversies surrounding potential negative side effects and associated monitoring requirements, which includes providing doses in the prescribed amount and ensuring children with Inattentive ADHD take them (Ryan et al., 2011).

These more traditional interventions can address many learning barriers associated with Inattentive ADHD. However, they do not fully engage and motivate children with Inattentive ADHD. One alternate intervention, which will be explored in the next section, has the potential to improve learning opportunities for children with Inattentive ADHD.

3. COMPUTER GAMIFICATION

One approach to addressing Inattentive ADHD symptoms and enhance learning is to incorporate computer gamification into instructional plans. Computer gamification is the inclusion of game components ("Game," n.d) and elements (Groening & Binnewies, 2019) into different situations that typically do not involve digital games. Examples include creating subject-specific instruction using Minecraft or rewarding points for classroom behavior through ClassDojo. The purpose of computer gamification is to create the feeling of tasks being like a game (Groening & Binnewies, 2019). The central components of games are rules, challenges, interactions, and goals (Game," n.d.), which should be part of computer gamification. Rewards, leaderboards/levels/rarity, cooperation, competition, missions/objectives, avatars/characters, narratives/stories/novelty, rewards, renovation are some of the elements of computer gamification that promote the components of computer gamification.

To maximize benefits of computer gamification for children with Inattentive ADHD, it is important for educators and parents/guardians to determine goals, such as helping with a particular subject, improving a behavior, coping with emotions, or understanding how to make decisions and solve problems.

The gamification of education approach has the advantage of introducing what really matters from the world of video games – increasing the level of engagement of students – without using any specific game. The aim is to extract the game elements that make good games enjoyable and fun to play, adapt them and use those elements in the teaching processes. Thus, students learn, not by

playing specific games but they learn as if they were playing a game (Simões et al., 2013, p. 347).

As children with Inattentive ADHD are often able to concentrate on tasks they deem enjoyable for extended periods of time (Peñuelas-Calvo et al., 2020), computer gamification can provide a beneficial method for delivering instruction and overcoming barriers that impede learning.

To further ensure computer gamification meets the instructional and learning needs of those involved, educators should take steps to ensure the goals, rules, challenges, and interventions serve their intended purpose. Applying these steps can assist in employing computer gamification: 1) Recognize the needs of each child with Inattentive ADHD and where and when learning will occur, 2) establish a purpose, 3) explore the computer gamification in practice, 4) determine what is needed to create the experience, and 5) implement elements (Nand et al., 2019). An additional step should include the evaluation of the elements and components in use.

Before elements are implemented, the components involving goals need to be determined. Goals--learning and game, rules, challenges, and interactions are the foundation of merging learning with computer gamification.

3.1. GOALS

Goals are what a "person or system" seeks to attain (Weitze et al., 2014, p226). Two types of goals involved in computer gamification are learning and game goals (Weitze et al., 2014). They can be delivered together or separately (2014). The method of concealing something not enjoyable with something that is without having a

relationship between them is termed "chocolate [sic] covered broccoli" (Weitze et al., 2014, p. 227). For example, a game may involve completing a task with an unrelated game used as a reward for another task. Another method is to have the learning goal as a step to reach the game goal.

Game goals are the objectives that the player attempts to fulfill in the game (Weitze et al., 2014). There typically is a main goal and smaller goals or sub-goals (Weitze et al., 2014). Each level requires a goal to be completed in order to reach the next level of the game or to complete the main goal. Goals should be solid and easily understood, include challenges that are obtainable, created to make the goal and process of achieving the goal desirable, and distributed with some goals occurring sooner and others later with a meaningful relationship between them (Weitze et al., 2014). Additionally, the game goal and process of achieving that goal need to be desirable (2014).

Learning goals are the "knowledge and intellectual" (Weitze et al., 2014, p. 227) capabilities expected to be developed from the game. Improving the abilities to focus, persist, solve problems, maintain relationships, and achieve are some of the learning goals of computer gamification for children with Inattentive ADHD.

Learning conditions, setting, goals, content, process, and evaluation/assessment (Weitze et al., 2014, p. 233) are aspects to consider when incorporating learning goals into a game. Conditions involve existing knowledge compared to what is required to complete tasks in the game (2014). Setting involves the time and environment of the game. Goals are the objectives of the game that are both "short-term and long-term" (Weitze et al., 2014, p. 233), which can be agreed upon with child, parents/guardians, and

educator to allow for the child's control in learning objectives (Weitze et al., 2014). Content encompasses the educational material selected to assist the child in achieving goals (2014). Process includes the context, instructional styles, and learning theories involved in the game (2014). Evaluation/assessment is determining if goals are met and monitoring progress toward them (2014).

Coordinating game and learning goals (Weitze et al., 2014) is essential for computer gamification to be effective.

When designing learning goals you should also be aware of the progression in the learning to make the goals attainable. Learning progressions within a content area begin at the novice level with the core concepts and skills as the learning goals; these core concepts and skills are considered fundamental. To progress through a content area to reach the learning goal, every learner needs to master these core competencies. For example, you could say that the student must learn and master the rules and procedures within each learning topic to achieve the learning goal. (p.235)

While developing these goals for children with Inattentive ADHD, it is important to remember they prefer ones that are easily defined and understood (Lumsden et al., 2016).

3.2. RULES

Rules serve to guide challenges to reach goals (Weitze et al., 2014). These rules must be learned in order to confront and defeat challenges in the game (2014). Rules can either be structured or unstructured. If the purpose of the game is purely for play, rules will not be as fixed because players have more control of the game (2014). With a

purpose of achieving goals in the game, the rules are more structured (2014). When learning and game goals are blended, the rules tend to be the latter.

To achieve goals, rules must be present to govern the game. Structured rules are most appropriate for learning goals because they provide organization and consistent rules (Weitze et al., 2014). Structured rules determine how much time, as well as number of attempts, is allowed on each task (2014). They are informers of goals being met. If rules are unstructured, players have more flexibility in action taken (2014). As game and learning goals need to be in harmony for success, rules need to accommodate both.

3.3. CHALLENGES

Challenges are what a player must overcome to reach a goal (Weitze et al., 2014). These challenges can be sub-goals on the path to the main goal (2014). Challenges can be related to the main goal or a separate activity to invite more enjoyment into the game (2014). Challenges can be delivered in the form of cooperation or competition. This will vary according to the overall objective of the game.

Challenges can vary in relation to the abilities of players or according to the progression of the game (Weitze et al., 2014). For learning purposes, a game that logarithmically increases in difficulty as the player improves is best (2014). If playing a game for gaming or competition purposes, players may need challenges to occur periodically or increase in difficulty with advancement without regard to the players' skill levels (2014).

As previously mentioned, children with Inattentive ADHD may become easily frustrated if tasks are too difficult. By having sub-goals and a main goal, challenges are

more manageable. Furthermore, challenges should logarithmically increase in difficulty to reduce frustration of game and learning challenges.

3.4. INTERACTIONS

Interactions are how players communicate with the system (computer interaction) and/or other players (human interaction). These include actions taken or choices made by the player (Weitze et al., 2014) and how the system responds in the form of feedback (2014).These interactions inform players when they succeed in goals. Rewards are a positive source of interaction. Additionally, there may be interaction in the game between avatars/characters or in the form of cooperation.

Interactions can be minimal or frequent depending on the chosen learning goals of computer gamification. If a player is competitive and enjoys a more stressful environment, they would prefer competition over cooperation. For a player more interested in working with others or is easily stressed, cooperation would be more helpful.

For the components to be effective, children with Inattentive ADHD would benefit from elements being selected that promote the computer gamification experience rather than hinder it. Many elements have been shown to help address barriers associated with Inattentive ADHD, such as rewards increasing performance and motivation (Morsink et al., 2021) and virtual reality being used in the classroom to aid cognition (Shema-Shiratzky et al., 2019)). Including them in the creation of goals, rules, challenges, and interactions will enhance the computer gamification experience.

3.5. INTERVENTION OF ADHD SYMPTOMS

Computer gamification can improve symptoms and learning outcomes for children suffering from Inattentive ADHD by serving as an emotional, behavioral, cognitive, social, and/or environmental intervention. Goals, rules, challenges, and interactions help guide the process of computer gamification and are the framework for this thesis.

3.5.1. Behavioral Intervention. The computer gamification goal of behavioral intervention is to help children with Inattentive ADHD confront issues related to attention, which includes engagement and motivation in completing tasks. Rules should be structured to allow for them to maintain focus on the learning goals. They should be allowed more than one attempt to prevent them from giving up on the learning goal. Assistance should be provided by educators as required. Furthermore, tasks need to begin with less difficulty so they can become familiar with the game being used. As familiarity and skills increase, the tasks can logarithmically increase in difficulty. Interactions should be minimal due to the tendency for children with Inattentive ADHD to become distracted, which would include limiting elements involved.

A behavioral intervention goal of computer gamification for children with Inattentive ADHD may be to improve behaviors involving participation, movement, and completion of tasks. Rules that allow for feedback in the form of rewards, display of progression, and activities that allow for stimulation, while keeping focused on goals, are encouraging to maintain focus on the assignment. Challenges to these rules may include changes in levels, different types of sub-goals or activities that offer a variety of interesting events while working toward a main goal, an achievable progression of

difficulty, frequent offering of rewards without them demanding more to obtain, and the ability to customize different items or characters within the game. Interactions could be feedback in the form of rewards or levels, reattempts, or new tasks within the game.

Behavioral issues can further be confronted through computer gamification by assisting Inattentive ADHD in focusing on tasks, assisting in guiding behavior through rewards and feedback (Mese et al., 2019), and interacting with peers using avatars (Koppitsch & Meyer, 2021). Computer gamification can also increase extrinsic and intrinsic motivation for inattentive ADHD sufferers. Extrinsic motivation is derived from accomplishing a task for the purpose of receiving an external benefit (Mekler et al., 2017). Rewards are an external benefit that was found to improve motivation in inattentive ADHD sufferers in a study involving thirty-four participants with ADHD from the ages of eight to sixteen (Morsink et al., 2016). Intrinsic motivation involves engaging in tasks for the purpose of pleasure (Mekler et al., 2017). Extrinsic and intrinsic motivation may be explained as behaviors that are driven by "external reward or punishment" or "personal ambition or enjoyment" (Brigham, 2015, p. 475). The enjoyment and engagement provided by computer gamification can increase intrinsic motivation (Lumsden et al., 2016). Engagement through interest is important to maintain attention (Low, 2021). Computer gamification also creates a link between the material presented and its purpose to aid in learning (Denny, 2016).

Combined with motivation, engagement aids in behavioral changes and encourages inattentive ADHD sufferers to finish assignments (Farcas & Szamosközi, 2016, p. 26). Computer gamification can change attitudes about assignments by treating them as missions (Lynch, 2017). Additionally, computer gamification encourages

participation (Nand et al, 2019, p.2) and inspires a "sense of accomplishment and progress" (Brigham, 2015, p.474), which stimulates behaviors necessary for learning. Feedback, such as point and levels (Mese et al., 2019), can serve as an "effective method supporting students to direct to intended behaviors" (Mese et al., 2019, p.121).

 3.5.2. Cognitive Intervention. Cognitive interventions with computer gamification may include goals of problem solving, task switching, or subject-specific improvements. To assist with these goals, rules should be structured to allow for new attempts at tasks, learner initiated changes in environment, and frequent rewards with added bonuses. To challenge children with Inattentive ADHD, include sub-goals, missions/objectives to complete, and levels to advance. Interactions can be in the form of narratives/stories/novelty, rewards as feedback, and choices that impact the game.

 Computer gamification can improve learning outcomes (Farcas & Szamosközi, 2016) for inattentive ADHD sufferers. One way is by improving working memory including problem solving, decision making, and task switching (Lumsden et al., 2016). Another is through offering reinforcement (rewards) (Farcas & Szamosközi, 2016) and immediate feedback (2016) to assist in overcoming learning barriers for children with Inattentive ADHD. Providing prompt responses allow mistakes and accomplishments to be recognized (Lynch, 2017). A third option is to incorporate learning with physical activity. Exergaming, the combination of exercise and gaming, was shown to promote executive function in one study of fifty-one children with ADHD (Benzing & Schmidt, 2019). Combining learning with exercise may help inattentive ADHD sufferers who exhibit hyperactivity and impulsivity (2019, p. 1243). Narratives/stories, points, badges,

cooperation, and mission/objectives are some of the elements that can aid in problem solving and decision making.

3.5.3. Social Intervention. Using computer gamification as a social intervention for children with Inattentive ADHD would involve goals to encourage positive interactions and help learn to participate in teamwork. These goals may be to learn to work in groups, to focus on a conversation, or to respond to conflict with others. To help reach these goals, rules could include socially-related and/or task-related rewards, choices of avatar or character, and opportunities to complete tasks again if improvements are needed. Challenges could be cooperation or competition with consideration given to skill level and individual preferences for competing. Interactions should be kept at a minimal in regards to the number of people involved to avoid too many distractions.

Social interventions offered by gamification can positively influence relationships with peers, address self-esteem, and feelings of belonging for children with Inattentive ADHD. Social interactions can be improved by the social elements offered by computer gamification, such as cooperation (Groening & Binnewies, 2021), competition (2021) and leaderboards (Sitra et al., 2017). These interactive aspects of cooperative gaming "facilitate cooperation among players to achieve a common goal, such as trying to impair other players or outperform them, and help players build individual in-game identities by assuming meaningful roles and receiving recognition from other players" (Safapour et al., 2019, p.2). Computer gamification also teaches a new way to interact with others, while learning (2019). One reason is "children learn by playing with others, creating and improving their zone of proximal development; as they play, they are more involved in

carrying out complex activities" (Nand et al., 2019, p.2). Avatars/characters can encourage interactions with other avatars/characters (Koppitsch & Meyer, 2021).

  3.5.4. Emotional Intervention. Goals of emotional intervention through computer gamification focus on coping with emotions and reducing stress, anxiety, and anger. Rules should be structured and permit reattempts at achieving the main goal. Challenges may include cooperation. Rewards should come frequently without it becoming more difficult to obtain them. The game should logarithmically challenge children with Inattentive ADHD so tasks increase at a level in accordance with their skill. Interactions should incorporate positive feedback, frequent rewards or bonus activities, and should use a limited number of elements.

  "Gamification forges emotional connections" (Denny, 2016, p.16), which in turn impacts "actions and reactions" (Alqithami, 2021, p. 3). Additionally, it can reduce stress, anxiety, and hostility (Denny, 2016) that may be present in children with ADHD. Emotions have been linked to self-regulation and attention (Alqithami, 2021). Self-regulation improvements can enhance "engagement, completion, and accuracy" (Harrison et al., 2020, p. 56) of tasks. When tasks create an emotional relationship with performers and are deemed important, attention is promoted (Alqithami, 2021). "Attention is a mental muscle that can be strengthened by exercising the brain" (Alqithami, 2021, p.2), which can be assisted with computer gamification. Computer gamification also increases satisfaction (Gafni et al., 2018).

  "Gamification can be more successful in motivating players by putting more accent on positive (pleasure, sympathy, connectedness, competition) feelings, while holding back on negatives (envy, anger, desperation, helplessness)" (Imran, 2019, p. 3).

Narratives, rewards, and competition are some of the elements that inspire emotions. Computer gamification feedback has been shown to increase dopamine levels (Denny, 2016), which has been shown to be lower in children with Inattentive ADHD. Additionally, graphics offer visual stimulation, which helps govern attention.

3.5.5. Environmental Intervention. By nature of being a game, computer gamification serves as an environmental intervention in itself, which can promote many goals for children with Inattentive ADHD. Some goals may be to learn to focus on tasks or complete them in a timely manner without frustration. Rules that would assist with these goals allow for renovation in the game, consistent rewards for tasks, and ability to manipulate the environment by completing sub-goals within the game. Challenges could include missions with clear objectives, competing or working with others, or earning bonus items, such as smaller missions or new paths within the game.

Environmental obstacles can be confronted through the design and use of computer gamification by inviting attention, concentration, and engagement. The design of computer gamification can offer a variety of benefits, such as creating structure (Betker, 2017) (e.g. missions/objectives, narratives/stories), offering visual focus (Alqithami, 2021) (e.g. avatars, narratives, graphics), and furnishing hurdles to defeat (Alqithami, 2021) (e.g. competition, missions). Ability to manipulate the environment is a benefit of Augmented and Virtual Realities (Alqithami, 2021). Augmented Reality has been used to improve behavior by gamifying cognitive behavior therapy (Alqithami, 2021). In one study involving fourteen children with ADHD between the ages of eight and twelve, Virtual Reality combined with physical exercise was shown to improve executive function and memory (Shema-Shiratzky et al., 2019).

3.5.6. Overall Computer Gamification Intervention. Through appropriate goals, rules, challenges, and interactions, computer gamification can assist in reducing the aforementioned barriers that are encountered by children with Inattentive ADHD. To encourage success in using computer gamification as an intervention for Inattentive ADHD, rules should be structured, allow for a predetermined number of reattempts (based on the child's aptitude) combined with interventions before maximum attempts are reached or the child becomes overly frustrated, and rewards should be consistent without becoming more difficult to obtain as tasks require more abilities. Challenges should logarithmically increase as skills improve and goals are met. Interactions should be minimal with consideration given to the number of people and elements included. Additionally, interactions should include rewards. These are represented by Figure 3.1.
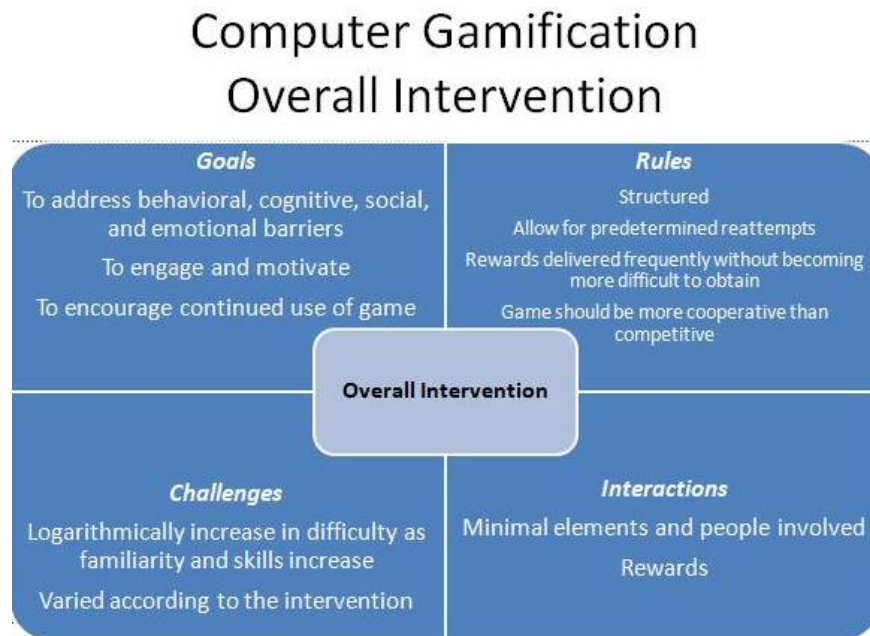

Figure 3.1 Overall Computer Gamification Interventions

4. CONCLUSION

Children with Inattentive ADHD can benefit from learning with computer gamification. Computer gamification has the potential to serve as an intervention to overcome the behavioral, cognitive, social, emotional, and environmental barriers that this population may experience. Goals are important to examine from both learning and gaming perspectives for successful gamification. Rules, challenges, and interaction support these goals. Elements add enjoyment and help ensure goals are met with greater ease through strengthening the abilities of children with Inattentive ADHD by promoting focus, persistence, problem solving, positive relationships, and learning achievements.

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