

# **Visual Design Guidelines for representing curriculum-based digital content for Children living with ADHD in typical learning environments**

**PhD Dissertation**

Submitted in partial fulfillment of the requirements of the degree of  
Doctor of Philosophy

by

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Dedicated to my beloved parents.



## Declaration

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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**CERTIFICATE OF COURSE WORK**

This is to certify that **Phalke Sandesh Sanjeev** (Roll No. 196105006) was admitted to the candidacy of Ph.D. degree on 28 July 2019, after successfully completing all the courses required for the Ph.D. programme. The details of the course work done are given below.

S.No	Course Code	Course Name	Credits
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# Abstract

Attention deficit hyperactivity disorder is an incurable neurological disorder affecting acquisition of education when present in Children. It can be effectively managed if identified in early childhood (Centers for Disease Control and Prevention (2023)). A recent and an effective method of managing children living with ADHD (ChADHD) is the use of digital devices and platforms in various contexts, including curriculum-based education. While these digital devices and platforms have demonstrated effectiveness in their use, there are still in their nascent stage (Weisberg et al. (2014); Sonne et al. (2016)). One of the ways which can help make the design of digital devices and platforms better is the utilization of ChADHD specific visual design guidelines (McKnight (2010)).

Interestingly the curriculum-based content designed for ChADHD often mirrors the curriculum-based content that of neurotypical school children. This results in negligible impact to enhance the attention span of ChADHD in typical-learning environments. We find that the present visual design guidelines (VDGs) are either unavailable or exist in formats unsuitable for interpretation and application in designing of curriculum-based content for digital devices and platforms used by ChADHD (McKnight (2010); Weisberg et al. (2014); Sonne et al. (2015); Powell et al. (2019)). There is, therefore, a critical need to systematically design the curriculum-based content using VDGs to enhance the attention span and in turn to facilitate the ChADHD management. This study addresses the gap of VDGs in-availability, by establishing a relevant and valid set of elements of visual design guidelines (eVDGs) for the designing of curriculum-based digital content for devices and platforms used by ChADHD in a typical teaching-learning environment. In addition, the study addresses gap in existing knowledge in terms of finding a specifically adapted methodology to help with the proposal of eVDGs for ChADHD.

This thesis presents these eVDGs by following a novel methodology - an adaptation of NIH stage model (NIHSM)(NIH (2022)) and the co-design approach in a complementary manner. This results in a design research methodology with an inclusion of rigorous procedures from

the domain of behavioural sciences. The methodology spans across three main stages - Stage 0, Stage I and Stage III. In addition, it systematically engages experts in special educational needs, clinical psychologist, teachers designers, ChADHD, their parents and caregivers during various instances across the three stages.

This thesis contributes to the existing knowledge by establishing a relevant and validated set of 15 eVDGs. These eVDGs, when used to design curriculum-based digital of devices and platforms used by ChADHD in typical learning-environment, have shown through empirical experimentation an enhancement in the ChADHD's attention span. The study, in addition to eVDGS, delivers a novel design research methodology, an adoption of NIH stage model combined with co-design approach, for the systematic establishment of relevant and valid set of eVDGs, and for similar other research objectives.

**Keywords:** *Elements of Visual Design Guidelines, NIH Stage model with co-design, Children living with Attention Deficit Hyperactivity Disorder (ADHD), Representation of curriculum-based digital content.*

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# List of Abbreviations

<b>ADHD</b>	Attention deficit hyperactivity disorder
<b>ChADHD</b>	Children living with ADHD
<b>CDC</b>	Center for Disease Control and Prevention
<b>VDG</b>	Visual Design Guidelines
<b>eVDG</b>	Elements of Visual Design Guidelines
<b>NIH</b>	National Institute of Health
<b>NIHSM</b>	NIH Stage Model



# Chapter 1

## Introduction

### 1.1 Children Living with ADHD

This thesis deals with the elements of visual design guidelines (eVDGs) of curriculum-based digital content representation for Children living with Attention Deficit Hyperactivity Disorder (ChADHD). Attention Deficit Hyperactivity Disorder (ADHD) is a non-curable neurological disorder commonly identified in the children population. The global prevalence children living with ADHD (ChADHD) between 3 to 12 years of age is 7.6%, and in teenagers aged between 12 to 18 years is 5.6% respectively (Salari et al. (2023)). Further, the percentage of ChADHD in the total children population is increasing every year globally (CDC (2022)). Figure 1.1 presents percentage rise in ChADHD between 1997 and 2022. In this figure NSCH refers to National Survey of Children's Health and NHIS refers to National Health Interview Survey

Unfortunately the statistics with respect of ChADHD in India is no different either. Suthar et al. (2018) identify a population percentage of 5.7% of ChADHD in the overall Indian children population within the age group of 6 to 12 years. Within this group, they find a maximum prevalence of ADHD further between the age group of 9 to 10 years of age. A comparison

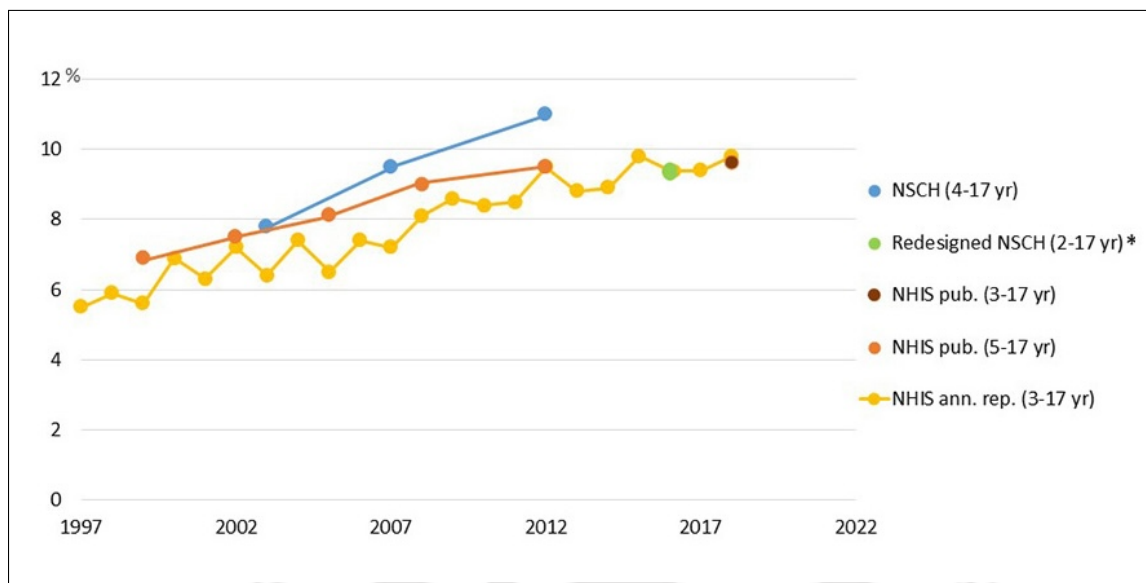


Figure 1.1: Percent of children with a parent-reported ADHD diagnosis, adapted from (CDC (2022))

between the gender suggests that the number of male ChADHD are significantly higher than the number of female ChADHD.

Education is an enabling factor for ChADHD that helps them become an integral part of the mainstream. ADHD management does address educational requirements for ChADHD as part of ADHD management. Infact, an early diagnosis with intervention administered at appropriate timings show improvement in the educational outcomes for children. This helps grounding their personal and social development. Conversely, in cases when ADHD management is not addressed for an affected child, the chronic nature of ADHD often persist through to adulthood. It begins by affecting early-age or adolescent's schooling, friendships, and daily life, and later on disrupting work and relationships (CDC (2022); Bowling and Nettleton (2020)).

The Government of India has laid down it's mandate to manage, engage and provide equal opportunities for children with special educational needs between the age group of 6 to 14 years (Ministry of Human Resource Development, Government of India (2018)). To quote their perspective on inclusive education, i.e. *Samagra Shiksha*, for children with special needs;

*Inclusive Education for children with special needs has been one of the major interventions of the erstwhile Sarva Shiksha Abhiyan (SSA) RTE and RMSA schemes. From the year 2018-19, Samagra Shiksha lays emphasis on improving quality of ed-*

*ucation for all students, including children with special needs. Thus, this intervention is an essential component under Samagra Shiksha. The component provides support for various student oriented activities which include identification and assessment of children with special needs, provision of aids, appliances, corrective surgeries, Braille books, large print books and uniforms, therapeutic services, development of teaching-learning material, assistive devices and equipment's, environment building and orientation program to create positive attitude and awareness about nature and needs of children with special needs, purchase/development of instructional materials, in-service training of special educators and general teachers on curriculum adaptation, stipend for girls with special needs etc. The component also emphasizes the implementation of the Right to Free and Compulsory Education (RTE) Act, 2009 for children with special needs (within the age group of 6-14 years).*

As part of this act, the government provides right of equal education for ChADHD with the inclusion of assistive tools, techniques and methods under the supervision of experts in special educational needs, and school counsellors.

To this research, the literature is suggestive of almost none-existent and often a limited availability of tools, techniques, and strategies for ChADHD to help in the educational sitings. In specific, the known knowledge on representation of curriculum-based digital content is scanty. In addition to this gap, there is no standard methodologies to identify, develop and test such a knowledge. These limitations in the stage-of-art in the domain of content representation for ChADHD contributes to the motivation of the current research.

The rest of the chapter is organised in the following manner. The next section helps developing an essential but brief understanding of ADHD, along with problems and challenges faced by ChADHD. Following these mentions are the current state of non-pharmacological ways of managing ADHD and relevance of VDGs in representing digital content for ChADHD. The further sections to continue brings details of the research gap and questions, along with the hypothesis for this current research. The chapter ends with suggestions on how the rest of thesis document is organized across chapters.

## 1.2 ADHD - An Overview

### 1.2.1 Understanding ADHD

ADHD is one of the commonly observed neurological disorders in the children at a very early age (Association (2023)). There are several reasons why children may experience ADHD; however, the exact causes of ADHD remains unknown. While the exact cause of ADHD is unknown, there are several speculations. One such widely recognized speculation is that variations in brain genes result in ADHD. Other well-known speculations include brain injury, exposure to hazardous environmental factors like lead, maternal use of alcohol and tobacco during pregnancy, premature delivery, and low birth weight (Centers for Disease Control and Prevention (2023)). Furthermore, there are also some myths considered as speculations such as eating too much sugar, watching too much television or digital screens, and other social and environmental factors like poverty and chaos that are thought to lead to ADHD. However, all these speculations lack valid research proof, according to the Center for Disease Control and Prevention (CDC (2022)). This thesis work is aligned with the understandings and speculations of the CDC.

ADHD is broadly classified into three major categories: (a) predominantly hyperactive-impulsive presentation, (b) predominantly inattentive presentation, and (c) combined presentation CDC (2022).

- **Predominantly Hyperactive/ Impulsive Presentation:** Children with this type of ADHD may fidget, squirm and talk a lot. They feel restlessness and cannot sit in a place or wait in longer lines. These children jump or run excessively and cannot sit in a place for longer duration's. Children with impulsivity may interrupt others a lot, grab things from people, or speak at inappropriate times. They find it difficult to wait for their turn.
- **Predominantly Inattentive Presentation:** These children face difficulties in paying attention to the details of the task, to complete a task. Face difficulties to follow instructions. Is easily distracted and forgets to perform daily activities.
- **Combined Presentation:** Symptoms of both hyperactive and inattention types are present in these children.

The diagnosis of identification of ADHD in children is complex and most of the times parents and teachers consider the behaviour ChADHD as deliberate and mischievous. However, such behaviours should not be ignored and a systematic diagnosis must be conducted. In fact the diagnosis of ChADHD is a process and there is no single test to diagnose ADHD. However the identification is possible by following way Mayo Clinic Staff (2019):

- Medical exams to rule out other possible cause symptoms.
- Information gathering, such as any current medical issues, personal and family medical history, and school records.
- Interviews or questionnaires for family members, your child's teachers or other people who know your child well, such as caregivers, babysitters and coaches.
- ADHD criteria from the Diagnostic and Statistical Manual of Mental Disorders DSM-5, published by the American Psychiatric Association.
- ADHD rating scales to help collect and evaluate information about the child.

Clinical psychologists, doctors, and trained experts in special educational needs often conduct the identification of the type and severity of ADHD. Informed parents, teachers, and guardians are ones who can help in the preliminary identifications, as they are first ones to observe the child. Such, identifications are relatively very less and often the identification of children take place in their later age span. However, it is known that ADHD should be managed in early childhood; if not managed effectively, it can create a negative impact on such children. The identification and effective management of ADHD in early childhood becomes very necessary choice by nature (CDC (2022); Fayyad et al. (2017)). Researchers and domain experts propose distinct ways of managing ChADHD. These include - pharmacological, non-pharmacological and therapeutic interventions, techniques, tools and methods. Each of the management way have their own applications and limitations but prove to be effective in managing ChADHD in their own way. As the researcher comes from the non-medico background his research area interest lies around the non-pharmacological ways of managing ChADHD. The next section briefly explains on the non-pharmacological ways of managing ChADHD.

## 1.2.2 Non-pharmacological Management of ADHD

The non-pharmacological ways consist of different sub-domains which include therapy-based management, assistive aids, and use of distinct digital devices and platforms for the management of ADHD. Therapy-based management refers to use of therapeutic mediums by the experts in special educational needs, psychologists, teachers, caregivers, and parents to help in the management of ChADHD with or without the use of medication. The goals of behavioural therapy are to learn or strengthen positive behaviours and eliminate problems and challenges that rise due to the inherent ADHD. Here, different emotional and behavioural therapies are used for the management of these children. Generally, parents and caregivers are trained for the management of such child. Parent and caregivers work hand in hand with experts in special educational needs and educators to bring behavioural changes in the child. These changes focus on improving the ability of the child to enhance the attention, and reduce the hyper activeness. Every child needs a individual behavioural therapy plan and subsequent implication specifically depending upon the type of ADHD and the child's age. This make the management of ChADHD complex and difficult in community settings. Further, in the case of limited human resources, as experts in the field are scarce, it further complicates the management of ChADHD, with the potential for a negative impact on the child.

The next type that experts in special educational needs use on a large scale is deployment of assistive aids designed for ChADHD. These aids include tangible toys, study materials, paper cutting, and the use of educational study aids, among many others. There is a vast array of such assistive aids utilized by experts in special educational needs at remedial centers and suggested for use at the residence of these children. However, in most cases, their use remains limited to remedial centers, thus restricting the duration of the management process. Furthermore, to achieve a significantly positive impact on ChADHD, it takes a comparatively longer duration compared to other management methods, with no assurance of sure improvement in the child. However, these assistive aids can be used in parallel with other management methods to enhance the management process of ChADHD.

Another way of managing ChADHD, which is also the recent and most used method, is the use of digital platforms and devices. Various digital devices and platforms are used today to manage ChADHD for different purposes. The overall goal of all digital devices and platforms is nearly

the same: enhancing the attention of ChADHD and bringing about behavioral modification. These digital devices and platforms vary across different management techniques such as e-learning, reducing anxiety, enhancing attention, and developing life skills. They come in the forms of serious games, alarms, guidance modules, and teaching-learning applications. The use of these digital devices and platforms is limited; however, their impact is comparatively better with fewer or no side effects when used with ChADHD. Although digital devices and platforms are one of the effective ways of managing ChADHD, their impact can be further enhanced through a few changes and modifications. One such enhancement is the use of specific and relevant visual design guidelines (VDGs) in the digital devices and platforms used for the management of ChADHD. We find that researchers have attempted to identify relevant set of VDGs. But, such set of VDGs are either in valid or not in a state of applicability. In the next section we briefly highlight these gaps and need of VDGs.

### **1.2.3 Relevance of finding Elements of Visual Design Guidelines (eVDGs)**

Although all these digital devices and platforms have positive impact on managing ChADHD, however, the impact of these application can be enhanced. One such way of enhancing is through the use of systematically established valid set of VDGs. In the context of this study we define VDGs as an appropriate set of directions and recommendations for representation of visual element such as text, pictures, layouts, spacing's, color combinations and other content representation aspect of any digital screen. However, on a systematic survey of the literature we identify that VDGs for the representation of content on digital devices and platforms used by ChADHD are absent or have limited applicability. The existing guidelines are generally opinion based, literature based or an adoption of usability guidelines presented for the ChADHD community. Use of such VDGs to design digital devices and platforms used by CHADHD have high chances of impacting negatively. Further, the researchers who pose such guidelines also suggest the testing and validation of such guidelines before their deployment. Further, the here are very specific set of eVDGs for the designing and representation. In such eVDGs we identify two limitations (a) limited applicability in representation content, (b) difficult to predict their impact when used with standard representation style of that specific digital device and platforms. Thus, creates an urge to identify the relevant and valid set of eVDGs to generate

a positive impact on the attention span of ChADHD. Here the attention span is estimated by the experts in special educational needs by viewing the task recordings against testing (a traditional observation based method to estimate the attention span of ChADHD). This thesis focuses on identifying and validating the eVDGs that will assist the designer, experts in special educational needs, and people within the domain to design effective digital platforms and devices.

## **1.3 Research Gap, Questions and Hypothesis**

### **1.3.1 Research Gaps**

Identified research gaps have resulted from a systematically conducted review of literature, and also by interviewing subject matter experts in the area of ChADHD management. These gaps are listed as below:

1. The VDGs for the representation of curriculum-based digital content used by ChADHD in a typical-learning environment are either non-existent or inadequately detailed. Further, whenever such suggestions are available, there are almost none empirical evidence in support.
2. ChADHD management with education in focus is a specialised trait. For effective representation of curriculum-based digital content using VDGs, it is important to have a complementary research methodology- one that satisfies requirements of a specialised trait, in addition, to being sensible towards the human-centered design of visual design elements. We do see a gap in the existing knowledge with no recommendation of any standard methodology to help identify, develop and test applicability of a relevant set of VDGs for representing curriculum-based digital content for ChADHD.

### **1.3.2 Research Questions**

1. What is the state-of-the-art of VDGs for content representation on digital devices and platforms for managing ChADHD?
2. Which methodology is appropriate to identify the relevant set of VDGs for the content representation of relevant curriculum-based digital content deployed for ChADHD.
3. Which set of eVDEs has a relevance in content representation on digital devices and platforms for ChADHD in typical learning environment?
4. What is the long-term impact of implemented eVDEs on the attention span of ChADHD when used to represent the digital content on digital devices and platforms?

### **1.3.3 Hypothesis**

An appropriate representation of curriculum-based content on digital devices and platforms used by ChADHD, where such a representation is achieved by using a relevant and validated set of elements of Visual Design Guidelines (eVDGs), will help enhancing the attention span of ChADHD in a typical-learning environment.

## **1.4 Aim, Objectives and Scope of the Research**

### **1.4.1 Aim**

To establish a relevant and validated set of eVDGs for the representation of curriculum-based digital content for ChADHD in typical learning environments.

## 1.4.2 Objectives

1. To systematically identify the existing, and known eVDGs from the literature which are proposed for the representation of content on digital devices and platforms used by ChADHD.
2. To find an appropriate research methodology which will help identifying and validating a potential set of eVDGs for the content representation on digital devices and platforms used by ChADHD.
3. To identify and refine a relevant set of eVDGs applicable in curriculum-based content representation on digital devices and platforms used by ChADHD.
4. To study the long-term impact of identified eVDGs on the attention span of ChADHD in typical learning environments when the same have been used to represent curriculum-based digital content for ChADHD.

## 1.4.3 Scope

This thesis focuses on establishing a relevant and valid set of eVDGs for the representation of curriculum-based digital content used by ChADHD. The scope of this research is defined across three main directions.

First, this study includes ChADHD who are within the age group of 5-14 years. Further, there is approximately an equal number of ChADHD along three types of ADHD - Attention deficit, Hyperactivity and Combined type. These ChADHD have four comorbid conditions - autism, opposition defiant disorder, learning disabilities and anxiety. There are ChADHD who have IQ less than 80 and/ or are living with other neurological disorders and disabilities like mental retardation. Such a group of ChADHD is beyond the scope of the present research.

Second, this study considers the curriculum-based digital content only for the application of identified and validated set of eVDGs. This has been done very consciously considering education as an integral part of ChADHD management with abilities to equip ChADHD to lead a mainstream life.

Third, the curriculum considered as part of this study belongs to Bal Bharti Series of Books (Standard 2nd to 7th) of Maharashtra State Board of the state of Maharashtra in the western part of India.

## 1.5 Organization of the Thesis

This thesis is organized across seven different chapters. Each chapter emphasises on specific aspects of the current research.

- **Chapter 1**

This chapter introduces the reader with the details of the research project. This includes the context of the design problem and it's relevance. It includes other formal and important details such as the aim and objectives of the research, research gaps which are followed by a mention of the research questions and hypothesis.

- **Chapter 2**

The research methodology chapter reviews distinct methodology used by different researchers within the domain of designing digital devices and platforms for ChADHD. Further, the study also reviews the methods followed within the domain of behavioural interventions for ChADHD. This review helps to understand the methods and procedures followed in both the domain design and behavioural studies respectively. Reviewing these method researcher systematically draws the insights from both the domains to design and adopt a novel methodology. This methodology is a combination of NIH stage model and the co-design approach.

- **Chapter 3**

This chapter critically examines existing peer-reviewed literature with focus on content representation for digital platforms and devices for ChADHD. In this chapter, the author builds up the argument emphasizing on the need of a formal knowledge that captures different elements of visual design to be presented before the stakeholders as Visual Design

Guidelines. This chapter, in addition to presenting critical analysis of theories surrounding child psychology, inclusive education and visual design principle to build a strong theoretical framework. This frameworks guides readers to understand the need of establishing eVDGs for digital devices and platforms used by ChADHD.

- **Chapter 4**

This chapter identifies and validates a relevant set of eVDGs which can be used to represent curriculum-based digital content on digital devices and platforms used y ChADHD. Researchers identifies and validates these eVDGs by engaging with stakeholders namely experts in special educational needs, clinical psychologist, teachers and designers. He engages these stakeholders through systematic and planned interviews, feedback surveys, design tasks and validation survey. At the end of this chapter researcher presents a relevant and valid set of expert validated eVDGs.

- **Chapter 5**

Chapter 5 engages ChADHD across two studies to refine, and validate the expert validated VDGs. In the first part which is the pilot study section of this chapter researchers verify the applicability of the method use in testing the eVDGs with ChADHD. In the main study researchers refine the eVDGs by following the methodology tested in the pilot study. This chapter follows the protocols of stage 1 of NIHSM by incorporating experts in special educational needs, designers, and caregivers along with ChADHD through a co-design approach. Chapter results in identifying a potential set of refined and validated eVDGs which can help enhance the attention span of ChADHD when used to represent curriculum-based content on digital devices and platforms used by these children.

- **Chapter 6**

This chapter tests the impact of the eVDGs by testing them with ChADHD in real time for a span of nine months and comparing them with the existing treatments and management techniques used by participating ChADHD. The results show that the identified set of eVDGs have a significantly positive impact in enhancing the attention span of ChADHD when used in the representation of digital content on digital devices and platforms used

by ChADHD. Chapter presents the novel and established set of eVDGs for the representation of digital content on digital devices and platforms used by ChADHD.

- **Chapter 7**

This chapter concludes the work reported in this thesis by summarizing contributions, acknowledging limitations and presenting avenues for future research.





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# Chapter 2

## Research Methodology

The research methodology chapter reviews distinct methodology used by different researchers within the domain of designing digital devices and platforms for ChADHD. Further, the study also reviews the methods followed within the domain of behavioural interventions for ChADHD. This review helps to understand the methods and procedures followed in both the domain design and behavioural studies respectively. Reviewing these method researcher systematically draws the insights from both the domains to design and adopt a novel methodology. This methodology is a combination of NIH stage model and the co-design approach.

### 2.1 Introduction

The researchers working in the area of designing for special needs, including use of assistive digital technologies for ChADHD have proposed using various research methods and methodologies. We reviewed these proposals while we were attempting to detail methodology for the current research study. Initially, we believed that a comprehensive account of methodology was perhaps available which we could replicate in this study as well. However, as we will soon

demonstrate, such a comprehensive methodology with potential to address the objectives of the current research study was seemingly absent. To begin with, we found two distinct streams of such research methodologies - (first) methodologies which had a strong bent towards management, rehabilitation of ADHD and medical sciences in general, and (second) methodologies which had a strong bent towards design as a discipline of interest. Note that this research project is aiming to design better representations of curriculum based content for ChADHD. We realize that perhaps there is a need to borrow better features of both these streams of methodologies in order to evolve a set of complementary methods which are not only scientific, but also addresses needs of interdisciplinary area of research like ours.

## **2.2 Chapter Objectives**

This chapter has the following objectives:

1. Study the existing design research methodology used for designing digital interventions used by ChADHD.
2. Elaborate the need of adopting NIHSM combined with co-design approach.
3. Present the novel design methodology adopted for the curriculum-based content representation of digital platforms, and devices used by ChADHD.

## **2.3 Research Methodologies for Digital Content Representation**

Digital content representation for ChADHD invites attention from a design perspective. In this section we discuss methodologies employed by some of the relevant studies with a design perspective in their work done for ChADHD.

An interesting pointer to begin is the work done by McKnight (2010). In her work, she presents guidelines for designing interactive software for ChADHD. Her methodology seems

to have two major calls for action - (first) gather insights from the literature, and (second) analyse the insights further to generate guidelines for screen design for ChADHD. In her review of literature, she considers both peer-reviewed and non-peer-reviewed literature with focus on finding systematic ways of designing for digital devices and platforms for ChADHD. She derives insights from these sources, and then commences to the analysis phase. In the phase of analysis, she collates these insights into relevant themes. We, however, see no details of the basis of formation of these themes in McKnight (2010). She concludes by suggesting these themes as guidelines for design of interactive software for ChADHD. We find this study quite intriguing because McKnight searches for the relevant design guidelines beyond the academic databases like ACM portal, ScienceDirect, IEEE Xplore, or Web of Science. She gives reason for her choices of sources of literature as well. She suggests that the literature regarding content representation for ChADHD is minimal, or non-existent. This calls for finding information from non-conventional sources as well.

Pykhtina et al. (2012), a group of researchers from Newcastle university, discuss their case of the use of Magic Land with two children, who in addition to emotional problems were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) suffering difficulties with memory and concentration. The two children were Mark, and Jenny of age 6 and 8 years respectively. These two children were diagnosed with ADHD and were referred for management using play therapy. In their reporting, we see authors assisting these children in using the Magic land. While they assist them, they carefully observe children as well. Pykhtina et al. (2012), based on their observations, create an overview of the problems encountered by these ChADHD. In addition, they exercise speculation and wondered on principles which help play-therapy based systems align better with the objectives of the ChADHD management. Their research study is a clear testament of the merits of observation based speculative method to draw insights.

Another interesting approach from a research methodology perspective is seen in the work done by Weisberg et al. (2014). In this study, Weisberg and his team, attempts to design assistive and tangible interfaces for ChADHD with the ability to enhance their executive functions. Across different stages of their research study, they demonstrate an inclusion of educational psychologist, psychiatrist and parents. They interview these stakeholders in order to understand the nature of challenges and their extent which ChADHD face. These stakeholders inform the researchers also about the current interventions for ChADHD, and about distinct techniques to

manage these challenges. They continue to use interviewing as an essential research method in their interactions with six parent-pairs of ChADHD. These parent-pairs had ChADHD who were more than twelve years of age. They conduct these interviews with parent-pairs at the locations of respective homes of ChADHD but not in the laboratory settings. In these interviews, the parent-pairs help researchers gather vital information on the typical daily routines of ChADHD with details of challenges that they face. In their work, we see these details playing a vital role in the planning and execution of design interventions for ChADHD. Their interaction with parent-pairs spreads across the duration of the study. In their follow-ups, one of the researchers visit ChADHD participants at their homes and present them with the paper prototypes of the proposed intervention. They ask participants to club tasks with objects using the table. This help ChADHD place the cardboard cubes in the locations where corresponding tasks will be performed the next morning. At the end of such a session, they ask both the parent-pairs and ChADHD regarding this experience of the activities undertaken. They collate a general impression of the proposed intervention, "TangiPlan". They record data of these interactive sessions as video recordings. They transcribe the recorded data and create thematic groups with the help of two independent researchers. Their research design, as we conclude here, essentially includes interviewing, feedback sessions and data analysis using thematic analysis techniques.

We find a mention of cyclic process of designing assistive technology for ChADHD in work done by Sonne et al. (2015). In their attempt to design a child activity sensing and training tool, they interact with teachers having an experience of including ChADHD in classroom. They conduct interviews of these teachers and also observe ChADHD in their classroom environment. This team interviewing experts, medical professionals, and observed children of class 2-5 in their natural seating's to gain insights, and generate design strategies.

Sonne et al. (2016), another group of researchers from Denmark, seems to have followed a similar research methodology like McKnight (2010). In their proposal of a design framework of assistive technology for ChADHD, they start by shortlisting empirical studies with a clear focus on digital assistive devices for ChADHD management. On the basis of these empirical studies, ADHD research, and related work on assistive technologies they map the existing assistive technologies and potential new research efforts to the framework concepts. The design framework comprises two parts: 1) two taxonomic dimensions: a technology dimension and an ADHD symptom dimension; and 2) A set of practical design strategies. We observe that unlike

McKnight (2010), Sonne et al. (2016) limit their search of relevant studies across peer-reviewed academic databases only.

Schuck et al. (2016) conducted a pilot study to evaluate the utility of a web-based application (iSelfControl) designed to support control classroom behaviour. They piloted this application in the classroom of grade five, consisting of 12 Male children between the age of 9-11 years over a period of six weeks. Here the authors collected the data from all the children along with their classroom teacher. The data collection began on the first day of school instruction in the autumn and analyses were conducted with only paired dyadic observations. In which the teacher recorded the student's points earned for each "center" (30 minute period of the token economy) and the corresponding student also recorded his perception of his points earned. For every 30 minute period ("center"), students earned points for demonstrating adaptive behaviors key to school success including: 'Following Directions', 'Following Rules', 'Staying on Task', and 'Getting Along' with others. Demonstrating maladaptive behaviors reduced the number of points a student earned each center. The point system is part of the school program, where the earning of points and subtraction of points for behavior are clearly taught to children. Data was only included for analysis when each dyad (teacher and student) entered concurrent ratings during the same "center point check" or period of time, resulting in a total of 13 days of dyadic data. The software to run iSelfControl was developed as a Web application, deployed using Google App Engine, and included as its primary components a database implementation, HTML pages, and Python code. This application can run in any Web browser, and can be accessed via each individual classroom iPad privately to a secure and encrypted web-based data source. For the data analyses a multilevel modeling (MLM) analyses were used due to the hierarchical structure of the data in order to adjust for the non-independence (i.e., clustering) of repeated observations nested within the same individual, and thus, allows for the examination of interpersonal and intrapersonal differences in outcomes over time. Additionally, qualitative and quantitative data was collected anonymously from the teacher and students who used the application. This information was collected utilizing a structured consumer satisfaction survey developed specifically for the evaluation of this app in the program.

Later in the year 2018, Asiry et al. (2018) studies the impact of varying text color and background color on the attention span of ChADHD in a text reading activity. Their research design is essentially of the type empirical experimentation. The participant population consists

of twenty-one ChADHD studying in third grade. They designed the stimuli in the Arabic language with content from the third grade curriculum. In their experimentation, they vary both text color and background color across three different factors respectively. Their research design is a within group study with colour schemes (involving combinations of text color and background color) as independent variables, and attention span as the dependent variable. They record experimental data using a complex web camera along with a mouse tracking system. They estimate the attentions span of the ChADHD using the collected data.

Tavakoulnia et al. (2019) in 2019 present a poster to design wearable assistive technology for ChADHD. In this study they included teachers, staff, and ChADHD of age ten to thirteen years in design workshops across two groups. In the first group children were divided into two sub-groups, and participated in four workshops. In these workshops children had an opportunity to familiarize with the smart watch, and then sketch their thoughts, and concerns on wearing smart watches. Next, they included teachers, and staff in a workshop and enquired on the potential uses of smartwatch, and their experience with ChADHD. Finally, the outcomes from both the groups were qualitatively analyses, using open, and axial coding. This, process resulted in generation of guidelines to design assistive wearable technology for ChADHD.

Another study where we see a detailed mention of the research methodology is the one carried out by Cerezo et al. (2019). Their study reveals guidelines to design tangible table tops for ChADHD. Their guidelines have two areas of focus - (a) the design of interactive tabletop interactions for ChADHD, and (b) content representation of these interactive tabletops. Their within group research design involves first carrying out a preliminary study which is followed by a secondary study. In the preliminary study, they interview educators and professionals of an association for ADHD families to generate ground truth for the creation of tangible table tops for their empirical study. We, however, do not know the exact number of these educators and ADHD professionals. In their secondary study, they recruited a total of twenty-six ChADHD belonging to an age group of 6 to 14 years. These children, arranged in a within group study design, experienced tangible activities with tangible tops. The experts in special education and the psychologists, while observing participants and the screen capture of the tangible table tops in real-time, estimate the attention span of ChADHD across activities of interest. This analysis then concludes in the form of design guidelines for tangible table top designs for ChADHD.

There is another study of relevance which we speak about now. Alqahtani et al. (2019) em-

empirically studies the impact of variation in the style of information representation on the visual processing of ChADHD. Their research design is a split-plot design involving both between-group and within-group variables. In the between-group study, the independent variable is the condition of the participants: the neurotypical group, and the group with ADHD. Whereas in the within-group, the independent variables are the information presentation methods and the difficulty of the questions. They investigate a total of three information presentation methods namely, (a) the textual method, (b) the tabular method, and (c) the graphical method. They ask their participants, not ChADHD but six males and six females with identified ADHD in the age group of 16-20, to answer three groups of questions with different levels of difficulty based on the visual information presented to them. They measure participants' performance in terms of time taken to complete the test task, and from the quality of the answers provided by the participants. They also collect subjective data involving satisfaction and preference ratings through a post-test questionnaire. Note that they use a Tobii X2 60 system to study participants' eye movement to better understand the visual scanning patterns while interacting with different information representations.

In case of study by Feket and Lucero, they test a diversity for design (D4D) framework across two parts (a) engaging three experts through interviews, and (b) co-design activities with four male ChADHD of age seven to ten years Fekete and Lucero (2019). In the interview sessions one of the interviewees is the chief pediatrician at ADHD Ambulance at Bethesda Hospital in Budapest, with 20 years of experience. The other interviewee is a clinical child psychologist, general neuro-psychologist, and relaxation therapist with more than 10 years of experience. Based on the two expert interviews, further elements were added in the adapted D4D framework, so as to refine strategies to support participation in follow-up workshops. A practice-informed version was developed by testing the framework during three co-design workshops. Three experts (i.e., two psychologists and a social worker) helped to plan and provide feedback on the first workshop program draft. Next, three facilitators with diverse background (i.e., design, psychology, and social care) conducted the co-design sessions. The latter had experience in mentoring children with ADHD, and had ADHD himself. Before the workshops, the facilitators discussed the background of the study, and the workshops were rehearsed in advance. After the workshops, the final step was to qualitatively analyze the observations, and audio recordings. To further develop the practice-informed D4D, the three facilitators reflected on the design practice and the observed behaviors of the children, and comparatively analyzed

features of the theory-informed version based on what was anticipated regarding engagement during the three workshops.

A research group from US Cibrian et al. (2022) present a more of position paper which emphasise on the interdisciplinary approach of not only including experts in special education, caregivers, and children in a intervention design research, but also include medical experts, psychologist, and other medical practitioners. These suggestions guide us firm our understanding on involving stakeholders of all the domain, and not limiting to the experts in special education in the initial research stages. This concept closely compliments the learning's presented by Fekete and Lucero (2019) of following a co-design experimental approach for designing, and testing of guidelines, and frameworks. We believe that having a co-design approach is an essential part while designing, and developing interventions for ChADHD. Further, she emphasises on the importance of co-design approach and states that literature searches, publication standards, and dissemination norms must allow human computer interaction researchers to learn more about clinical theory and clinicians and clinical researchers' practices to engage with and appreciate iterative design approaches of human computer interaction. The work carried out in this section helps us to understand, learn, and critically compliment the works of different researchers within the domain of our research. This insights prove to be very useful to design our methodology for this research work. The next section presents our novel, and relevant methodology based upon our learning from past studies.

### **2.3.1 Key Inferences**

- In case of designing interventions and identifying design guidelines for ChADHD, where there is a scarcity of literature on the representation and related aspects, the literature review method still stands highly relevant. The work reported by McKnight and Sonne et al. (McKnight (2010); Sonne et al. (2016)) are strong exhibits of this approach. One may even complement a scarcity in peer-reviewed literature (McKnight (2010)) by looking at alternate sources of relevant knowledge. McKnight (2010) encourages, however without specifying the exact sources, researchers to explore possible sources of knowledge other than peer-reviewed databases e.g. ACM portal, Science Direct, and IEEE Explore. There are advantages of this approach of establishing the state-of-art as it doesn't restrict the

search periphery to a limited set of knowledge. In addition, there lies a possibility of finding missing themes of research relevance within the area.

- In case of studies aiming at addressing research issues with ChADHD, the research methodology may essentially include key stakeholders, other than ChADHD themselves across relevant stages. These include experts in special education, clinical psychologists, and perhaps even caregivers of ChADHD. ChADHD is a population with special needs. Researcher's intervention through direct interactions with ChADHD may contaminate the research design, especially during the stages of establishment of ground truth, intervention design and data collection. It may even have larger implications for the ChADHD management when experts in special education are not included. All the studies (Cerezo et al. (2019); Alqahtani et al. (2019); Asiry et al. (2018); Sonne et al. (2015)), reported a systematic way of engaging the experts in special education, psychologist and perhaps the caregivers of ChADHD.
- Further, it is beneficial from a research perspective if the engagement of the stakeholders along with medical practitioners is extended along a larger part of the research process. Typically such an engagement is limited to enquiry and validation of the adopted guidelines only. If adopted in an extended manner, the stakeholders and medical practitioners can be engaged in the design and development phase of such guidelines as well. Such engagement will help to eliminate the chances of errors in the guidelines during the design phase. It will also help to ensure a full proof identification and development of the design guidelines (Fekete and Lucero (2019); Cibrian et al. (2020)). Further the engagement of the medical practitioners will ensure the prevention of negative impact on ChADHD and medical care when needed during the establishment phases of the guidelines.
- Validation, beyond mere identification of guidelines for ChADHD, is coming across as an essential and not just a necessary condition. The peers, with stakes in any such research, will benefit immensely when guidelines are not only identified but also tested (Schuck et al. (2016); Weisberg et al. (2014); Alqahtani et al. (2019)).

The adoption of the research methodology from the domain of design will be helpful in identifying and testing the guidelines with the children community. But, in case of this research study the target population belong in the category of children with special needs. In such cases it is

important to also include the rigor of researching in the field of medical and behavioural science. Thus, in the next section researcher reviews the methods used to develop behavioural interventions for ChADHD. Here, researcher don't consider the design methods less relevant, however ensures on not missing the critical or unseen methodological aspects from the behavioural sciences. The next section 2.4 reviews the methods from the domain of behavioural interventions for ChADHD.

## **2.4 Research Methodologies for Behavioral Modifications**

Power et al. (2012) evaluated the effectiveness of a family-school intervention, referred to as Family-School Success (FSS), designed to improve the family and educational functioning of students in grades 2 through 6 who meet criteria for ADHD combined and inattentive types. Study was conducted through an ADHD center within a pediatric hospital located in a large metropolitan area in the Northeast section of the U.S. Children meeting DSM-IV criteria for a psychotic disorder, bipolar disorder, chronic tic disorder or tourette's disorder, anxiety or mood disorder serious enough to warrant separate treatment, history of major neurological illness, and history of suicidal or homicidal behavior or ideation were excluded. Furthermore, children were excluded if they were currently receiving psychotropic medications, and their parents chose not to undergo a new medication trial as part of the study. Children with learning disabilities (as assessed using standardized tests administered for this study or as reported by school multi-disciplinary evaluation teams), disruptive disorders (oppositional defiant disorder and conduct disorder), and internalizing disorders (anxiety and mood disorders, with the exception of bipolar disorder) were included. Potential subjects for the study were identified in two ways: (a) parent-initiated referrals from the clinic within the hospital's ADHD center; and (b) referrals from school and community providers (e.g., primary care and mental health professionals). FSS was provided over the course of 12 weekly sessions, which included 6 group sessions, 4 individualized family sessions, and 2 school-based consultations. Families participating in the study were given the choice of placing their children on medication; 43% of children were on medication at the time of random assignment. FSS provides intervention using three formats: (a) parent group meetings (6 sessions) held simultaneously with separate child group sessions; (b) individualized family therapy (4 sessions), including the parents and child; and (c) family-school consultations

(2 sessions) held at the school, including parents and teachers. While parents attend group sessions, their children participate in a group designed to introduce them to the strategies being taught to their parents. Children (n=199) were randomly assigned to FSS or a comparison group controlling for non-specific treatment effects. Outcomes were assessed at post intervention and 3-month follow-up. During this study one clinician was assigned to work with each cohort of parents. This clinician conducted parent group sessions and had responsibility for working with families in individualized family sessions and school-based sessions. In addition, three clinical assistants (graduate students in applied psychology) were assigned to work with each child group to ensure that children's behavior was managed appropriately and safely during program sessions. Sessions were held on a weekly basis. The initial session lasted 3 hours. Subsequent group sessions were 90 minutes in length. Individualized family sessions lasted 60 minutes. Each school session was approximately 45 minutes in duration. Two phone conferences between the clinician and the teacher (approximately 10 minutes each after sessions 5 and 7) were conducted to monitor the child's progress and to refine interventions, if needed. The Treatment Acceptability Questionnaire (TAQ), an 8-item measure, was used to evaluate treatment acceptability from parents' perspectives. Parental self-efficacy was assessed using a 10-item version of the Parent as Educator Scale (PES). The Homework Problem Checklist was used to assess parent perceptions of homework performance. The Parent-Child Relationship Questionnaire (PCRQ) assessed parent perceptions of the parent-child relationship. A linear mixed-effects regression model was utilized to analyze outcomes at post intervention and follow-up. The analyses were based on an intent-to-treat approach, whereby participants were analyzed as a function of the treatment group to which they were assigned and medication status at baseline. The amount of missing data was relatively low; 95% of cases were missing two units of data or less on outcome measures at baseline and post intervention.

Abikoff et al. (2013) of New York University Langone Medical Center, and Duke University Medical Center compared the efficacy of two behavioral interventions to ameliorate organization, time management and planning (OTMP) difficulties for 180 numbers of 3rd–5th grade of 8-11 year old male and female children with ADHD. The IQ of the selected children had to be greater than 85, and tested for ADHD all type on a revised conners parent, and teaching rating scale. Recruitment of these specific children relied on referrals from schools, community resources (clinics, physicians, agencies), parent mailings, and newspaper ads. Medicated children who failed to meet ADHD screening criteria had a one-week washout to confirm

ADHD status off medication. Further, they also excluded children who attended an all-day special education classroom; having an individualized educational plan or paraprofessional aide to help specifically with organization; diagnosis of pervasive developmental disorders, psychosis, bipolar disorder, post traumatic syndrome disorder, or any other condition judged to contra-indicate participation; or currently receiving behavioral treatment for ADHD. Children with diagnoses of conduct disorder, oppositional defiant disorder, anxiety or mood disorders were not excluded. To begin with in a 3-group parallel design, stratified for site, and baseline medication status, children were randomly assigned to: (1) skills-based treatment (OST), (2) Parents and Teachers Helping Kids Organize (PATHKO), or (3) wait-list control (WL), in a ratio of 2:2:1. Outcome data were collected between March 2007 and June 2010. All children were assessed at baseline, post treatment and one-month after treatment had ended (Year 1, Month 1 [referred to as Y1M1]), while still with the same class, and with same teacher. OST and PATHKO participants had additional follow-up assessments one-month (Year 2, Month 1 [Y2M1]) and four-months into the next school year (Year 2, Month 4 [Y2M4]), with teachers blind to the treatment the children had received. Outcome measures were obtained at all assessment points, except for academic functioning and attitude to school measures, which were not assessed at Y1M1. Changes in medication status were assessed every two weeks during treatment and the waiting period. Changes in services were inquired about at post treatment. Measures assessed were organizational functioning and other key domains including academic functioning, homework behaviors, family functioning, and attitudes to school and teachers.

Pfiffner et al. (2018) developed a collaborative life skill program which is a school-home intervention for students with ChADHD. They used a 2-level (students, schools) cluster randomized controlled design accounted for treatment (CLS) or Business as Usual (BAU) within level 2 (schools). Entry into the study was staggered into two cohorts (Fall and Winter) during each of 3 school years. Schools within cohorts ( $n = 3-5$  schools) were randomized into CLS ( $n = 12$ ) and BAU ( $n = 11$ ), with randomization of schools stratified based on the percentage of students receiving free or reduced lunch. Participants included 135 children (grades 2 through 5, mean age = 8.4 years, 71% boys) in general education classrooms at participating schools in an urban public school district. Approximately 6 students participated at each school ( $N = 135$ , grade range = 2–5). Measures were completed at baseline, after treatment, and follow-up during the next school year. Eligibility criteria were: (1) elevated ratings of ADHD symptoms, (2) cross-situational impairment (home and school), (3) full scale intelligence quo-

tient (FSIQ) equivalent of  $> 79$ , (4) a caretaker available to participate in treatment, and (5) a primary classroom teacher who agreed to participate in the classroom component. Children taking medication were eligible as long as their regimens were stable. All 72 CLS cases and 59 of 62 BAU cases who had completed post-treatment measures completed follow-up measures. CLS included three manualized components delivered by the school mental health providers (SMHP) at their school site during the 10-12 week core intervention period and a subsequent maintenance period into the following school year. Components were integrated via joint sessions with teachers, parents, and children and establishment of an active partnership and shared goals and responsibilities for all parties. Measures were completed at baseline, post-treatment, and follow-up. Follow-up assessments occurred in late fall of the following school year (immediately after the end of the maintenance period) for all cohorts (Fall cohorts: 8-months after core treatment, Spring cohorts: 5-months after core treatment).

Huang et al. (2021) reported a long-term effectiveness of behavioural interventions in preschool children with ADHD in Southeast China following a randomized control trial. At the start of the study, children were randomly assigned to the conventional group or the behavioural group according to the medical card number using SPSS software. The conventional group was subjected to biofeedback and distributed a health education booklet, while the behavioural group received behavioural intervention based on the conventional group. The intervention lasted for one year. Children were followed up for six months after the end of the intervention. If the children or their parents declined to cooperate during the treatment, they were dropped from the study. The physicians evaluated the children at the three time points: before the start of the intervention (T1), at the end of the one-year intervention (T2) and 6 months after completion of the program (T3). Preschoolers with ADHD were recruited from January 2018 to May 2019 to participate in the behavioural intervention study at Fujian Maternity and Child Health Hospital in Southeast China. Inclusion criteria: Children with ADHD who were diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5) by at least two qualified developmental behavioural paediatric psychiatrists. None of the children had received treatment via medication or behavioural intervention. Exclusion criteria: (a) full-scale IQ  $< 75$ , (b) history of seizures and/or taking medication to prevent seizures, (c) childhood history or concurrent diagnosis with pervasive developmental disorder, schizophrenia or other psychotic disorder, sexual disorder, organic mental disorder or eating disorder, (d) lack of functional impairment, and (e) placement in special education classrooms. An electroencephalograph or

EEG biofeedback system was used to suppress the 4-8 Hz theta wave and strengthen the 12-15 Hz sensorimotor rhythm. Collecting the brain waves of children enabled real-time feedback with a variety of images. Each treatment consisted of five stages, of which the first stage was basic state detection and training target setting. The remaining four stages were feedback therapy stages with 20-30 times/course of treatment, for three courses of treatment. Continuous variables were reported as the mean $\pm$ SD. Categorical variables were shown as numbers (percentages) to describe baseline characteristics. Linear mixed-effects models (LMMs) were used to test changes in outcomes over time, and age was used as a moderating factor. The subjects who quieted the experiment were analysed for baseline data. If applicable, all hypotheses tests were two-tailed.  $P < 0.05$  indicated statistical significance. Statistical analyses were done using SPSS 26.0.

### 2.4.1 Key Inferences

- The first takeaway we learn from the above studies is the process of identifying, and recruiting ChADHD (Power et al. (2012); Abikoff et al. (2013); Huang et al. (2021)). Each of the study emphasise on a very specific behavioural intervention for the management of ChADHD. Each study had a distinct intervention, but the techniques of identifying, recruiting, and managing stakeholders, and ChADHD was nearly same. In the above studies the identification were done by collaborating with a hospital, center, or school for the children with special needs. The studies suggested to include the children having an IQ greater than 75, which is above normal. Further, we observe that children suffering from mental instability, seizures, psychotic disorder, or such conditions were excluded. However, ChADHD with comorbid conditions such as learning disabilities, Autism, Opposition defiant disorder, anxiety, and mood disorder were not excluded. The children were also re-validated for ADHD type, and IQ level to verify the conditions of the recruiting children (Abikoff et al. (2013); Huang et al. (2021)). Authors didn't mention to stop the ongoing medications of these children, thus we assume that children had to continue their medications to prevent uncertain impacts of stopping the medications. In each of the case recruitment of children was through a formal consent, and children had the right to stop or quit the study if they felt uncomfortable, or unwell. Thus, we learn

a process of systematic identification, and on boarding of a venerable community like ChADHD where child care, and assistance is the primary concern.

- The second takeaway we acquire is the process of deploying, and testing the intervention for a longer time span of six months, to an year to test the interventions impact. Researchers have deployed the intervention for a time span of ten weeks to an year. From these studies we gain a knowledge insight that the impact of an intervention can be significantly observed in a long term, a span of six months and more, test deployment (Huang et al. (2021); Abikoff et al. (2013)).
- While engaging the children to use a behavioural intervention it is necessary to follow a certain set of research directions and strategies. We state these directions, strategies based upon the personal observations and learning from the above studies. These include (a) engagement of the children to use the intervention in real-time, and in their natural seating's, rather than in a lab environment, (b) testing under the supervision of medical practitioner, or a remedial expert, (c) training parents, and caregivers for the intervention use before the introduction of the behavioural intervention (Huang et al. (2021); Pfiffner et al. (2018); Abikoff et al. (2013)).
- We understand that to develop an intervention, it is important to conduct a within group study. This will constitute a formative evaluation, one that is suggested by Cibrian et al. (2020), to help with the progressive development of the intervention. However, once the intervention has been developed and is ready for a test of application, use of summative evaluations is recommended. For example, in the studies we have seen (Power et al. (2012); Pfiffner et al. (2018)), a between group study mimicing a randomised control trial or RCT is being done to measure the efficacy and effectiveness of the proposed intervention for ChADHD. This will help us in comparing the impact of an intervention with respect to an existing process or method. This can assist the researchers to strongly place their findings, and improve their intervention further wherever needed.

## 2.5 Methodology for Current Research

In the last two sections, we have seen two different streams of methodologies - one that focuses on digital content representation and the other with focus on behavioral modifications. Each of these methodologies have a specific grounding with strong positives that can be considered further. In specific, we note a strong case for using co-design methods which warrant involvement of diverse stakeholders across the entire duration of the development of the intervention. Co-design lends a valid emphasis on formative evaluations. While this is something that seems essential while devising methodology for a research like ours, we see a great need to borrow the rigor of testing deployments for longer periods of time - a quality that lies explicitly with methodologies focusing on behavioral interventions. This lends credibility to the research claims as it can be considered a form of summative evaluation spread across a longer duration of time with the between-group test participants. This research attempts to combine these two best-halves of methodologies with focus on content representation and behavioral modifications.

Cibrian et al. (2022) recommends following an interdisciplinary approach by engaging different stakeholders, not limiting to remedial expert, ChADHD, caregivers, and designers but also medical experts through a co-design approach. Co-design with ChADHD and experts leads to better and more inclusive design. Further she states that in their research, they are conducting a formative evaluation with a small number of participants, using a more human computer interaction approach. However, they also use standardized assessments for pre and post-evaluations in keeping with clinical research standards and with the aim of moving toward an randomized clinical trials to examine efficacy. Next, she suggests that literature searches, publication standards, and dissemination norms must allow human computer interaction researchers to learn more about clinical theory and clinicians and clinical researchers' practices to engage with and appreciate iterative design approaches of human computer interaction. Here, Cibrian et al. (2022) encourages researchers to follow the clinical methods along with the design research with a focus on developing innovative technologies that are stable enough to withstand clinical quality evaluations. We consider this suggestion, and look into further possibilities bringing medical research methods along with the design research methods as identified in the previous sections.

We identify the rigor from the medical perspective to be missing in the content, and intervention design methods. On a systematic review of literature we identify NIH stage model as a proposed method to develop the behavioural interventions. This method is strongly recommended by the National Institute of Health (National Institute on Aging (NIA) (2018)). Further, Onken et al. (2014); Onken (2019) enlightens the readers to understand the use and impact of NIHSM. If we look into aims, and objectives of our research study one can notice that the guideline identification is potentially for the behavioural modification of ChADHD, with the enhancement of the attention span. Due to this specific reason, we plan to adopt the NIHSM as our research method. We adopt the NIH stage model (Onken (2022); National Institute on Aging (NIA) (2018)) combined with the co-design process (Thabrew et al. (2018)) for this research study. We identify recommendations, and implications of NIHSM and co-design from the literature. Using, these insights we split our study across the NIHSM stages, and involve experts in special educational needs, designers, ChADHD, and caregivers at different stages of the study. In the adoption stage of NIHSM stage 0, we carry both secondary, and primary research to identify the existing, and potential VDGs for the content representation of digital platforms, and devices used by ChADHD. Here, experts in special educational needs, and designers were involved in the identification, and validation phase of VDGs. We incorporated the principles of co-design while engaging the stakeholders in this research study. Further on identification, in the refining phase stage 1(A), and 1(B), and validation phase stage 3 we included all the stakeholders to validated, and establish VDGs for content representation of digital platforms, and devices as detailed in the Figure 2.1.

In the stage 0 of our study we attempted to identify all the possible design guidelines for the content representation of digital platforms, and devices used by ChADHD. We adopted the same strategies as that of McKnight (2010) and Cerezo et al. (2019) of searching the relevant literature for content representation. However, on a systematic identification we understood that this identified literature needed a formal validation from the experts in special educational needs, and formal test with ChADHD as suggested by McKnight (2010) and Cerezo et al. (2019). Thus, continuing the principles of stage 0 of the NIHSM we involve experts in special educational needs, clinical psychologists, and designers to further strengthen our identification of VDGs for ChADHD. The involvement of these experts was conducted in a planned manner across distinct activities and task. We conducted interviews with remedial expert, and clinical psychologist to generate an initial set of visual design recommendations. Next we validated

with a larger set of experts in special educational needs and identified a potential set of VDGs. However, from the previous studies we understand that the need of checking the usability, and applicability of these VDGs. Thus we tested these VDGs with designers through a planned re-design task in presence of a proctor. The outcomes were in form of recommendations, suggestions, and feedback, which were later collated, and then validated with another set of experts in special educational needs through surveys to establish a set of expert validated VDGs. Though these expert validated VDGs look to be sufficient, it is very essential to refine, update, and test for effectiveness, and efficacy of the VDGs by testing them with ChADHD possibly in the real-time environment, and natural settings.



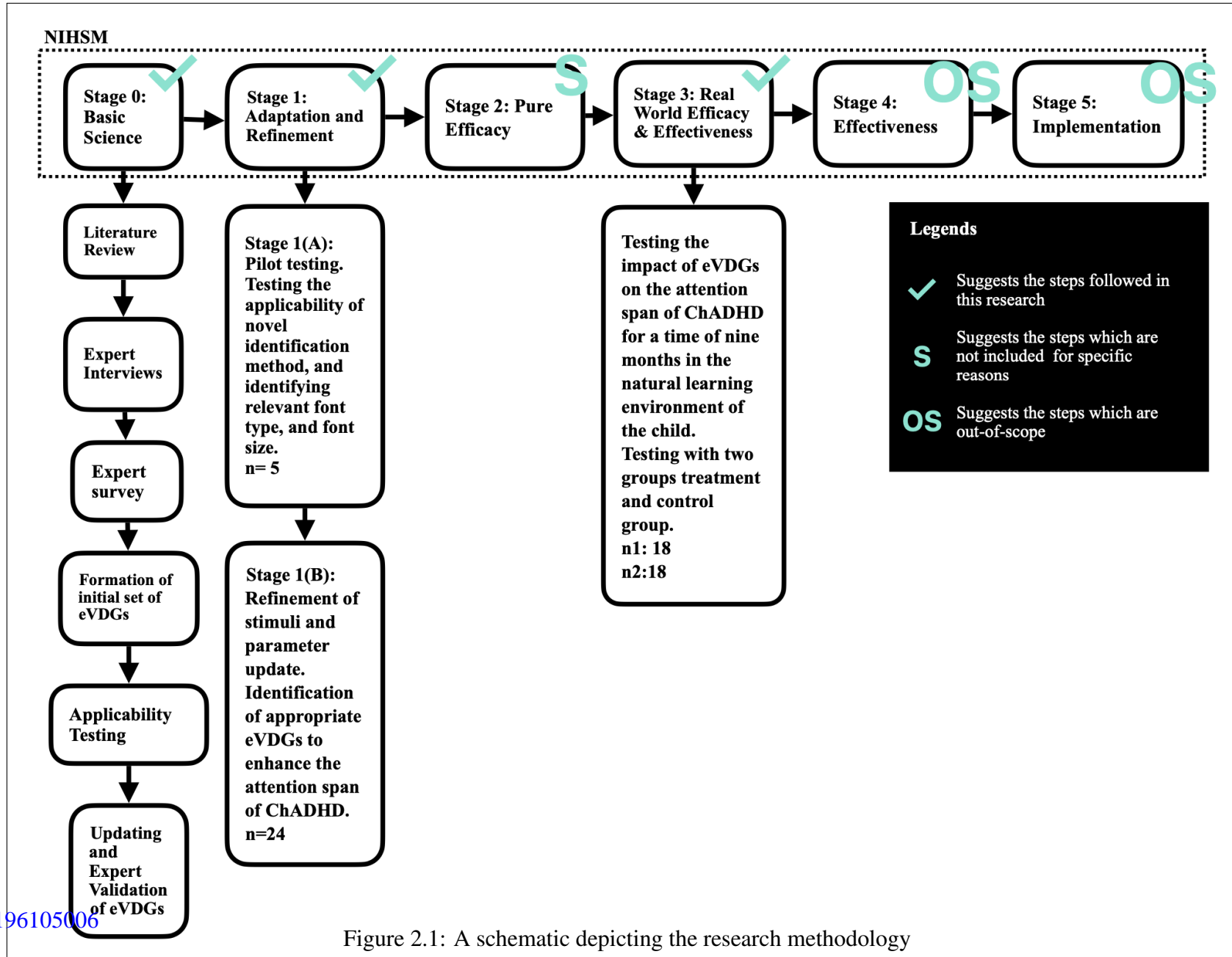


Figure 2.1: A schematic depicting the research methodology

In stage 0 we identified the expert validated VDGs however, it is necessary to refine and update the VDGs. This is achieved in stage 1.

In stage 1 of NIHSM, experts in special educational needs, designers and caregivers along with ChADHD are engaged. We divide this stage in two parts stage 1A: pilot study, and stage 1B: main study. In the pilot study we validate the applicability of the testing method adopted from Cerezo et al. (2019) of observing, and estimating the impact of the eVDGs on the attention span of ChADHD. In the next step we refine all the eVDGs by testing with ChADHD in real time following the tested and verified method in the pilot study.

Next we propose using the stage 3 of the NIHSM skipping the stage 2. The reason for this is that if the stage 1 is performed in real-time and in natural settings, researchers can skip stage 2 and start following stage 3. This statement is well presented in the NIHSM (NIH (2022)). We thus adopt the stage 3, and follow the stage protocols for longitudinal testing of nine months with ChADHD. This study is a combined efforts of experts in special educational needs, clinical psychologist, designers, caregivers, and ChADHD along with the authors under strict protocols stated in chapter 6. We restrict our study to the longitudinal testing at stage 3, because of the testing in real-time, and natural setting with ChADHD. We validate the impact of eVDGs on the attention span of ChADHD through the curriculum-based content representation on digital platforms and devices testing with ChADHD. We can also move to the stage 5, the deployment stage but that remains beyond the scope of this study. This is so as as the scope of this study is limited to the establishment of the relevant, and valid set of VDGs and not the deployment in digital devices, and platforms.

## 2.6 Chapter Summary

This chapter helps reader understand the novel methodology used in this study. The details of the research methodology are presented along with the specific and relevant reasons of adopting this methodology. The chapter also brings details of how the research methodology has been evolved in a systematic manner through a careful review of the methods used by different researchers working with ChADHD or in related domains of research interest. Further, this chapter reviews the studies from the domain of behavioural science so as to not miss the

rigour of research in behavioural sciences. The chapter concludes with the proposal of adopting NISHM in combination with the co-design approach in a novel, and effective way to determine eVDGs for digital curriculum-based content representing on digital devices and platforms used by ChADHD. In the next chapter, we present further analysis of the literature in the domain, and presents gaps which needs to be addressed.





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# Chapter 3

## Literature Review

This chapter presents the review of literature on the existing VDGs. Researcher systematically draws attention towards the existing knowledge on VDGs, and highlight the need of VDGs for the content represent of digital devices, and platforms used by ChADHD. He then showcase a theoretical framework emphasising on the importance of VDGs. Thus, he systematically, and rigorously study the literature, which assists us to present the domain knowledge from the literature to the stake holders in the next phase of our researcher.

### 3.1 Introduction

The researcher working in the area of designing assistive digital technologies for ChADHD have proposed several design recommendations, guidelines, and frameworks. He reviews these proposals to know about the existing set of design recommendations, guidelines, and frameworks. Initially, he believes to have a relevant, and sufficient knowledge about the guidelines, and frameworks to design the digital content. However, as we will soon detail, a comprehensive knowledge on the existing VDGs is either non-existential, or inadequately detailed to use.

## 3.2 Chapter Objectives

This chapter presents review of literature with focus on the following:

1. Review the literature to identify, study, analyse the existing design guidelines for representation, and designing on digital devices and platforms used by ChADHD.
2. Point out the gaps, and limitations in the existing literature on guidelines for representation, and designing on digital devices and platforms used by ChADHD.
3. Present the need of VDGs for content representation of digital devices, and platforms through a theoretical framework.

## 3.3 Method

The systematic literature review, presented in this chapter, follows a strict PRISMA methodology established in the studies Guo et al. (2019) and Beuckels et al. (2021). This involves identification, screening and analysis of the peer-reviewed data. In the process of identification, researcher identifies all the peer reviewed article focusing on guidelines, and frameworks to design digital devices, and platforms used by ChADHD. In the screening process, he shortlist the relevant articles of the identified article based on the inclusion and the exclusion criteria. In the final stage, he conduct a systematic analysis to present a detailed analysis to meet our objectives.

### 3.3.1 Identification

The protocol for the identification of relevant literature is in lines of the suggestions made by Guo et al. (2019) and Beuckels et al. (2021). The researcher incorporates two databases — Web of Science and Scopus. He selects Scopus as it is the largest multidisciplinary database of science, technology, medicine, social science, and arts and humanities, which are useful in mapping smaller and multidisciplinary research fields Feng et al. (2017); Beuckels et al. (2021).

The researcher selected Web of Science as it is considered as one of largest multidisciplinary database (Guo et al. (2019)) in the field of technology, medicine, and psychology which was relevant for our research directions. Specific and relevant keywords and their combinations were used to identify relevant articles using “title-abstract-keyword” search. First, researcher searches for relevant papers by combining the keywords “ADHD” and “technology” using the “AND” Boolean logic. Second in a new search activity, some separate strings of keywords were added including “design principles,” “design guidelines” and “design frameworks.” The specific formulas were: formula 1: “ADHD” AND “assistive technology”; formula 2: “design guidelines” OR “” OR “design frameworks” OR “design principles”. We use these keywords to locate all the relevant articles from May 2013 (since the implementation of DSM-V) to April 2022 (implementation of DSM-VTR) (American Psychiatric Association (2024)). The main reason for selecting this timeline is the update in the DSM guidelines. The DSM IV was published in 1994 post that there were not any updates in the DMS guidelines. The DSM V was published and brought into effect in 2013, the next major update took place in 2022 ie. DSM VTR. Thus, the author selects this timeline. This initial search results identification of a total of 230 articles, and he store them in RIS format. Each article included all the necessary information for subsequent analysis, such as title, abstract, author(s), keywords, year, and references.

### **3.3.2 Screening**

During the screening process the researcher skimmed the identified articles under strict inclusion and exclusion criteria. The inclusion criteria were: (a) studies focusing on children community living with ADHD, (b) articles in English language only as it is most used language in research Guo et al. (2019), (c) articles within the period 2013-2022, (d) articles focusing on designing guidelines, and frameworks for designing of digital devices, and platforms used by ChADHD. The researcher of the studies excluded studies based on (a) the language of the article was other than English, and (c) article identified as a duplicate study. After screening, the researcher identified many duplicate studies which were eliminated and a single copy was included for this study. The screening was carried out by reading the titles and the abstracts. All the articles provided a clear focus of the study through their titles and abstracts; thus, the screening process was eased. However, in case of doubt on inclusion of a study, there was a dis-

cussion among the researcher to decide the inclusion and exclusion of the study. Through this screening process we obtained 21 relevant articles for our study. Figure 3.1 shows the PRISMA flow diagram for article selection.

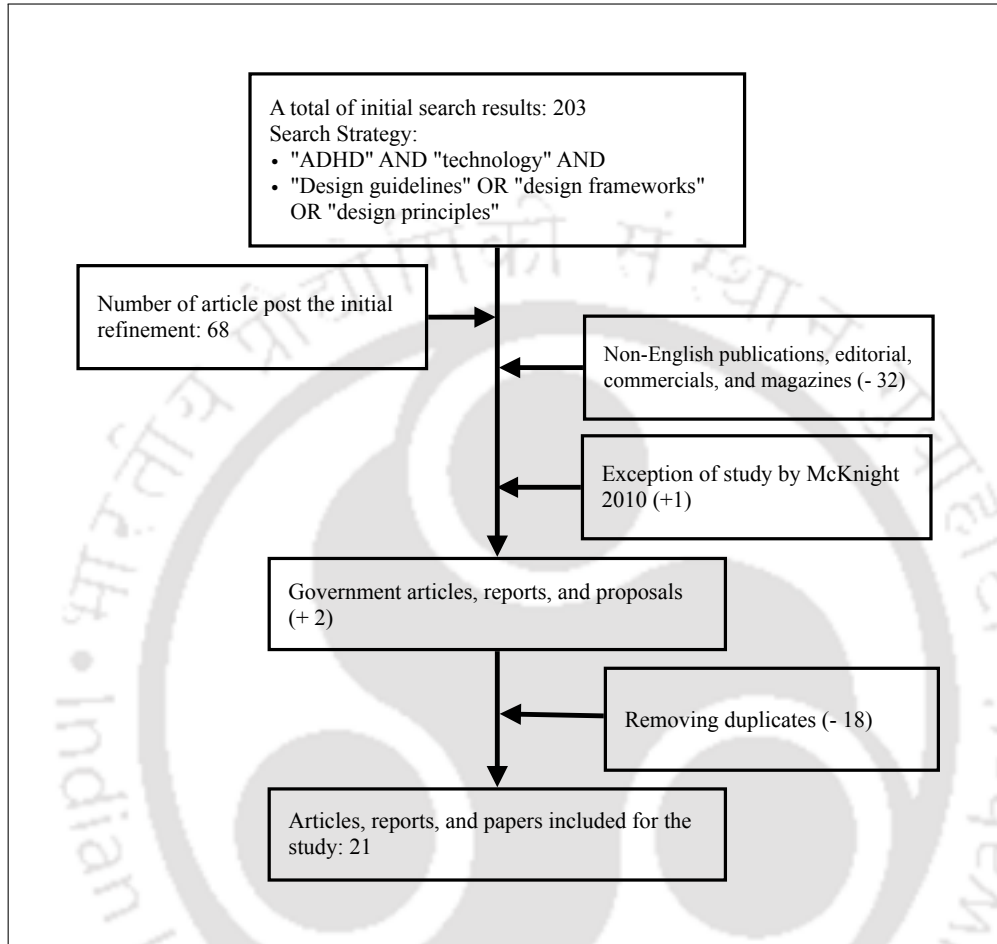


Figure 3.1: PRISMA flow diagram

### 3.3.3 Analysis

Researcher systematically reviews the shortlisted articles, and note the the details of the finding in a specific format. He generates the collated sheet of all the selected articles in a single table. He notes the title, author, year, and finding of the article. Then he segregate these studies based on the type of the method, and their finding. This helps the author to build a strong discussion on the need of identifying the relevant set of eVDGs.

### 3.4 Results and Discussion

We identify a total of 20 potential articles for the analysis phase within the time span of DSM-V and DSM-VTR. We also consider an exception of including a study published in 2010 by McKnight (2010). We make this exception because we see this study as a very relevant and important study to include in our literature. Further, this study is the first study to explicitly state the guidelines for the design of digital devices, and platforms used by ChADHD. We see a general observation that most of the shortlisted articles fall within the years of 2019-20 (see figure 3.2). From this observation we infer that researchers across the globe consider the vital need of designing digital devices and platforms for ChADHD. It also suggest the rising interest of researchers working in this research domain. Based upon the vital need and growing interest of the researchers we consider the need of establishing design guidelines to design digital devices, and platforms used by ChADHD. Thus, this systematic review helps us to study the proposals presented in the shortlisted studies and analyse the present guidelines for the designing on digital devices and platforms. We report and analyse these guidelines in the following sections.

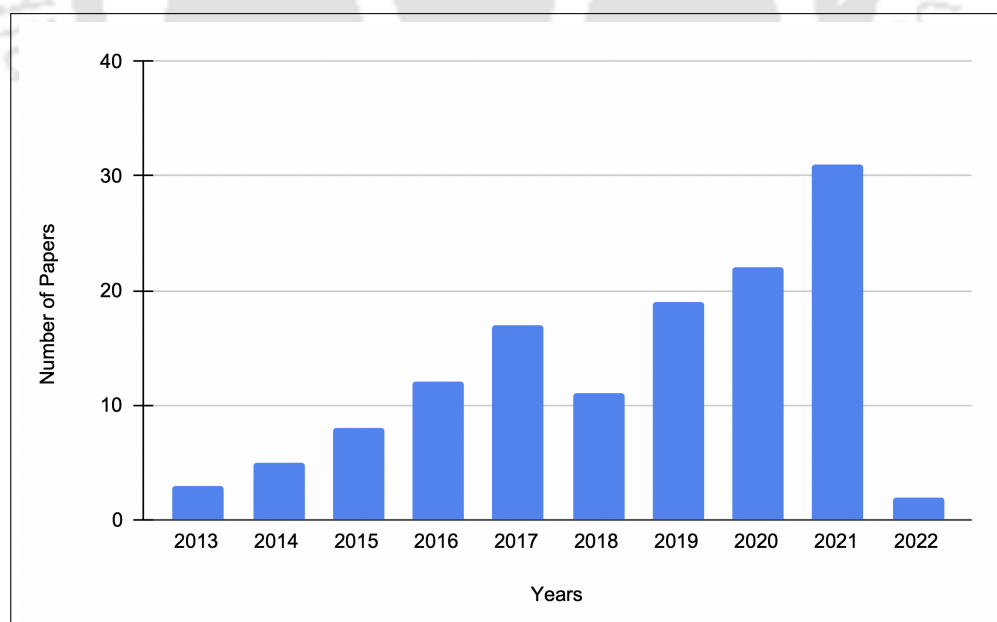


Figure 3.2: Number of studies published over the years with focus on digital devices and platforms for ChADHD

### 3.4.1 Visual Design Guidelines

As we mention about the relevance of inclusion of guidelines by McKnight (2010), her study delivers 15 relevant guidelines for the designing of devices, and platforms used by ChADHD. She presents these guidelines through a survey of literature, which are found to compare closely with usability guidelines in many cases. She state a list of potential guidelines to consider before designing a software for ChADHD. The proposed guidelines state the following:

1. Maintain a clean and clutter free screen layout. Use a minimalist design to reduce confusion and easily search items when needed.
2. Use clam background with soothing colour. Exclude the use of extra decorations and distractions. Although she list this guideline but does not specify the the detailed re[presentation.
3. Provide a high-reinforcement environment – reward good behaviour and completion of all tasks that are asked of the children, using positive language.
4. Organise items in an orderly way.
5. Distinguish important information by putting it in bold or colour. Signpost sections and group related information into panels.
6. Use large print (12-14 point) and a clear sans-serif font such as Arial.
7. Help pupils follow text by writing/highlighting alternate lines in different colours.
8. If the pupil needs to work through a series of questions, help them keep their place by using a marker.
9. Use brief and clear instructions.
10. Allow ample rest periods and exercise breaks.
11. Have a work station that is enclosed, in a soundproof environment, with few distractions around.
12. Keep technology shut away unless it's being used.

13. Keep to a routine, e.g. don't change teachers.
14. Have minimise surprises.
15. Maintain eye contact. While obviously difficult for software to achieve, this is cited as an important strategy in maintaining attention. While software could use eye-tracking techniques, or onscreen characters who look directly at the child, it may be that there are simpler methods for determining if the child's attention has wandered, e.g. detecting a long delay on input, or repeated input that is irrelevant to the task.

We look closely to these guidelines and find them relevant for design on digital devices and platforms. However, McKnight (2010) herself says that although the guidelines seem relevant they remain untested in context of software design and much more research would be needed in order to apply her recommendations on designing for ChADHD. Thus, we make a note of this statement of her, and look for other studies that focus on presenting guidelines, recommendations, and frameworks for designing of different devices and platforms used by ChADHD.

Weisberg et al. (2014) proposes a set of design guidelines to design assistive technology to enhance the executive functions of ChADHD by working with field experts, and ChADHD. Based upon their empirical finding they formulated preliminary design principles for designing of assistive devices to enhance the executive functions. They state the assistive technology design for enhancement of executive function should have following points: (1) Facilitate organization, time management and planning, (2) involve caregivers in the process, but strive to reduce conflict with experts and other stakeholders, (3) implement intervention techniques suggested by experts, (4) avoid distraction by mobile phones, (5) avoid external intrusion during the use. Further, these limit to the testing of the paper prototype and need an in depth study. However, we can consider these relevant in the case of designing the assistive devices.

Zuckerman et al. (2015) states on designing and testing of the KIP3: robotic companion. We identify this intervention as an assistive aid to assist children with ADHD to regain their attention on a particular task or activity. Authors state to observe a positive impact on regaining the attention spans of ChADHD. They further state that the guidelines for designing of this robot are adopted from two sources namely Barkley's principles, and empathy objects guidelines without a detailed mention of the procedure and steps to design the robot. Further, the guidelines adopted can not be really considered for applicable for design if similar assistive devices until the detailed investigation through future studies. Although the study limits in

presenting design guidelines we look towards this study suggesting a potential research gap of identifying design guidelines focusing the ChADHD community. In 2015 another researcher Bul et al. (2015) develops a game named "Plan-it-commander," to promote behavioral learning and promotes strategy use in domains of daily life functioning such as time management, planning/organizing, and prosocial skills. They state that the game content design and approach is based on psychological principles from the Self-Regulation Model, Social Cognitive Theory, and Learning Theory. The game is designed with challenges, task, and mini-games, where the child has to complete the stages using logic, planning, and management skills. The study focuses more from the perspective of designing the user flow and interaction of games used by ChADHD. This study is focused on development of serious games and designing to enhance the interactions of such games.

In 2016 Sonne et al. (2016) proposed a framework to design assistive technology for ChADHD. This framework will assist to identify new opportunities for novel research on technologies for the ADHD domain by both advancing existing excellent research as well as establishing completely new technologies. It further states strategies for human computer interaction research within the domain of designing for ChADHD. These include provide structure to facilitate activities, minimize distractions, encourage praise and reward, integrate and report standardized ADHD measures. The frame work presents relevant insights in designing assistive technologies for ChADHD. Researchers Colombo et al. (2017); Boyd et al. (2019); Tavakoulnia et al. (2019); Cerezo et al. (2019) propose similar directions of designing the assistive technology, engaging interfaces and serious games to enhance the engagement and attention span of ChADHD. The finding of these researchers are based upon the similar design principles as mentioned in the detailed work of previous researchers. We move further to review studies emphasising on the representation design of the digital devices, and interfaces.

Ben-Yehudah and Brann (2019) studies finds that the digitally displayed text is more challenging for students with ADHD than their peers, particularly when the conditions of the comprehension task favor good self regulation of learning skills. They suggest to investigate ways to improve self-monitoring during technology-enhanced learning, and to explore interventions that will enable students with ADHD to benefit from the affordance of learning with technologies. We infer the research need on a very basic representation element the font. The identification of relevant font and font representation can help in effective engagement and enhancement in attention span of ChADHD.

We find a supporting study by Asiry et al. (2018) who study the impact of text color on ChADHD. They identify that highlighting the text had a higher impact on the attention span of ChADHD. This assures that the visual representation significantly impacts the attention span of ChADHD. To further strengthen our research claim on the impact of visual representation, we pose the study by Alqahtani et al. (2019). They investigate how ADHD affects visual information processing under three information presentation methods (textual, graphical, and tabular). They identify that the graphical representation is the preferred way of content representation over the textual and graphical method. We pose that the visual representations have a significant impact on the attention of ChADHD. Jena and Devi (2020) states that the cartoon-based e-learning can be applicable for the formal learning during the time like COVID or when on vacations. The cartoon based e-content instruction strengthens the performance of learning in Environmental Studies among students with ADHD irrespective of their gender, personality, intelligence, socioeconomic status. Further, the use of cartoons can enhance the cognitive strength of children. Thus, from this set of studies we can infer that visual representation of the content in a systematic and planned way can help in enhancement of the attention span of ChADHD. Thus, a set of well established visual design guidelines for the content representation of digital platforms, and devices can help to enhance the engagement and effectiveness on the attention span of ChADHD. Post the review of these studies we identify a limited information on the systematic designing of digital devices, and platforms for ChADHD, especially from the perspective of visual design.

### **3.4.2 Gaps and Limitations**

In the above section 3.4.1 we explain the details of existing guidelines for the design of digital tools, devices, and platforms used by ChADHD. We identify that several researchers have worked to present guidelines, and frameworks of designing effective digital tools, devices, and platforms for ChADHD. However, if we take a closer look of these guidelines we identify two major gaps and limitations: (a) there is need to validate the guidelines through formal testing and validation with experts and ChADHD, (b) limited applicability to develop a specific tool, device, or a platform. The study by McKnight (2010) present a detailed information on designing a software considering the aspect of representation as well as user flow. However,

the study needs an in depth research before using these guidelines as suggested by the author herself. Further, in the case of other researchers, they propose guidelines, frameworks and recommendations to design effective assistive tools, and serious game. These researchers focus on enhancing the engagement and interaction of ChADHD with their respective proposed tools. These researchers limit to discuss on the representation style and importance of visual design guidelines.

We do identify a limited studies emphasising on the aspects of content representation and impact of visual elements like font and cartoon based content representation. These studies evaluate the impact of a very specific element on the attention and enhancement of ChADHD. When we look at a composition we can identify a large set of visual element impacting the representation of the content. If a single visual element like font representation has a significant impact on the attention span of ChADHD, then certainly other element like pictures, background, color schemes, and screen layout will have an impact on the attention span of ChADHD. However, a validate set of visual design guidelines directing the use of all these elements remain absent. The closest set of VDGs that we identify is the Government of India guidelines for e-content representation for children living with Autism by Jayanthi Narayan et al. (2021). Here, they state the use of different elements for the consent representation but for a commonly observed comorbid condition with ADHD which is Autism. We can adopt these guidelines, however it would just mean the adoption of the guidelines without a formal validation. Thus, we infer a need of identifying, and validating a set of visual design element to establish visual design guidelines for the content representation of digital devices, and platforms used by ChADHD.

### **3.4.3 Key Inferences**

We infer the following:

- The existing guidelines for the designing of assistive digital tools, devices and platforms have a limited applicability. These are limited to design a specific game, interface, or an application, majorly focusing on the user flow and interactions.
- There is a need establishing relevant and valid set of eVDGs for the content representation on digital devices and platforms used by ChADHD. The present guidelines are either in

need of formal validation or pose the impact of only a single visual design element on ChADHD.

- The absence of valid set of eVDGs creates a research gaps of identifying and validating elements of visual design used for content representation to establish a cumulative set of eVDGs for the content representation of digital devices, and platforms used by ChADHD.

### 3.5 Theoretical Background

The current research has few very specific underlying constructs. These are *content representation, content design, behavioral modifications in children, especially in ChADHD, the age of the children to receive interventions with respect to the cognitive processes that forms basis of learning and acquisition of knowledge in children, and conditions of learning*. Also lying at the base of the current research are the relationships between these constructs. For example, one may wonder why do we hypothesize that an appropriate design of curriculum-based digital content for ChADHD would have a relevant impact. Such a hypothesis would be an indication of presence of relationships between these constructs. These constructs and their relations with each others along with context conditions are informed essentially by three theories in the current research. Two out of these three theories, the Piaget's cognitive development theory and Dewey's educational psychology, belong to the domain of child psychology and development. Whereas, the third one, the Garret's five planes of user experience, is from the domain of visual design and Human-computer interaction.

#### 3.5.1 Piaget's Cognitive Development Theory

Children with and without any disability or disorder attain cognitive growth in a similar but specific pattern. However, children with neurological disorders like ADHD need proper treatment through extra attention, and care for a healthy cognitive growth. If ChADHD receive a proper treatment at a young age then their cognitive growth is not hampered. But, the suggestion of treating ChADHD at a young age remains very unclear, and a right span of age needs to

be known along with a specific treatment type. To know the exact age span for the treatment of ChADHD we refer to an interesting theory put forth by Piaget. According to Jean Piaget's theory of cognitive development the intelligence of children change as they grow cognitively (Piaget (2000); McLeod (2018)).

She says that a child's cognitive development is not just about acquiring knowledge, but the child has to develop or construct a mental model of the world. Further, Piaget states that there are four stages of development of any child: (a) Sensorimotor stage: birth to 2 years; (b) Pre-operational stage: 2 to 7 years; (c) Concrete operational stage: 7 to 11 years; (d) Formal operation stage: 12 and up. According to this theory every child has to go through all these stages, in the same order but at a different rate. We understand even ChADHD have to go through these four stages of development. We suppose that the chances are high of ChADHD going through stages of development in the same ages as said by Piaget, because commonly ChADHD have an average or higher than average IQ. Thus, we consider ChADHD to grow according the Piaget's cognitive development theory. According to this theory the first stage (pre-operational stage) is where the child develops his/her sensory organs like touch, smell, eating, talking, and walking. In this stage of development there is a limited formal or informal teaching process for the children, children generally grow naturally observing the things, and people around them. The second stage (ore-operational stage) is where the children develop their gross motor skills, and begin to learn the fine motor skill from parents, caregivers, and people around. In this stage the neurological development of the child begins. We consider this stage as an important stage to identify the potential disabilities, and disorders in children but not for the treatment. We consider this stage only for the identification of disability, and disorder because in this stage the child's neurological growth begins, and identification of disability, and disorder prior to this stage is not possible.

The third stage of Piaget's theory ie. Concrete operational stage (7-11 years of age) is the most important stage of the child's development. We say this stage as the most important stage because the major characteristic changes, and development takes place in this stage. At the age of 7 children don't have more information about the world than they had at 2; but there is a fundamental change in how children see, and think about the world at the age of 7. Children in this stage generate the understanding of logic, they start obtaining formal education in schools, and institutes. In this stage of development the child starts the formal interaction with the ed-

ucation, and the system. Though the identification of disability may start in the previous stage of cognitive development, it is in this stage that the parents, teachers, and caregivers identify if the child suffers from any disorder or disability. The possible identification of ADHD in the third stage of cognitive development is also very true in case of ChADHD. It is necessary to manage ChADHD in the early age as possible on a systematic identification (Mayo Clinic Staff (2019)). Thus, the intervention deployment, and management of ChADHD should start in the age group of 7-11 years. However, in certain cases like early, or late identification of ADHD in children the treatment may vary by a few years. Thus, from this theory we infer that the cognitive development age is the suitable for deployment of any intervention. However, due to the special condition, and state of mind of ChADHD we suggest to consider an age group of 5-14 years. Researchers, working in this domain have also included ChADHD within the age group of 5-14 years.

### **3.5.2 Dewey's Educational Philosophy**

Traditionally, children with special needs, and care encounter exclusion, discrimination and segregation from the standard educational setup. These children are put in special schools, and remedial centers. In some cases, these children are even denied access to any education. Globally over 90% of children with disabilities don't go to schools. UNICEF-appraises that only 1 in 50 children receives a formal education. The portion of the significant reasons for exclusion are: improperly planned educational programs, wrong instructing learning material, blocked off structures, and instructors, lacking important abilities to oblige children having differing scope of requirements. Today inclusive education, or inclusion in education is a conceptual approach aimed at achieving quality education by making changes to accommodate all learners regardless of their physical, social or psychological differences. To understand this concept of inclusive education, it is necessary to understand the implications of John Dewey's educational philosophy of inclusive education in the 21<sup>st</sup> century Williams (2017). Dewey believed that traditional education as just described, was beyond the scope of young learners. Progressive education should include socially engaging learning experiences that are developmentally appropriate for young children. In the current time the use of digital devices, and platforms is an effective way

of engaging children in learning. By designing instruction to meet the social needs of students through the use of appropriately aligned technology, Dewey's social learning theory is evident in inclusive classrooms. Based upon these implications from the Dewey's emphasise on the use of digital devices, and platforms for the engagement of ChADHD. By planned designing the devices, and platforms specifically for ChADHD can help to enhance the attention span and classroom engagement. In current time we see an absence of such devices, and platforms designed for ChADHD. Thus, we infer the need of systematic design of digital devices, and platforms for ChADHD.

### **3.5.3 Garrett's Five Planes of User Experience**

From the reference of the Dewey's educational philosophy we infer the need of systematic design of digital devices, and platforms used by ChADHD. While designing such applications it is necessary to know which aspect to consider of designing digital devices and platforms. To identify the important design aspect we refer the Garret's five planes of user experience (Garrett (2006)). Garrett (2006) initially designed the five plane model of user experience with an intend to systematically design the web-based portals. The scope was limited to enhance the user experience of the web-based portals. However, in the recent studies, researchers have found it's applicability in designing of systematic software's and application other than web-based portals (Permatasari et al. (2021); Pan and Wang (2019)). Thus the use of five plane mode of user experience is not limited to designing of web-based portals but is also useful to design application, software's, devices and platforms. Inferring from the recent researchers we adopt the concepts of five plane model of user experience to reveal the importance of visual design element in this research work. As seen in our redrawn Garret's five planes of user experience (see figure 3.3) Garrett (2006) distinguishes visual design (at plane 5) from three other design sub-planes (at plane 4) – interface design, information design, and navigation design. Interface design refers to the design of interface elements responsible for supporting users' interactions with the product's functionality. Information design indicates rationale preferences in organizing and presenting information before the users for easier comprehension. Moreover, navigation design indicates decisions taken to improve users' movement across the information architecture present in an application. Visual design, in particular, refers to the representation of text and graphic ele-

ments, including images and navigational components. Thus, the designing of the e-content visually as per the needs of the ChADHD stand naturally important.

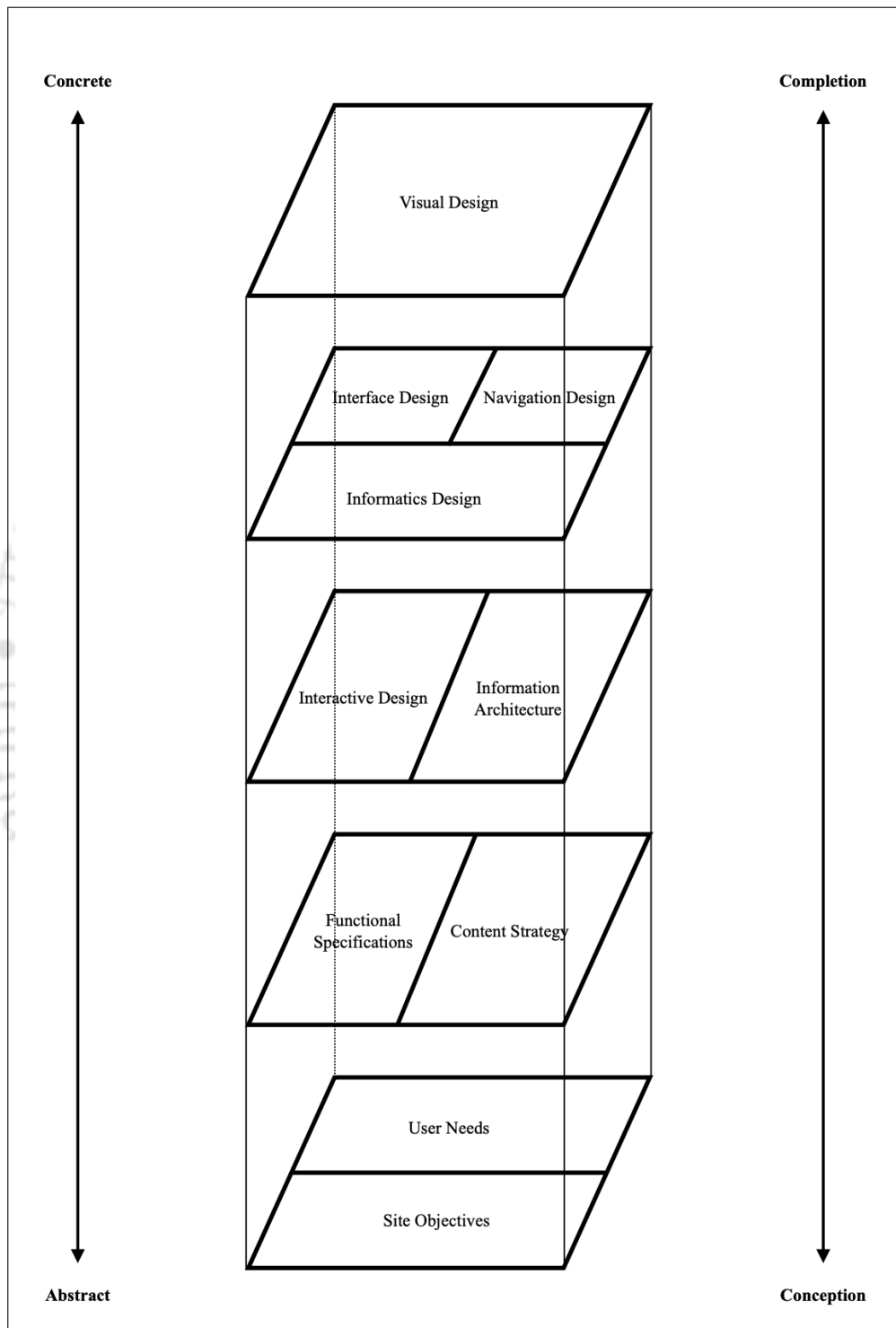


Figure 3.3: Garretts five planes of user experience, redrawn and adapted from Garrett (2006)

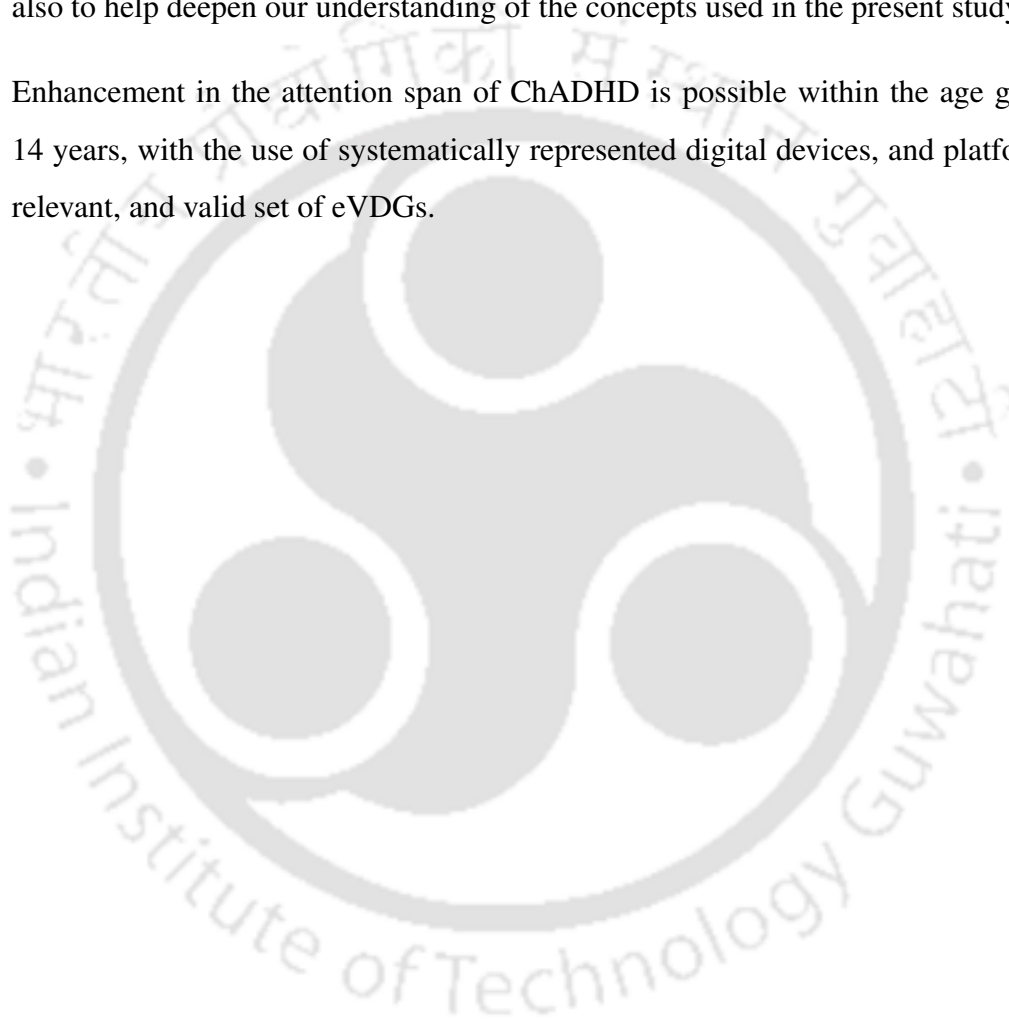
### 3.5.4 Key Inferences

As suggested already, the constructs used in the current research have their grounding in the three theories we have mentioned in detail. In summary, we gather the following takeaways:

1. We infer that the suitable age group for introducing the intervention to help with the management of ChADHD is between 7-12 years. This is the development age of children in concrete operation stage according to Piaget (2000). He, however, makes a clear distinction between the biological age and the development age of the Children. His suggestion of concrete operation stage is expressed with respect to the development age. It is quite possible, and even often seen that the biological age of the children varies from their development age. Considering this difference, in the current stage where we consider ChADHD with comorbid conditions, we consider a age-group of 5-14 years for all practical purposes in this research. This consideration is also inline with the studies having similar line of enquiry like ours (Cerezo et al. (2019); Powell et al. (2019); Fekete and Lucero (2019)).
2. Next we infer from the Dewey's educational philosophy that in the current times, use of digital assistive tools will be an effective way for developing an inclusive educational system. Use of appropriately designed digital devices and platforms can help in the enhancement of the attention span of ChADHD.
3. An appropriate design can help in enhancing the attention span of ChADHD. It, however, remains unclear as which aspects of design we mapped with the idea of an appropriate design here. Thus from the Garrett (2006) five planer model, we infer that perhaps the appropriateness in representing digital content for ChADHD be mapped to the visual design plane in the Garrett's model.
4. Taking together the three theories, we infer that an effective management of ChADHD is possible within the age group of 5-14 years, with the use of systematically designed digital devices, and platforms where visual design decisions are taken in accordance with a valid set of eVDGs.

## 3.6 Chapter Summary

1. There is a need of establishing relevant and valid set of eVDGs for the content representation on digital devices and platforms used by ChADHD.
2. We have theoretical background to help with the consideration of age of the ChADHD, also to help deepen our understanding of the concepts used in the present study.
3. Enhancement in the attention span of ChADHD is possible within the age group of 5-14 years, with the use of systematically represented digital devices, and platforms using relevant, and valid set of eVDGs.





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## Chapter 4

# Identification of a relevant set of eVDGs

This chapter identifies and validates a relevant set of eVDGs which can be used to represent curriculum-based digital content on digital devices and platforms used by ChADHD. Researchers identifies and validates these eVDGs by engaging with stakeholders namely experts in special educational needs, clinical psychologist, teachers and designers. He engages these stakeholders through systematic and planned interviews, feedback surveys, design tasks and validation survey. At the end of this chapter researcher presents a relevant and valid set of expert validated eVDGs.

### 4.1 Introduction

This chapter reports research work carried out to identify and validate an initial set of elements of visual design guidelines (eVDGs) for the content representation on digital platforms used by ChADHD.

The review of the literature (see chapter 3) has helped us understand gaps and limitations in the existing knowledge on different guidelines, strategies and frameworks for designing digital

interventions for ChADHD (McKnight (2010); Sonne et al. (2015); Cerezo et al. (2019)). In addition, this review has established with enough clarity that the proposals of such guidelines are quite often present only in their initial stages. These are not sufficiently either (formally) tested with ChADHD or validated with stakeholders. This negatively impacts the adoption and applicability of these proposals. In this chapter, we attempt to identify a set of elements of visual design guidelines (eVDGs) in a systematic and iterative manner.

The rest of the chapter is organized across the following sections. We list the objectives of the chapter, followed by the details of the method used. Presented nested in the method's section are the details of interviews with the experts, along with details of the survey and the workdone along with the designers. Subsequently, we mention results and discuss the outcomes of the research work carried out in this chapter. Finally, we conclude with a summary of the chapter.

## 4.2 Chapter Objectives

1. To identify a potential set of elements of visual design guidelines or eVDGs for the content representation on digital platforms and devices used by ChADHD through remedial expert interviews and surveys.
2. To test the applicability of the identified eVDGs in a testing session with design professionals.
3. To refine and modify the identified eVDGs in response to the feedback and suggestions received from the designers.
4. To check the validity of refined eVDGs with experts in special educational needs using survey method.

### 4.3 Method

The method used in this study follows the stage 0 of the proposed research methodology (see chapter 2). Stage 0 is the basic science stage that occurs prior to the intervention development. This involves adopting an inquiry led approach to understand and gather ground truth about the theme of interest (NIH (2022)). Subsequently, stage 0 adoption has enabled research approach in this chapter to be of the type iterative based on feedback received from the doTesting the experts. It is realised across three distinct phases (see figure 4.1), namely (a) interviews and surveys with experts in special educational needs as participants, (b) re-design tasks with designers as participants, and (c) a careful validation of study outcomes through surveys with experts in special educational needs as participants.

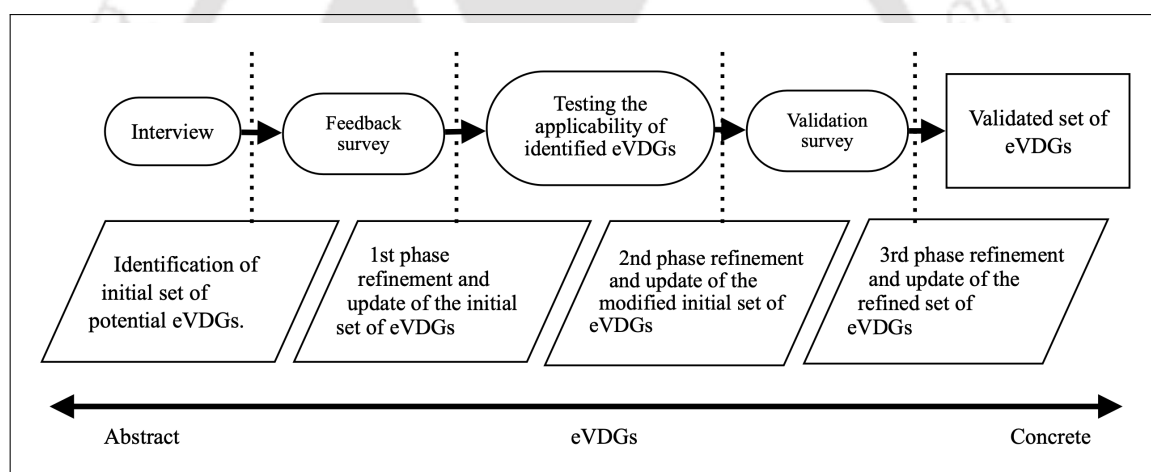


Figure 4.1: Research methods enabling detailing of eVDGs

### 4.4 Interview

Initial data collection through the use of interviews with experts in special educational needs constitutes the first phase of the design of the study. These interviews are semi-structured in nature. The questions for these interviews are based on the existing Government of India’s e-content design guidelines for children living with intellectual and developmental disabilities, multiple disabilities, and Autism Spectrum disorders (Jayanthi Narayan et al. (2021)). These

guidelines are comprehensive in nature but offer no information which is specific to ChADHD. Owing to the fact that the document focuses on children living with intellectual and developmental disabilities, one can see opportunities where discussions can be carried out and questions of the type, "whether or not a specific guideline applicable for children living with intellectual and developmental disabilities can be applied for ChADHD as well?", can be raised with the experts of special educational needs. This suggests the beginnings of our interactions with the experts in absence of a similar and a dedicated set of guidelines for ChADHD. This paved way to identify (with enough details) a set of potential eVDGs for the content representation on digital devices, and platforms used by ChADHD during expert interviews.

## **4.4.1 Procedure**

### **4.4.1.1 Setting and Data collection**

These interview sessions are organised through video conferencing with both the interviewer and the interviewee located across three different geographic locations (see figure 4.2). The interviewer's location is the city of Guwahati in the state of Assam, India. The interviewees' locations are the cities of Satara and Pune in the state of Maharashtra, India. The interviewer researcher connects with the experts in special educational needs using Google meet or Microsoft Teams video conferencing platform <sup>1</sup>. The rooms where the researcher and the remedial expert sit during the interview session are kept close so as to avoid any interruptions and/ or disturbances of various kinds. The sessions are conducted individually with each of the remedial expert and not in a group. The sessions are video recorded on receiving informed consents from the participating experts. Each of the interview sessions last typically for seventy to eighty minutes.

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<sup>1</sup>This part of the research study was carried out in September 2021 during Covid-19 Global Pandemic. Being able to connect with the experts in special educational needs over video conferencing platforms provided the researcher a mechanism to conduct the research

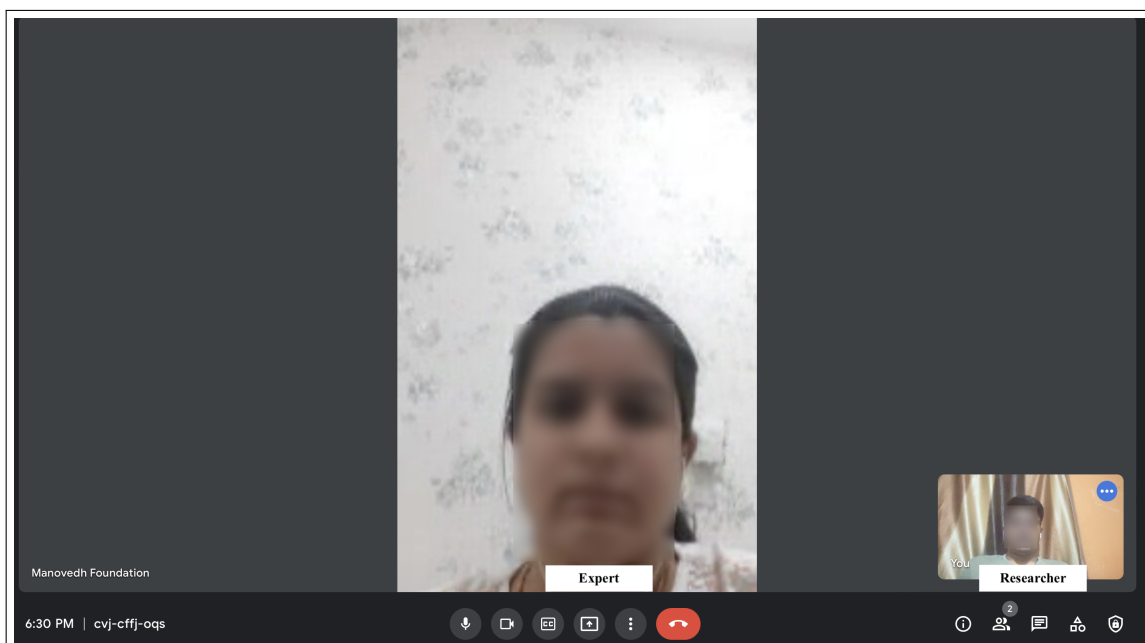


Figure 4.2: A typical interview session (in focus the remedial expert).

#### 4.4.1.2 Participant Recruitment

The researcher recruits two experts in special educational needs - a clinical psychologist and a remedial teaching expert for these interviews. The experts in special educational needs are both females with at least five years of experience of working with ChADHD.

The researcher receives contacts of the recruited experts in special educational needs from the institutes which have provided the support for this research study. These institutes have rendered letter of supports prior to the commencement of the research study (see appendix G). The researcher, while sorting through the suggestions, has sought recruitment of only those experts who have an educational, and professional background of managing, and treating children with special need, preferably ChADHD. In addition, they must have a minimum professional experience of five years to qualify to be recruited for the interview sessions. Further, both the experts were aware of the existing e-content representation guidelines by Jayanthi Narayan et al. (2021).

#### 4.4.1.3 Protocol

1. On establishing a live video conferencing link with the remedial expert at the other end, the researcher informs the experts in special educational needs of the objectives of the

interview session and of the study at large. The video conferencing is supported via the Microsoft Teams platform while following COVID-19 appropriate behavior.

2. The researcher requests the remedial expert to extend a verbal consent to participate voluntarily in the interview.
3. The researcher seeks permission to video record the interview session. He further informs the remedial expert that the interview can be interrupted at will if there lies some urgency at the end of the remedial expert which demands so. The remedial expert is encouraged to asked any clarifying question regarding the objectives of the interview session, the nature of the consent and about other things related with the interview session and the study. They were specifically informed of their privilege to raise queries or seek clarification on any question at will before and during the interview.
4. Researcher addresses the questions and the queries posed by the remedial expert, if any.
5. Researcher conducts the interview in a semi-structured format.
6. Researcher debriefs the remedial expert post completion of the interview session and conclude with an expression of gratitude for her/ his interest, energy and time.

#### **4.4.1.4 Analysis**

The researcher generates text transcripts out of recordings of the interview sessions. He analyses the transcripts to generate an initial set of potential eVDGs. In order to rule out any bias in generating these initial set of eVDGs and a possibility of missing out on or an erroneous inclusion of any critical information, he requests three more researchers to contribute in the analysis. These researchers are provided with the identified set of eVDGs along with the transcripts of the interview session. They are also provided with an access to the video recordings of the interview session at will. This enables them to conduct a careful verification of identified eVDGs against the transcriptions.

#### 4.4.2 Results and Analysis

We spend an average time span of 75 minutes for the two interview sessions. The inter-coder reliability for the first transcription is 86.3 and for the second one is 87.6. This reliability testing helps us to eliminate the chances of missing out any of the experts suggestions, and statements. Next, on combining the outcomes of the two interview sessions we generate an initial set of eVDGs. We attain a reliability score 97% for the initial set of eVDGs from a group of three researchers. We present the initial set of eVDGs in the following table 4.1.

Table 4.1: Initial most set of eVDGs obtained from the interviews

S. n.	Statements on eVDGs as interpreted from the interviews
1	The digital content for the ChADHD, adapted from the curriculum resources, artefacts should be of the same length as for the non-ChADHD. Such a content, however, can be distributed in sections or in parts, and be provided to ChADHD in a longer time span in comparison to the non-ChADHD.
2	Preferably adapt the educational content from the school books of Environment Science, English and General Knowledge subject.
3	The digital content should be interactive to engage the ChADHD for a longer time span. This can be achieved with the use of dynamic graphics, color scheme audio and/or audio.
4	Include audio-visual interaction-based content.
5	Present the illustrations in form of cartoon. Focus, on including non-human figured cartoons example Doreamon, and Chota Bheem.
6	The cartoon figures, their actions, and objects represented in illustrations must replicate to a similar form of figure, action, and object seen by ChADHD in her/his day-to-day life.
7	Try not to use complex moving animations. Prevent the use of moving, or animated text, and images.
Continued on next page	

Table 4.1 – continued from previous page

S. n.	Statements on eVDGs as interpreted from the interviews
8	The screen backgrounds should be calm, and soothing. Preferably, the background color should not be too bright, and too dull. Can, use light colors like white, sky blue, pink, and light green. Refrain the use of black, or dark colors.
9	While designing an illustration use both warm and cool colors. Use warm colors in foreground and cool colors in the background.
10	Limit the number of colors for an illustration/frame to three colors only. For moving images and illustrations try reducing the number of colors to only two colors.
11	The font type should be similar to the handwritten text by the children. The font representation should be clean and readable.
12	Font size be as big as possible. Preferably, equivalent to a font size fitting in a four line note book. This font size is around 30 to 32 pt. on an US size paper.
13	Try using minimum number of video representations.
14	In case of use of videos, and animations set the play back speed to 1X, and set soothing, and white backgrounds.
15	The auditory inputs should have a low pitch, adopting the sounds from nature.
16	The user-flow should be gamified in nature, with a privilege continuous evaluation of ChADHD.
17	Build a reward mechanism-based user flow including mini-games in form of challenges.
18	Have minimum surprises.
19	Set levels and stages in accordance to the syllabus and content.
20	Use varying forms of mini-games such as MCQs, true false, puzzles, drawing and painting, and any form preferred by the designer for the context representation.
Continued on next page	

Table 4.1 – continued from previous page

S. n.	Statements on eVDGs as interpreted from the interviews
21	Include ChADHD having an IQ greater than 80, to test, and validate the guidelines.
22	Try testing with children of all the three types of ADHD namely attention deficit, hyperactive, and combined type.

## 4.5 Feedback Survey

The researcher subjects the initial set of potential eVDGs, that are obtained from the analysis and interpretation of the interview data, to a validation exercise. In this exercise, a total of eight experts in special educational needs respond to a survey questionnaire.

The survey questionnaire (see appendix A) is designed with a focus to illicit subjective response from the experts in special educational needs against the identified eVDGs. It therefore has both questions which are open-ended along with the questions which are guided. The inclusion of open-ended questions help probing experts in special educational needs when details on an aspect of content representation are either missing or not detailed enough. Whereas, the questions which appear guided in nature are aimed at verifying one or more aspects of the identified eVDGs. The researcher created the questionnaire himself but invites three more researchers to verify the nature of the questions and their language with respect to the intent of the survey. He provides these researchers both the questionnaire and the data from the interviews and asks them to conduct review and verification. Later, an intercoder reliability test is conducted to help establish the internal validity of the questionnaire.

## **4.5.1 Procedure**

### **4.5.1.1 Setting and Data collection**

The researcher administers the survey questionnaire individually to each of the experts in special educational needs using the functionality of Google forms<sup>2</sup>. The remedial expert fills the Google form while staying in a quiet room which is away from ambient noises and interruption. While the expert responds to the Google form, the researcher ensures his presence over a live call during the survey. This is done so as to assist the expert in case of any ambiguity or misinterpretations due to the use of English as a language of the questionnaire. All the responses of the experts in special educational needs to the survey questionnaire are recorded and compiled as a single excel sheet for analysis.

### **4.5.1.2 Participant Recruitment**

The researcher recruits a total of eight experts in special educational needs (six females, two males) for responding to the survey. These experts in special educational needs belong to four different cities across two different stages. These are the cities of Satara, Satara Road and Pune from the state of Maharashtra, and the city of Guwahati from the state of Assam. Note that these experts are different from the experts who appeared for the interviews. Once again, the institutes who have committed support for the research study help the researcher in getting access to these experts. All the experts in special educational needs have an educational, and professional background of managing, and treating children with special need, preferably ChADHD. In addition, they all had a minimum professional experience of five years.

### **4.5.1.3 Protocol**

1. The researcher first connects with the remedial expert at a schedule of convenience over the call. He briefs the remedial expert about the objectives of the questionnaire.
2. The researchers specifically inform the participant of their privilege to raise queries or

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<sup>2</sup>Similar to the phase of interviews, there were several constraints due to Covid-19 Global Pandemic which have driven the choice of online mediums like Google forms for administering surveys to the experts.

seek clarification on any question at will before, and during the survey over the call.

3. Researcher seeks a verbal consent from the remedial expert over the phone indicating her/his voluntary participation in the survey.
4. The researcher administers the survey questionnaire by passing on a survey link to an online Google form over the email.
5. On completion of the survey, the researcher thanks the remedial expert for lending her/his invaluable time for the survey.

#### **4.5.1.4 Analysis**

The researcher generates excel sheets of the expert reported response. He compiles these responses in a single sheet. Then he systematically analyses the subjective responses by reading, and then generate an objective outcome in form of a updated initial set of eVDGs. In order to rule out any bias in updating these initial set of eVDGs he requests three more researchers to contribute in the analysis. These researchers are provided with the updated set of eVDGs along with the responses in the excel sheet. This enables them to conduct a careful verification of updated initial set of eVDGs against the responses in the excel sheet into eight relevant categories.

#### **4.5.2 Results and Analysis**

After the generation of the initial set of eVDGs, we test the validity of these eVDGs with a larger set of eight experts in special educational needs through a feedback survey. The reliability of the survey questionnaire is 96.6%. Next on receiving the experts response to the feedback survey researcher updates the initial set of eVDGs and classifies them into eight category (see table 4.2). He obtains a reliability score of 95% agings the classification, and the updated initial set of eVDGs from indepented group of three researchers.

Table 4.2: The initial set of eVDGs with updates post feedback survey

S. n.	Categories	Recommendations
1	Screen Layout	<p>Use a relevant grid system for the representation of the e-content.</p> <p>Design the screen as clean as possible.</p> <p>Highlight major points and quotes.</p> <p>Organize in an orderly way.</p> <p>Use calming backgrounds.</p>
2	Syllabus/e-content of the redesigning artifact	<p>Do not increase or reduce the amount of adopted e-content from the educational artefact.</p> <p>Divide the e-content across sections and subsections when ever needed.</p>
3	Font Type	<p>Use the font replicating school children handwriting.</p> <p>Use a font which is clean and readable.</p> <p>Use different font weights for different body styles representations.</p>
4	Font Size	<p>Use different font size to represent different body style.</p> <p>Use a font size of 30 pt. and above on an A4 sheet.</p>
Continued on next page		

5	Frame Colors	<p>Use maximum three colours in a single frame.</p> <p>Use tints and hues based upon the scenario of the context.</p> <p>Use warmer colors for foreground elements.</p> <p>Use light colors preferably.</p> <p>Refrain the use of dark and black backgrounds.</p> <p>Use white color or soothing light colors for background.</p>
6	Illustrations	<p>Use illustrations that replicate object, subject, or the context seen in everyday life.</p> <p>Preferably use of Cartoons-based illustrations, specifically non-human figured.</p> <p>Prefer use of non-human figure cartoons.</p>
7	Videos, animations, and sounds	<p>Prevent the use of moving, or animated text, and images.</p> <p>Use minimum videos possible.</p> <p>Set the playback speed of moving objects and animations to 1X.</p> <p>Prevent the use of brighter backgrounds in the videos.</p> <p>Use sounds with lower pitch.</p> <p>Use sounds heard in nature as they are pleasing for the ChADHD.</p>
Continued on next page		

8	User flow of the digital applications	<p>Apply a gamified user flow for a digital application designed for ChADHD.</p> <p>Design a reward mechanism-based user flow with mini-games in form of challenges.</p> <p>Include minimum surprises.</p> <p>Set levels and stages in accordance to the syllabus and content.</p> <p>Use varying forms of mini-games such as MCQs, true false, puzzles, drawing and painting, and any form preferred by the designer for the context representation.</p>
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The figure 4.3 presents the visual overview of the themes generated post the intercoder reliability procedure.

#### 4.6 Testing for Applicability of Identified eVDGs

Towards the end of the last two methods- interviews and the feedback survey, the researcher has not only compiled an initial set of eVDGs into eight distinct categories but has also verified the same with the help of experts in special educational needs. This indicates an iterative and a progressive build-up of the eVDGs in a format that may be used to represent content for the digital screens for ChADHD. However, eVDGs obtained at the end of feedback surveys can only be ascertained for their applicability if these be put to test in designing an actual content for the digital screen. This method, testing the applicability of identified eVDGs, attempts to accomplish the same.

In order to test applicability of the identified eVDGs, the designers are randomly provided with an educational artefact (e.g. either a poster, a chart, a poem or a section of the chapter) from

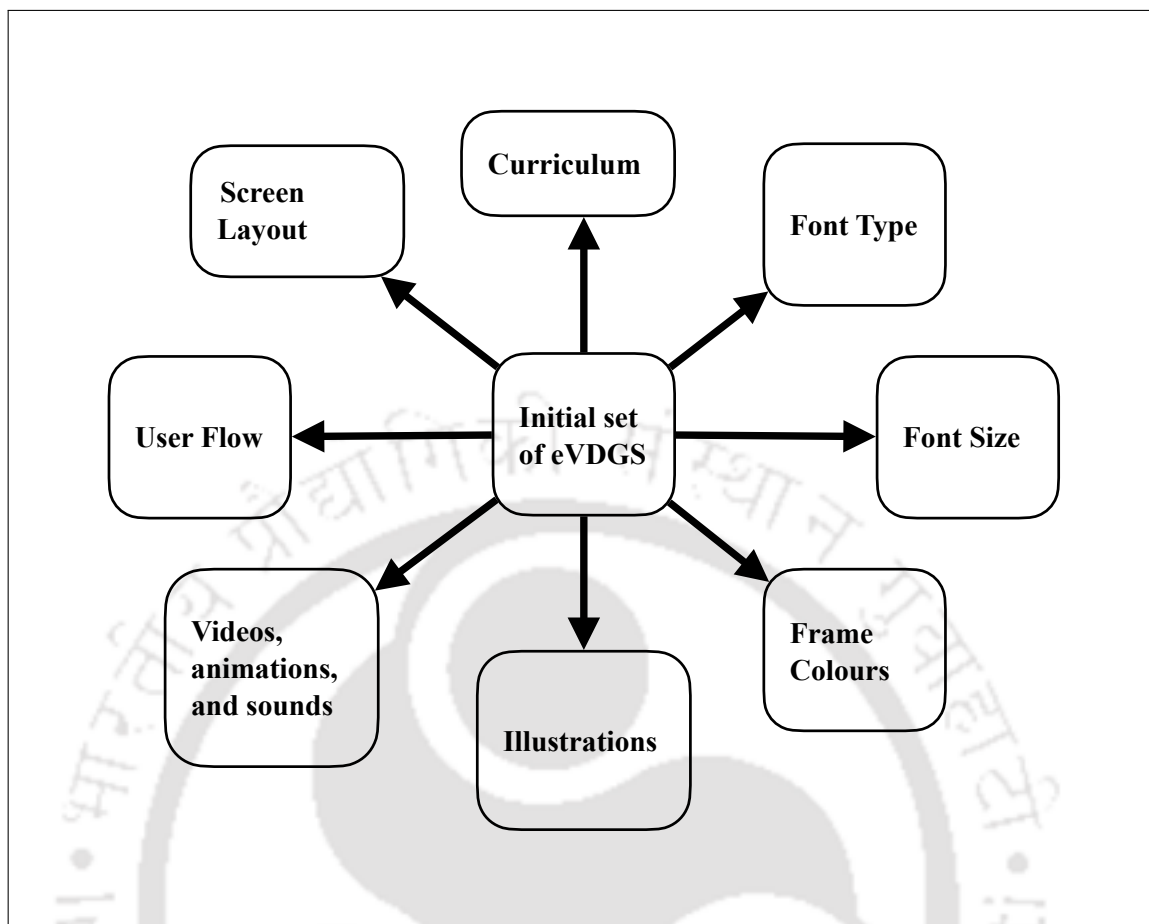


Figure 4.3: Visual Overview of the Generated Themes.

the curriculum texts of standard two to standard fifth in English language of subject English and Environment Science. The choice of the subjects and the nature of the educational artefact are driven by the suggestions made by the experts in special educational needs. The designers are also provided with a compiled set of eVDGs across eight categories. The designers are asked to represent the existing educational artefact using the provided set of eVDGs.

## 4.6.1 Procedure

### 4.6.1.1 Setting and Data collection

This exercise is carried out in a lab setting. It involves a dedicated room with a capacity to accommodate a maximum of two designers (see figure 4.4). Apart from this sitting arrangement for designers, the researcher has a place to sit in this room to facilitate the exercise and record

the observations. In case of a pair of designers participating in the exercise, they are asked to sit opposite to each other. This was done primarily to support discussions if needed between the two.

The researcher collects data in the form of notes mentioning queries, suggestions and feedback given by the designers across different stages of the design task. The data collected is stored in a feedback form (see appendix B). The researcher takes a care to not ask designers to fill this form post completion of their assignment, rather fill the form himself by listening to designers as they verbalise their issues and comments on the applicability of the identified eVDGs. This is done to mimic the approach followed in a think-aloud protocol (Gero and Milovanovic (2023)) which is well established for it's ability to capture a thinker's mind while she/ he realises a creative task at hand.

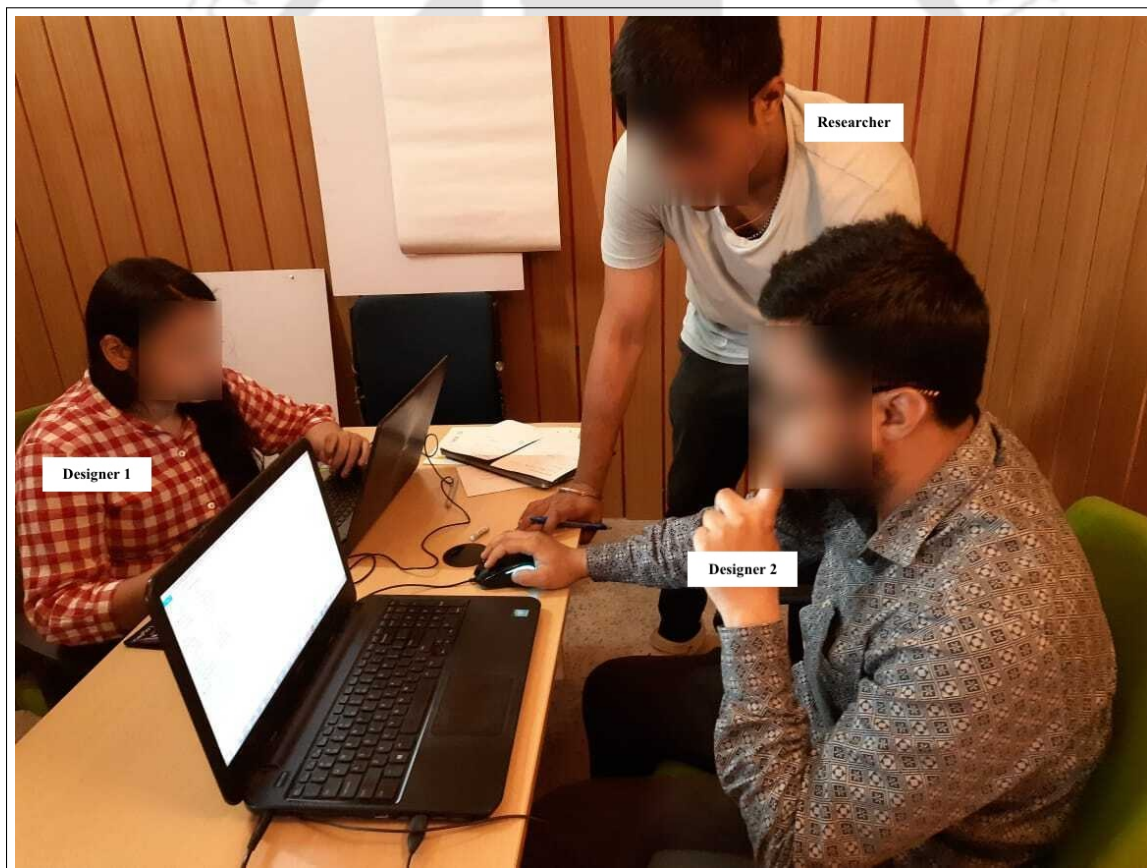


Figure 4.4: Administering design task

#### 4.6.1.2 Participant Recruitment

Table 4.3 summarises the profile of the participating designers. All the designers (4 females, 5 males, average age = 24.5 years, s.d. = 5.1) are drawn from a lot of students in the Department of Design of IIT Guwahati. The professional courses with their enrolments include a four-years Bachelor of Design, a two-years Master of Design and Doctor of Philosophy. However, the researcher resist recruiting design students in their sophomore years. All the designers in bachelor's course are at least in their third year of degree program, and all the designers in master's course are at least in their 2nd year of degree program. This ensures that they have a practical knowledge and an experience of content design (mean experience = 3.11 years, s.d. = 1.5) with adequate skills in design-based software.

Table 4.3: Profile of participating designers

S.n.	Qualification/ affiliation	Experience (in years)	Experience details	Age (in years)	Gender
1	Pursuing 3rd year of Bachelor of Design (B. Des.)	2	As a freelance Visual Designer	19	Male
2	Master of Design (M. Des.)	5	As a UX Designer in e-learning company	22	Female
3	Bachelor of Design (B. Des.)	1	As a Graphic Designer	21	Female
4	Pursuing 3rd year of Bachelor of Design (B. Des.)	2	As a freelance Visual Designer	20	Male
5	Pursuing 3rd year of Bachelor of Design (B. Des.)	3	As a freelance Visual Designer	20	Male
6	Research Scholar in Design with a Master of Design (M. Des.) in Architecture	4	As a Visual Designer	31	Male
7	Research Scholar in Design	6		33	Female

**Table 4.3 continued from previous page**

<b>S.n.</b>	<b>Qualification/ affiliation</b>	<b>Experience (in years)</b>	<b>Experience details</b>	<b>Age (in years)</b>	<b>Gender</b>
8	Research Scholar in Design with a Master in Design (M. Des.), co-founder of a startup	2		27	Male
9	Research Scholar in Design	3	As a Design Instructor	28	Female

#### **4.6.1.3 Protocol**

1. The researcher begins by briefing the designer(s) on the objectives of the exercise. He explains her/ him the task which needs to be executed as part of the exercise.
2. The researcher requests designer(s) to sign an informed consent indicating their voluntary participation in the exercise. On receiving the consent he informs them of the eventual start of the exercise while suggesting that they can stop at will if there is an emergency. The researcher mentions that they need to keep verbalising their issues and comments as they execute the design task.
3. The researcher makes notes and documents data in the feedback form during different stages of the task execution.
4. On completion of the task, the researcher probes them for any question of interest or an instance of their behavior which is left unexplained. He finally debriefs the designers mention his gratitude for their time and effort.

#### **4.6.1.4 Analysis**

Researcher accesses the suggestions, and feedback's of the designer participating in the task. He then organises the suggestion categorically in the previously generated categories. Then he compares, and relates the suggestions, and feedback's of the designer with the findings from the literature, and outcomes of the interviews, and feedback surveys. Next he identifies the short

comings in the initial set of eVDGs and updates them along with the help of two more design researchers.

## 4.6.2 Results and Analysis

We invite a total of nine designers for the redesigning task. All the participating designers used different design software during the tasks. During the task researcher receives queries along with suggestions, and feedback's from the designers. He addresses most of the design queries for the smoother redesigning of the educational artefacts. However, there were few queries which were difficult to address, researcher, considers these queries as feedback', and takes suggestions from the designer to solve them. The presence of these queries itself states that the updated initial set of eVDGs need further detailing, and update. We observe a constant pattern in the queries, suggestions, and feedback's of the designers. One such common queries, suggestions, and feedback's include lack of clearance on the use of font type. As we did not mention a specific font type designers spent a lot of time in identifying the relevant font type. In another instance the eVDGs lack in guiding a specific font size, thus the designers have to try different combinations for effective representation. Such instance result in frustrating the designer which may lead to bad designing of the artefact, or giving up the task. We observe one such instance where the designer existed the task without completion. Figure 4.5 represents one such instance of leaving the artefact incomplete. The limitations of potential eVDGs support our understanding, and knowledge from the literature review that the existing guidelines are often unavailable, or present in a format unsuitable for designers. To prevent any such instance in the future we adhere to the suggestions and feedback's given by designers. The summary of the queries, suggestions, and feedback reported by these designers across various categories is as follows:

### *A. Screen Layout:*

- Need to define the border parameters for the screen layout, for instance the thickness and the spacing of the border.
- Justifications for the type of layout for a specific digital content.

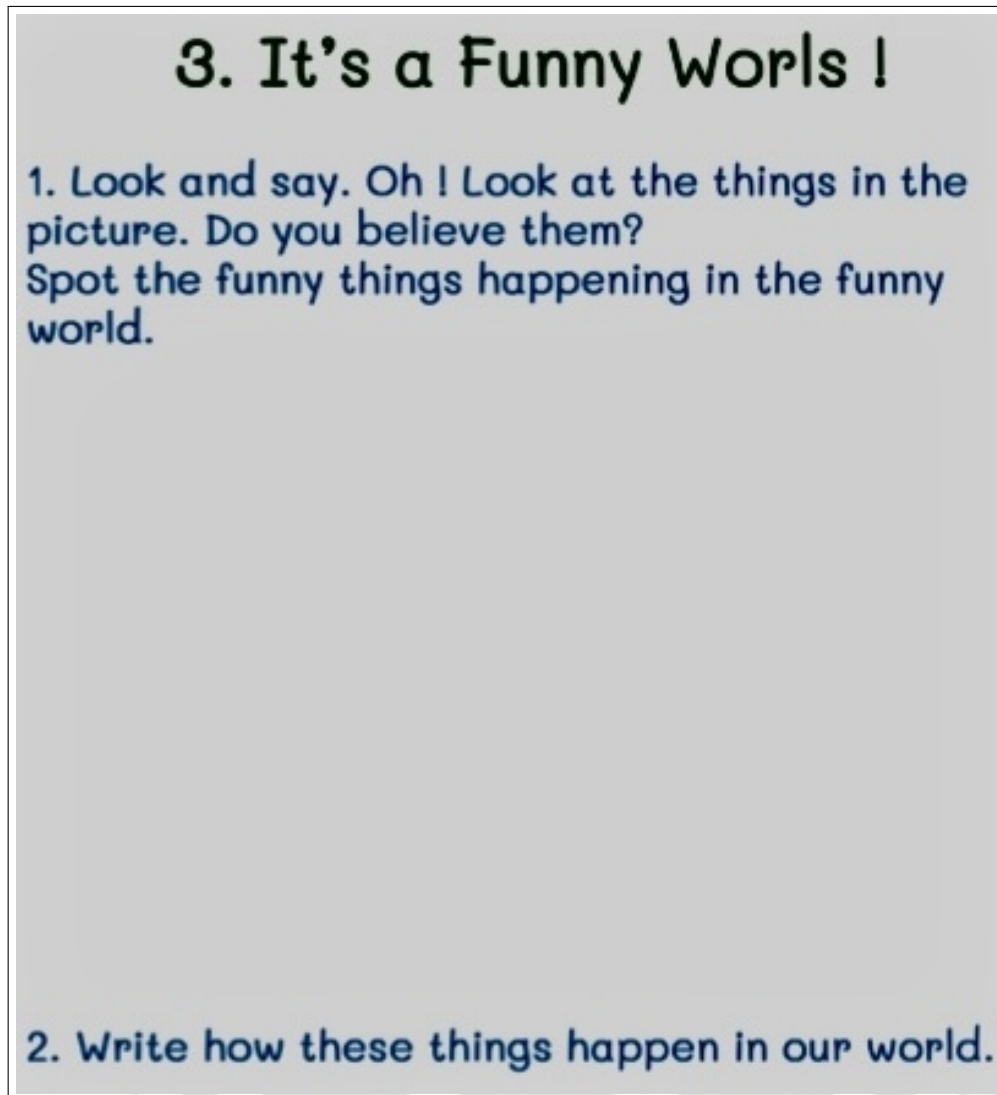


Figure 4.5: Incomplete artefact

- Define the sequence of texts, pictures, table, notations, and all miscellaneous digital content on the screen.
- The grid and gutter should be defined. Use a 4x2 grid and a 20 gutter.
- Define the number of words, characters, length of sentence and paragraphs to be used for the content representation of digital devices, and platforms used by ChADHD.
- Specify the line spacing. Preferably double-spacing fits, the attributes of clean, clear and readable text.

***B. Font:***

- Define a specific font type. The attributes are not enough. Suggested font types are Cavolini, Comic Sans, and Mali.
- Font color should be defined. Preferably use black color for font.
- Font style should be defined for each of the body style of the digital content.
- Define the font size for different platforms (tablets, phone, laptops).

**C. Colors:** Here we state the feedback on the color schemes and combinations provided by the designers during the design task.

- Define a specific color schemes for representation of a particular theme based digital content.
- Usage of maximum three colors in a single frame does that include the background color and the font color?
- Context based color recommendations are necessary as difficult to judge and define the color combinations.

**D. Illustrations and Animations:** The feedback for the illustrations is as follows:

- Due to the guidelines restrictions it is difficult to find illustrations. A pre-generated library is necessary.
- What type of illustrations are necessary, line drawing, 2D drawing or 3D that must be defined.
- Need details on how to generate relation of illustrations with the text for the ChADHD.
- For the illustration colors can we use different he, shades and tint combinations.
- Ration of animation and pictures to the text and context should be defined.

**E. Sounds and Music:**

- The sound library should be pre-defined.

- The type of feedback sound should be defined. Should it be male or female.
- The tones and prompts should be pre-defined before designing.

**F. User Flow:** The designers did not feel any difficulty while using the eVDGs regarding the user flow. Designers were happy with the freedom to design in terms of the user flow with a condition of not breaking the flow in the original artifact. This may be because the user flow was in the scope of the study as the scope is restricted to the visual representation only.

## 4.7 Validation Survey

This validation survey acts further on the updated and refined set of eVDGs which are obtained across the earlier methods in a progressive manner (see figure 4.1). A group of three experts in special educational needs and two school teachers, other than those participated in the interviews and the feedback survey, participated in this validation exercise. The questionnaire for this survey is designed keeping in mind that the eVDGs be presented with enough clarity and details, if possible even with an example included, before the experts in special educational needs (see appendix C). This helps ensuring that the experts in special educational needs have very specific data to look at and to respond on. Further, the questionnaire illicit experts in special educational needs' and teachers' responses across three different categories - Yes, No and Maybe. Once again, as we see, the eVDGs are already being updated across the earlier stages with the use of interviewing, feedback survey and applicability test as methods. This makes these eVDGs become more cohesive and concrete. By being able to illicit objective responses, the researcher is ensuring that validity be retained in these eVDGs. Note that in designing questionnaire for the validation survey, three research scholars other than the primary researcher rated the questions individually for their relevance. An intercoder reliability test is conducted to ensure reliability in the questionnaire design.

## 4.7.1 Procedure

### 4.7.1.1 Setting and Data collection

The researcher administers the validation survey in-person with himself and the remedial expert or the school teacher at the same location. These locations include remedial centres and schools in the cities of Satara, Phaltan and Pune in the state of Maharashtra. A quieter room is sought to administer the validation survey in order to avoid onlookers and other distractions (see figure 4.6). Often the centre head or the in-charge head is allowed to observe the session to Testing the tain logistical support.

The researcher collects the data using the validation survey which is designed over the Google forms (see appendix C). This data is compiled and downloaded for further analysis in the form of excel sheets.



Figure 4.6: A typical validation survey session (in focus the remedial expert).

#### **4.7.1.2 Participant Recruitment**

We recruit the remedial expert participant from institutes who have provided the research support for this study. Note that the researcher has already secured a letter of support from from these institutes prior to the interview session (see appendix G). We include those experts who have an educational, and professional background of managing, and treating children with special need, preferably with an experience of working with ChADHD. We ensure the that the participant experts have the educational qualification from a government approved organisation, and a minimum experience of more than five years. Further, we also include teachers from regular schools who are trained to teach, and mange children with special needs. In order to have valid set of responses we include only those school teachers who have an experience of more than five years, and are recommended by the school principle. All the experts participating in the survey are different from those participating in the previous interview, and survey session.

#### **4.7.1.3 Protocol**

1. Researcher connects with the remedial expert either on Google Meet or on Microsoft Teams video conferencing platform. He informs the remedial expert of the objectives of the sessions, and of the study at large.
2. Researcher sends the questionnaire to the expert over email, or WhatsApp by meeting in-person.
3. Researcher seeks a verbal consent from the participants, and briefs them about the questionnaire, and process to respond to the questions by meeting in-person.
4. Researchers specifically inform the participants about their privilege to raise queries or seek clarification on any question at will before, and during the survey.
5. Researcher conclude with an expression of gratitude for her/ his interest, energy.

#### **4.7.1.4 Analysis**

The researchers generates the excel sheet of the experts responses. He collate the yes, no, or maybe type responses of all the experts in accordance to the questions. Then he combines the response for each of the question to know the collective experts response of the experts for a particular question. This helps the researchers to verify the set of eVDGs, and present a validated set of eVDGs.

#### **4.7.2 Results and Analysis**

Based on the suggestions and feedback of the designers, we prepare an updated set of eVDGs. This set of eVDGs is relevant to use however, it becomes essential to validate them through expert survey, and testing with ChADHD, as said by McKnight (2010). Thus, we conduct a validation survey with five remedial exerts. The average similarity percentage for each expert recommendation is as high as 96%. Based upon the outcomes of the survey we propose a validated set of eVDGs (see table: 4.4).

Table 4.4: Expert validated set of eVDGs

S. n.	Categories	Recommendations
1	Screen Layout	<p>Standard border layout with no-border lines.</p> <p>Prefer a US letter page style format to generate relevance with their school books.</p> <p>4X4 grid system for the representation of the content.</p> <p>Keep the screen layout design as clean as possible.</p> <p>Highlight major point and quotes.</p> <p>Organize the screen layout in an orderly way.</p> <p>Use white backgrounds.</p> <p>Prevent the use of textures and patterns. Eliminate non-contributing elements.</p> <p>Use double line spacing.</p>
Continued on next page		

Table 4.4 – continued from previous page

S. n.	Categories	Recommendations
2	Syllabus/content of the redesigning artifact	<p>The amount of the content should not be reduced or increased. It should be same as that in the artifact.</p> <p>Divide the content across sections and subsections when ever necessary.</p> <p>Simplify the complex sentence and jargons wherever possible (Specifically done by content writers and designers).</p> <p>Short and complete sentences.</p> <p>Use less of jargons and quotations.</p> <p>Use motivational text.</p>
3	Font-Type	<p>Use font-type like Comic Sans, Mali, Cavolini, and Lucida handwriting.</p> <p>Should have the attributes of being clean, and readable</p> <p>Use of different font-styles like bold, italic, and underline for depicting different body styles representations.</p> <p>Use different weights for different body styles representations.</p> <p>Use black font color.</p>
4	Font-Size	<p>Use different font-size to represent different body style.</p> <p>Preferred font-size for a running text on a US-letter size page frame should be 30 pt or bigger.</p>
Continued on next page		

Table 4.4 – continued from previous page

S. n.	Categories	Recommendations
5	Frame Colors	<p>A single frame should consist of maximum three colors excluding the background color and the font color.</p> <p>Colors used in design: Analogous (Adjacent colors), Opposite colors (Complimentary), Triadic colors, combinations of colors found in nature.</p> <p>Individual choice of tints and hues based upon the scenario of the context.</p> <p>Use warmer colors for foreground elements.</p> <p>Use light colors preferably.</p> <p>Use white color for background.</p> <p>Black color for all the fonts.</p>
6	Illustrations	<p>Should replicate the object, subject, or the context seen in everyday life.</p> <p>Use 2D illustrations.</p> <p>Design illustrations replicating the actions in the corresponding text.</p> <p>Use of Cartoons is a must.</p> <p>Prefer use of non-human figure cartoons.</p> <p>Should be culturally unbiased.</p>

Continued on next page

Table 4.4 – continued from previous page

S. n.	Categories	Recommendations
7	Videos, animations, and sounds	<p>Prevent the use of moving object.</p> <p>Use minimum videos possible.</p> <p>The playback speed of moving objects and animations should be 1X.</p> <p>Prevent the use of brighter backgrounds in the videos.</p> <p>Use sounds with lower pitch.</p> <p>Sound heard in nature are pleasing for the ChADHD.</p>
8	User Flow of the digital applications	<p>The user flow of any digital applications</p> <p>A reward mechanism-based user flow. Having mini-games in form of challenges.</p> <p>Have minimum surprises.</p> <p>Set levels and stages in accordance to the syllabus and content.</p> <p>The mini-games can be in numerous forms like MCQs, true false, puzzles, drawing and painting, and any form preferred by the designer for the context.</p>

## 4.8 Chapter Summary

This chapter contributes with a relevant set of valid eVDGs for the designing of devices, and platforms used by ChADHD. The eVDGs proposed in this chapter can potentially enhance the attention span of the ChADHD. These eVDGs are rigorously iterated, and validated by two

groups of experts – (a) experts in special educational needs, and (b) designers. The proposed set of eVDGs is a combination of both adoption from the literature, and a novel set by working with experts in special educational needs, and designers through interviews, surveys, and design tasks. Until now, the eVDGs were either opinion based, or based on the literature survey. Often, it resulted in failures to assist the designers in designing effective representations of digital platforms, and devices used by ChADHD. However, the validated eVDGs eliminate the difficulty of interpreting the eVDGs, by providing a relevant, and validates set of eVDGs.



# Chapter 5

## Refinement and Modifications in eVDGs

In the previous chapter researcher has worked with experts in special educational needs, clinical psychologist, and designers to present a set of expert validated eVDGs. These, expert validated VDGs need refinement, and validation by testing them with ChADHD. This, chapter engages ChADHD across two studies to refine, and validate the expert validated VDGs. In the pilot study section of this chapter researcher verify the applicability of the method used in testing the eVDGs with ChADHD. In the main study researchers refine the eVDGs by following the methodology tested in the pilot study. The chapter follows the protocols of stage 1 of NIHSM by incorporating experts in special educational needs, designers, and caregivers along with ChADHD through a co-design approach. This chapter presents a potential set of refined eVDGs which can help enhance the attention span of ChADHD when used to represent curriculum-based content on digital devices and platforms used by these children.

## 5.1 Introduction

This study is a testing of expert recommended eVDGs (from Chapter 4) on the attention span of ChADHD. Here we onboard four distinct stakeholders remedial expert, designer, ChADHD, and caregivers. These stakeholders have a very specific roles for the eVDGs validation. To effectively validate the eVDGs this study is divided into two parts, pilot study and the main study. The pilot study evaluate the probable impact of the eVDGs on the attention span of ChADHD, and verify the applicability of the methodology used to test the eVDGs on ChADHD. The main study filters the expert recommended eVDGs to identify the relevant eVDGs by testing with ChADHD in a typical-learning environment. The division in two parts prevent from a negative impact on a larger ChADHD population if any, also assists in systematic, and relevant validation of the eVDGs.

## 5.2 Chapter Objectives

This chapter has two main objective:

1. To identify, refine, test and validate the appropriate eVDGs from the set of expert recommended VDGs in Chapter 4 for content representation of the platforms, and devices used by ChADHD in a typical-learning environment.
2. To test, and verify the applicability of child participant testing method used for this research study.

## **5.3 Pilot Study**

### **5.3.1 Introduction**

In the previous chapters we identify the potential expert recommended VDGs for the content representation of digital platforms, and devices used by ChADHD. Before applying these VDGs for the representation of digital platforms, and devices it is necessary to test these VDGs with ChADHD. In this study we check the applicability of our methodology to test the impact of eVDGs on the attention span of ChADHD. Further, we also see if there is any impact of two relevantly important eVDGs: font size and font type respectively on the attention span of ChADHD. Here, we choose font as a eVDG to test with ChADHD because font is most used representation elements in any content. Further, font size and font type were the very essential elements impacting the attention span of ChADHD as suggested by the experts in special education in Chapter 4. There is a need of testing the methodology to prevent the chances of negatively affecting the behaviour, emotion, and overall condition of the child participating in the study. This pilot study tests the impact of eVDGs, applicability of the testing methodology, and directs for conducting the main study.

### **5.3.2 Method**

#### **5.3.2.1 Research Design**

This study is first part (1A) of the adopted NIH Stage model as shown in Figure 2.1. This pilot study is a within group study to administer the impact of different combination of font size and font type on the attention span of ChADHD. The study onboard three distinct stakeholders experts in special educational needs, designers, and ChADHD. The font size has three levels: 16pt., 24pt., and 32pt., and the font type has three levels: Mali, Cavolini, and Lucida Handwriting. A randomized combinations of font size and font type were designed using a full-factorial analysis. The stimuli were administered with ChADHD as per the order generated in the full-factorial analysis. Each child was tested, and formally recorded for each of the stimuli

combination. The recordings were used to estimate the attention span and further analyse the impact of the eVDGs on the attention span of ChADHD, and test the applicability of the study method.

### 5.3.2.2 Stimuli

The stimuli were designed by a designer participating in this study of studying the impact of font size and font type on the attention span of ChADHD. To design these stimuli two eVDGs were selected font size and font type respectively. The different parameter values of these eVDGs are shown in the Table 5.1. Author, choose these specific font size and font type due to two main reasons (a) in the previous chapter (see chapter 4) experts in special educational needs suggest the use of font size 24. Next, the heading font size used in a standard document is 16 pt. Thus, based upon the suggestion that font size should be maximum the next parameter we choose 16 pt, which is the largest font size in a standard document. Further, considering a font size difference of 8 pt. in the two selected font size, we choose 32 pt. as the third font size.(b) in the case of font type researcher identified three relevant font types through a systematic study of font typed based on the suggestions of the experts in special educational needs. Thus, he selected Mali, Cavolini and Lucida handwriting. Further, he also verified his selection with remedial experts and designers who had previously participated in design tasks.

Table 5.1: Study variables

<i>Variable Type</i>	<i>Variables</i>	<i>Levels</i>		
<i>Independent</i>	Font size (pt.)	16	24	32
	Font type	Mali	Cavolini	Lucida Handwriting (LH)
<i>Dependent</i>	Attention span (in seconds)	-	-	-

The combination of these font sizes, and font types to a very specific font weights, and font style were used to design the stimuli of an digital US-letter size page. Table 5.2 states the font weights and font style used for stimuli design.

The content of these stimuli was adopted from the English language textbook of the class the child was studying in. The work count was limited to 400 words. Figure 5.1 is a representation of 'stimuli A' designed with a combination of font type Mali, and font size 24pt. Figure 5.2

Table 5.2: Font representation

<i>Sr. No.</i>	<i>Font Type</i>	<i>Font Weight</i>	<i>Font Style</i>	<i>Body Text</i>
1.	Mali	300	Normal	Body
2.	Mali	700	Bold	Heading/Title
3.	Cavolini	300	Normal	Body
4.	Cavolini	700	Bold	Heading/Title
5.	Lucida Handwriting	300	Normal	Body
6.	Lucida Handwriting	700	Bold	Heading/Title

is a representation of 'stimuli B' designed with a combination of font type Lucida Handwriting and font size 32pt.

**Green parrot, green peas, Green grass, green trees.**

**Red apple, red tomatoes, Red chilly, red rose.**

**White snow, white milk, White cotton, white silk.**

**Blue eyes, blue berry pie, Blue sea, blue sky.**

**Yellow lemons, yellow flowers, Yellow bananas, yellow stars.**

**I found a tiny little seed And planted it outside. Almost at once it started To grow up, tall and wide.**

Figure 5.1: Stimuli A

*Ishan: Come on, little friends! It's time to go back home.*

*Come here - and let me count. There should be nine children in all.*

*(Counts) 1, 2, 3, 4, 5, 6, 7 and 8.*

Figure 5.2: Stimuli B

### 5.3.2.3 Participant selection

This pilot study involves three different stakeholders in this study. These include two experts in special educational needs, one designer, and five ChADHD. The experts in special educational needs assisted in participant selection, and for the estimation of the attention span. Designer assisted in designing, and generation of the study stimuli. The ChADHD participants were patients of one of the experts participating in this study. The criteria for children selection were, the child should have ADHD, should be between 5-14 years of age, IQ should be greater than 85 and should be able to read English language books. The children should not have any physical or mental (other than ADHD and inclusive comorbid conditions) disability. Acceptable comorbid conditions were autism, learning disabilities, oppositional defiant disorder, behavioral disorder, and characteristics of anxiety. After identifying such children, we re-verified the children for the

type of ADHD, severity, and comorbidity using the Vanderbilt teacher and parent rating scale with the help of a remedial expert. Upon confirmation of the participant, we obtained written formal consent from the parents of the child, and verbal consent from the child. Each child had a unique ADHD condition. A total of five children were on-boarded with the recommendations of experts in special educational needs. Table 5.3 shows a detailed description of the child and comorbid condition. The average age of the children was 10.7 years. We were cautious to include children across all three types of ADHD.

Table 5.3: Participant Selection

<i>Sample No.</i>	<i>Age (in years)</i>	<i>ADHD Condition</i>	<i>Pursuing Class</i>
1	11.5	Attention deficit type in comorbid with oppositional defiant disorder and anxiety	6th std.
2	10	Hyperactive type in comorbid with oppositional defiant disorder and anxiety	4th std
3	10	Hyperactive type of ADHD	4th std
4	14	Inattention type in comorbid with anxiety and learning disability	7th std
5	8	Combined type in comorbid with oppositional defiant disorder	2nd std

#### 5.3.2.4 Experimental Setup

We tested each child at their respective homes, or schools, or remedial centers in a typical learning environment. The experimental setup consisted of an iPad Air M1 chip, a Sony camera, a tripod, and a chair table sitting arrangement where the children study at their respective learning arrangements. iPad was used as the reading device. Also, iPad was used as a screen recording device to check if the child was reading correctly. Sony camera was used for the frontal recording to check body or facial movements. The tripod was used to hold the camera and adjust the camera angles. In the chair table arrangement, the child could adjust the distance between the backrest and the table per their needs. The participating children had the freedom to adjust the brightness and the magnification level of the iPad as per his/her needs. The level of bright-

ness and magnification was observed for each of the runs. We observed and noted each child's brightness and magnification level during each set of the run. The English language content was provided to the child on the iPad. A new stimulus was presented for each unique variable combination. The variation was maintained to prevent the learning effect. The experimental setup used can be seen in Figure 5.3.

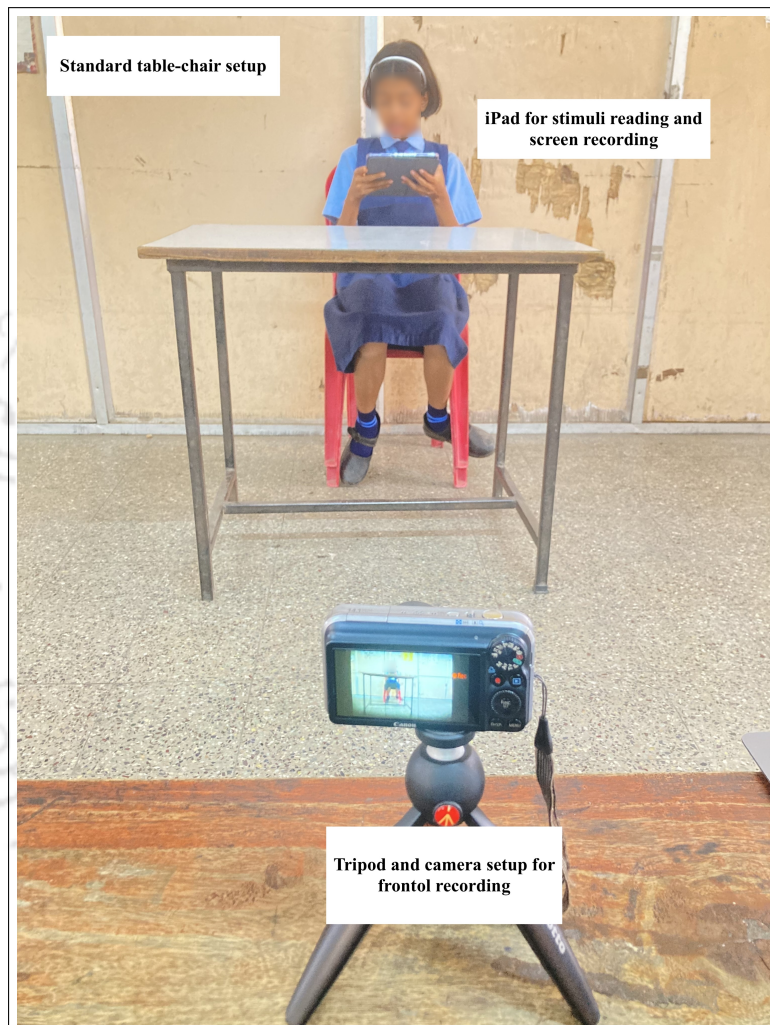


Figure 5.3: Experimental set up of the pilot study

### 5.3.2.5 Protocol

Each child was tested over nine days with nine different parametric combinations (see appendix D). Each parametric combination test lasted for approximately 15 minutes, including the setup time. Each of these parametric combination was recorded thrice at an interval of 5 minutes each. This testing of ChADHD was conducted at their respective studying zones at school, home, or

remedial centers forming a natural learning environment in presence of a caregiver, or remedial expert. They were assured that they could start the test when they were ready for the test, and could stop, or quit if they wanted to. Each child read the content aloud without any distractions. We recorded the children during the reading tasks for their facial, and body movements. We ensured to follow COVID appropriate behaviour, and safety protocols. Author recorded each of the child three times for each of the parametric combination, this was done to ensure that there wont be any human or bias error in this study.

#### **5.3.2.6 Data collection and analysis**

Researcher modified the traditional observation-based attention span estimation technique to estimate the attention span of ChADHD (Gordon et al. (2006)). This method was suggested and taught by the experts in special educational needs who participated in this research work. This method was further validated from three experts in special education needs. In this procedure recordings from front and the back were carried out for each of the stimuli. These recordings were used to estimate the attention span of ChADHD. The frontal recordings helped us in the monitoring the facial, and body movements of ChADHD. The back recording from iPad were used to observe the flow, and correctness of the reading. The participating experts in special educational needs estimated the attention span using both frontal, and backward recording. Both the experts estimated the attention span for a specific stimuli of a child. The estimations of both the remedial expert was averaged to avail the attention span for a particular stimuli. The estimated outcomes were correlated to the signify the impact of font size and font type on the attention span of ChADHD using the fit regression analysis model in the Minitab software. Further, we also noted the qualitative findings observed during the testing, and the recorded videos.

#### **5.3.3 Results and Discussion**

Appendix D represents the measured attention span per run per child. The first two columns of the table represent the standard order and the randomized order of different combinational runs. Columns five states the sample i.e., the child tested for that run. Further, columns six, and seven

represent the font size and font type for the specific runs. The last column states the respective estimated attention span for each run.

The table 5.4 presents the fit regression analysis for the estimated attention span for each of the stimuli combinations. Analysis observes a p-value  $< \alpha$  ( $\alpha = 0.05$ ), suggesting that the digital font type has a significant impact on the attention span of ChADHD. However, through inferential statistics, the font size has no significant impact on the attention span of ChADHD.

Table 5.4: Analysis of variance

<i>Source</i>	<i>DF</i>	<i>Adjusted Sum of Squares</i>	<i>Adjusted mean square</i>	<i>F-value</i>	<i>P-value</i>
<i>Regression</i>	7	23978.0	3425.4	11.38	<b>0.0</b>
<i>Font Size</i>	1	778.9	778.9	2.59	0.116
<i>Children Participants</i>	4	7012.9	1753.2	5.83	0.001
<i>Font Type</i>	2	16433.0	8216.5	27.31	<b>0.0</b>
<i>Error</i>	37	11133.2	300.9		
<i>Lack-of-Fit</i>	36	8955.2	248.8	0.11	<b>0.995</b>
<i>Pure Error</i>	1	2178.0	2178.0		
<i>Total</i>	44	35111.2			

Figure 5.4 shows the uniformity in data points distribution, to which we state that the font has an impact on the attention span and the sample size is sufficient enough for the study. Further, we also infer that the font size might not have a significant impact on the attention span but there is a marginal impact of the font size on the attention span of ChADHD. The existence of skewness suggests the marginal impact of the font size. Although the font type has a significant impact, it is necessary to further test for a longer time span and with higher number of participants.

To get a better clarity about the impact of font type and font size it is necessary to look at the inferential statistics. Figure 5.8, figure 5.9, figure 5.10, figure 5.11, and figure 5.12 presents the line chart of estimated attention span vs the eVDGs combinations for each child. Inferential statistics show that font type and each participant as a variable significantly impact

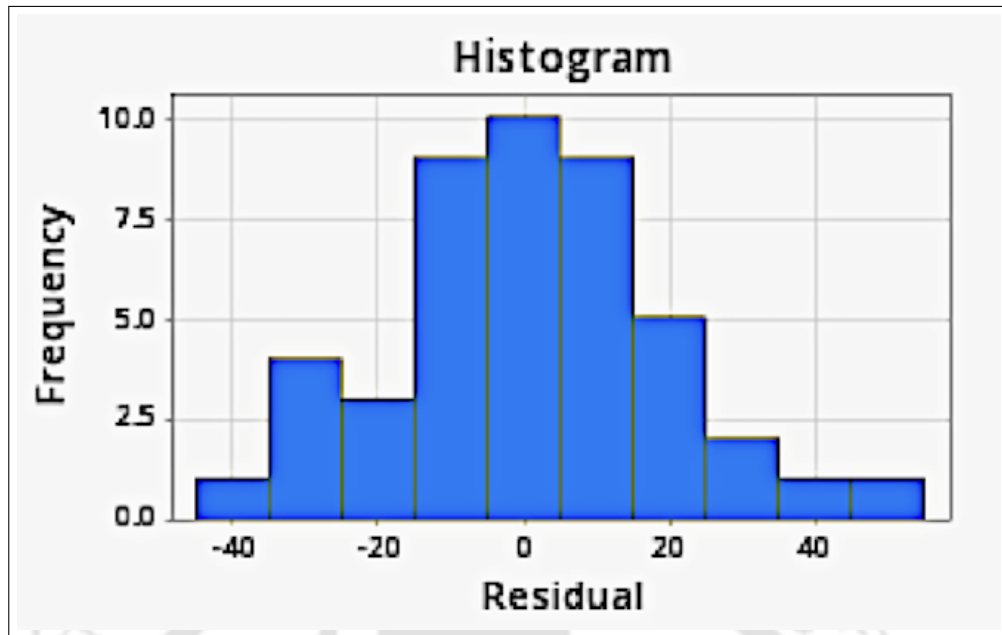


Figure 5.4: Histogram for attention span (in seconds).

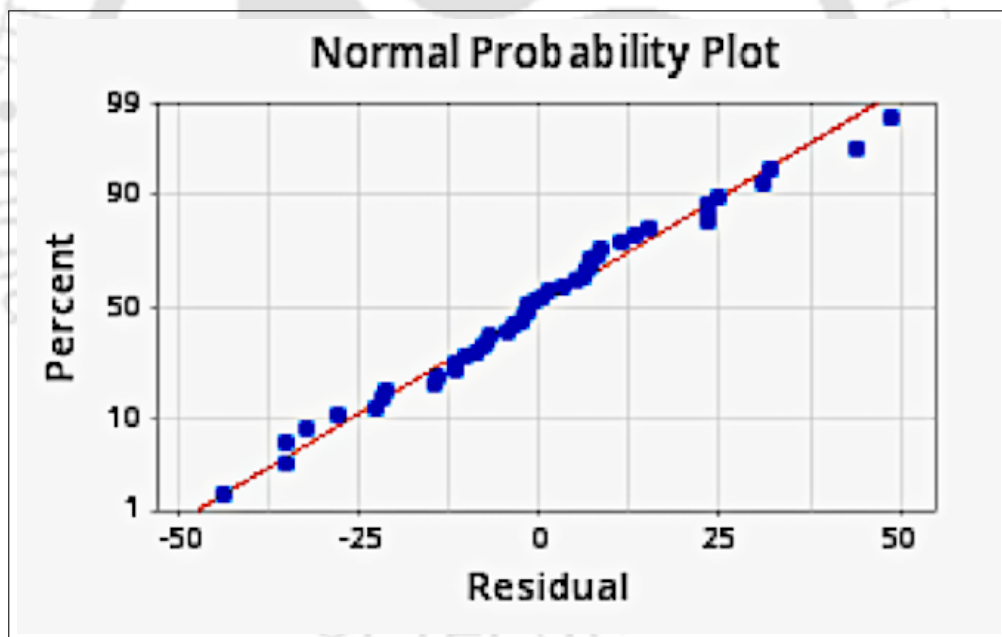


Figure 5.5: Normal probability plot for attention span (in seconds).

the attention span. The graph trend indicates a consistency in graph patterns in case of all the five participating children.

From figure 5.8, figure 5.9, figure 5.10, figure 5.11, and figure 5.12 in case of all five children, font type A, Mali, showed maximum attention span compared to the Cavolini and Lucida handwriting. Cavolini has a comparable impact to Mali font type. However, we could only ob-

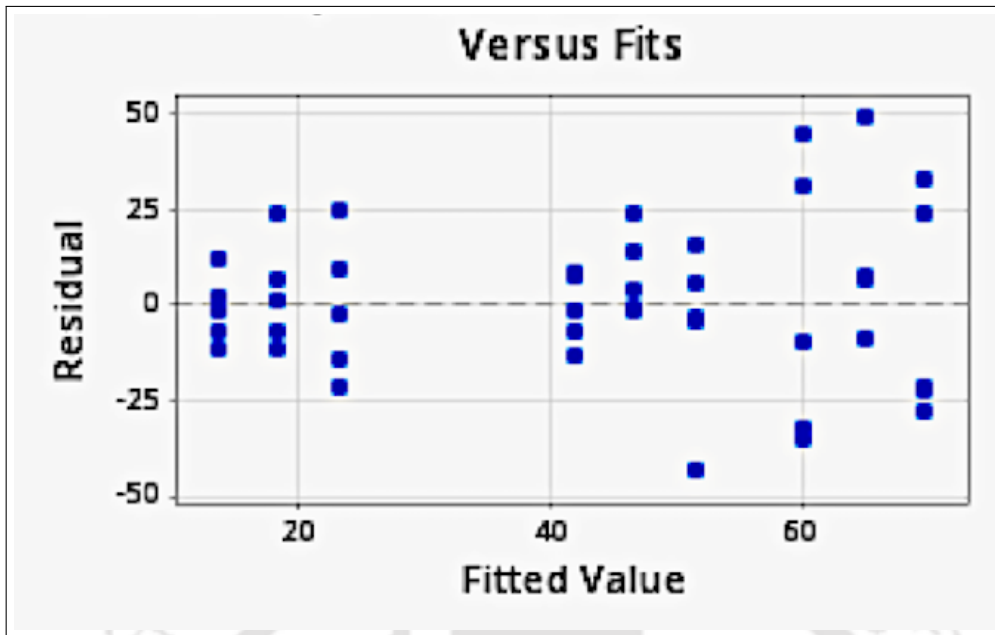


Figure 5.6: Versus fit plot for attention span (in seconds).

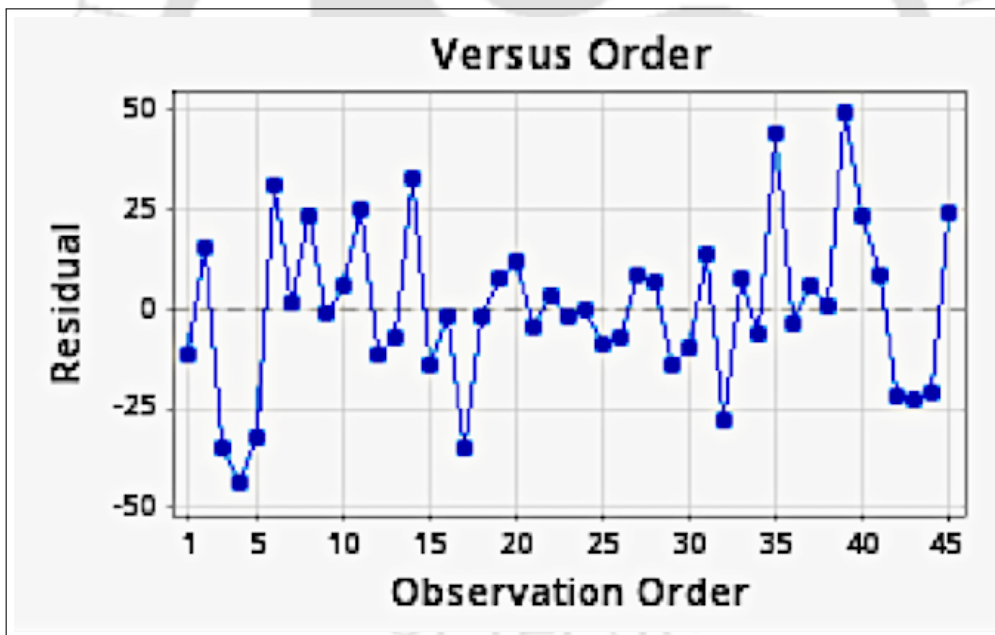


Figure 5.7: Versus order plot for attention span (in seconds).

serve the maximum impact due to the Mali font type. The use of Lucida Handwriting led to the least attention span in all five cases. Mali font demonstrated the highest attention span, possibly because it looks like a handwritten font and has clean visualization compared to the other two fonts. The Cavolini font type has a comparative impact on Mali. However, some letters created confusion, and children mispronounced them. One such instance is that the letter 'b' resembles the letter 'k' in Cavolini font type; thus, children pronounce it 'k' instead of 'b'. Further,

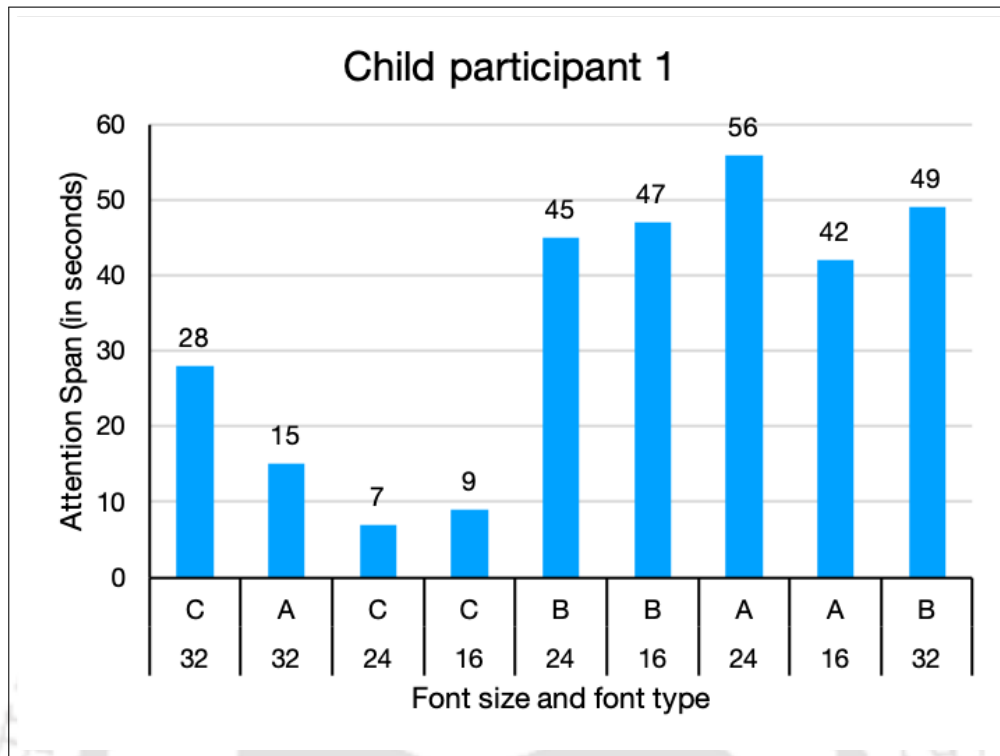


Figure 5.8: Line plots of attention span vs eVDGs combinations for Child participant 1

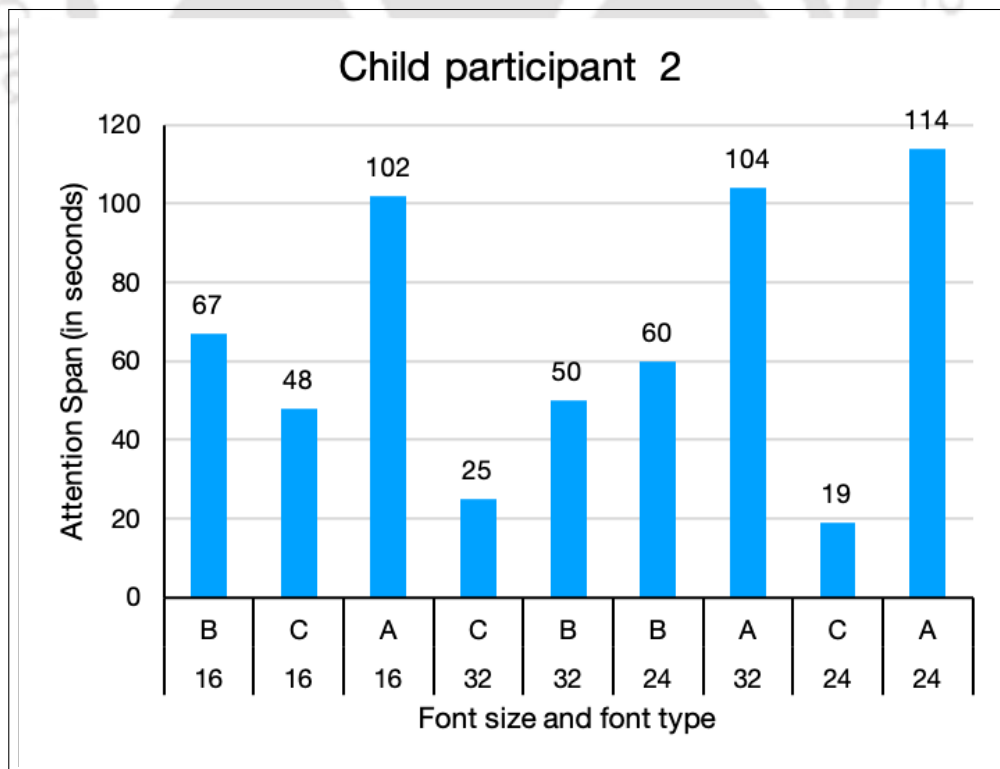


Figure 5.9: Line plots of attention span vs eVDGs combinations for Child participant 2

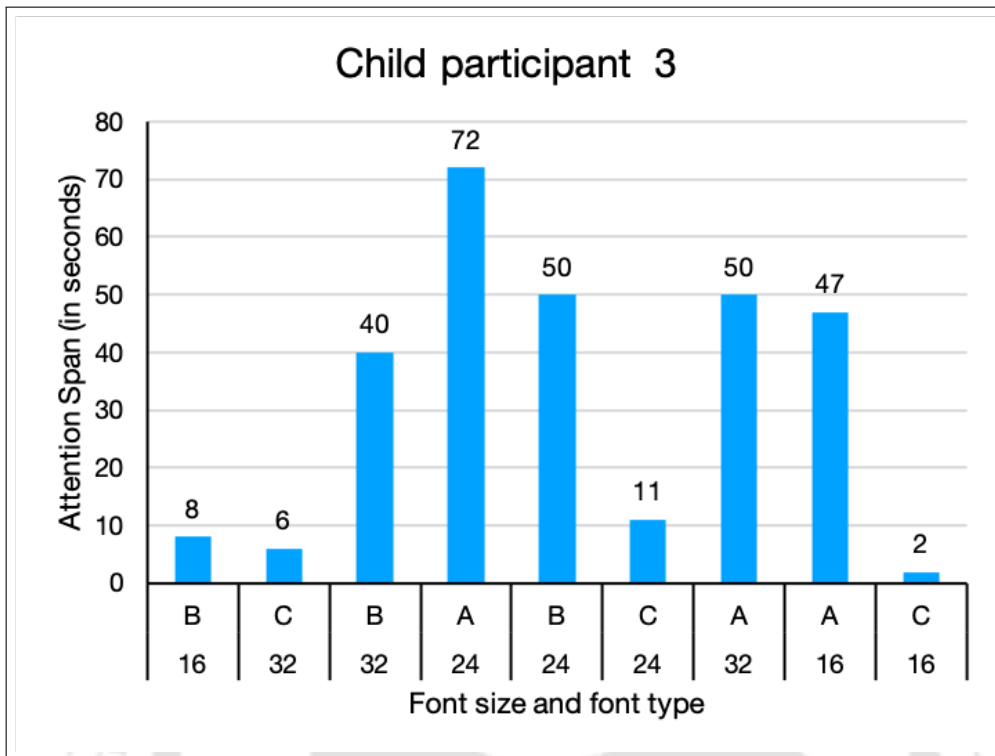


Figure 5.10: Line plots of attention span vs eVDGs combinations for Child participant 3

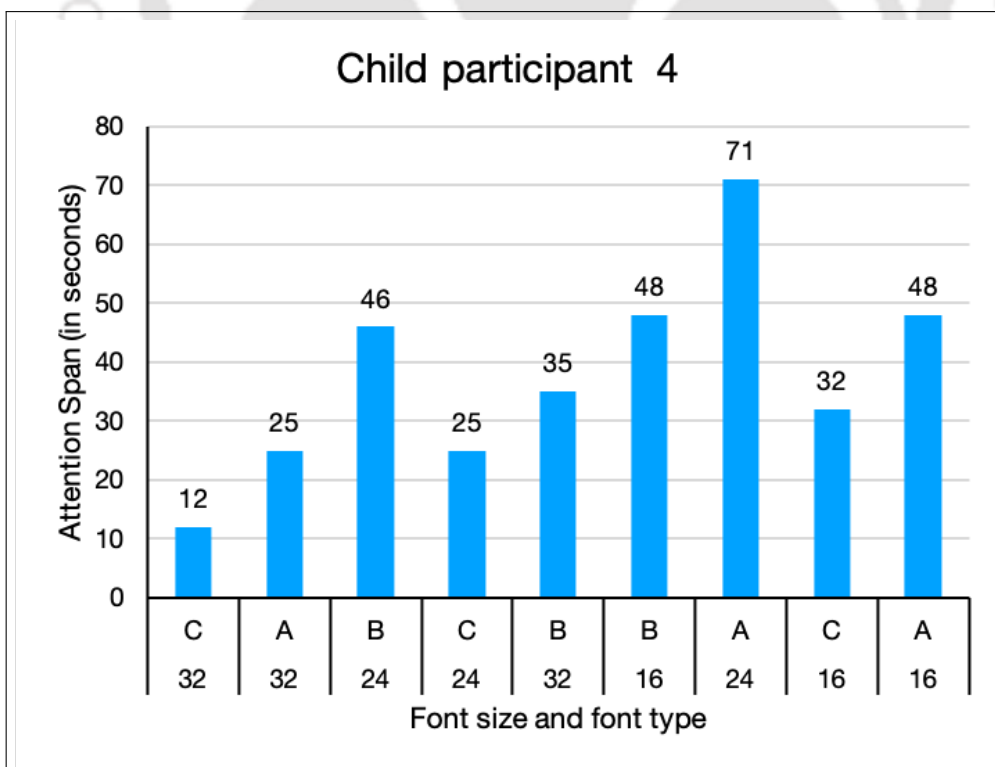


Figure 5.11: Line plots of attention span vs eVDGs combinations for Child participant 4

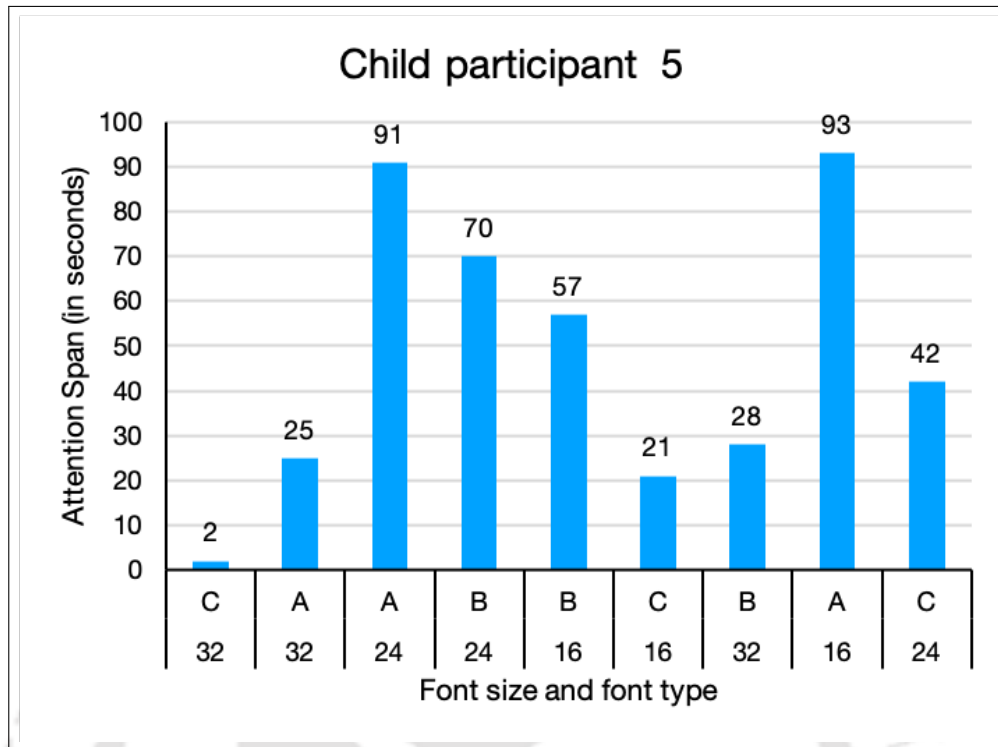


Figure 5.12: Line plots of attention span vs eVDGs combinations for Child participant 5

Cavolini is a clean font type, but the confusion created due to the visual similarities between letters had a negative impact on the ChADHD. Also, the children's attention span increased, but they read and learned the wrong words, or they just missed the flow due to improper sentence formation because of the wrong visualization. In the case of Lucida's handwriting, although it looks like a handwritten font type, it was not clean and clear and was difficult for the children to read. ChADHD needs a font type that resembles a handwritten font type, which is clean and straightforward to read through this observation. Thus we identify Mali is an appropriate for font type for ChADHD.

The three font sizes (16pt., 24pt., and 32pt.) had different attention spans. The combination of font type Mali and font size of 24 pt. had the maximum attention span in all five cases. This combination can further enhance and provide the maximum attention span of ChADHD. The font size had no significant impact on ChADHD through the inferential statistics. Nevertheless, the common observation was that font size had an impact on ChADHD. Thus, studying descriptive statistics through graphs, it is evident in all the five cases that the font size impacted the attention span of ChADHD. The font size of 24 pt. has the maximum attention span in each case. Thus, on an US page size page of a digital interface (tablets and mobiles) font size of 24pt. has an optimal impact on the attention span of the children living with ADHD. We find that font

size 24 pt. is suitable for the US letter size, but what in case of change in the canvas, or the page size. We find a proportional relation from non-peer reviewed articles, and suggestions from the participating designers. Though the calculation may need validation, it stands relatively strong in our case. The relation is that on multiplying the smaller length of the frame by 2.9 when the measurements are in inches, then rounding up to the closest integer we get the relevant font size. The optimal combination that designers and educators can use on digital interface US letter size sheet is the use of Mali as font type and 24pt. as the font size. In our case the frame size is US letter size, its dimensions are 8.5 x 11 inches.

$$\text{Fontsize} = \text{Smallerlength} * 2.9 \quad (5.1)$$

$$\text{Fontsize} = 8.5 * 2.9 = 24.65 \quad (5.2)$$

The calculations also revealed the a closer value of 24.65 pt. to our research finding of 24 pt. for a US letter size page.

Experiments also led to some non-calculated outcomes regarding brightness level, and the screen magnification percentage while reading the provided content. These outcomes were in a typical learning environment under complete illumination. Appendix D.2 shows that children preferred the brightness level to 40-50% of the total brightness. When the brightness increased or decreased from the 40-50% level, the children's faces showed irritation and stress, lowering their attention. children preferred a magnification level of 100% for a font size of 24pt., 16pt. or 32pt. Children report that a higher or lower magnification reduces the document's readability as the page size exceeds the screen size and thus again impacting the attention span. The optimal combination that designers and educators can use to design content for these children is Mali as the font type, 24 pt. as the font size, 40-50% of the brightness level, and 100% magnification level (fit size).

### **5.3.4 Summary**

This pilot study states that a systematic content representation of digital platforms, and devices can enhance the attention span of the children living with ADHD. Thus, the eVDGs do have an impact on the attention span of ChADHD. To validate this statement author has selected font size and font type for testing their impact on the attention span of ChADHD. Author choose font size and font type as these element are the most used element in the composition, also the experts in special educational needs had majorly emphasised on these two elements.

The variation in the combination of font size and font type affected the attention span of all the children in a similar pattern. A specific combination of Mali font type and 24 pt. font size enhances the attentions span of ChADHD. However, a common relation between font type and font size was not studied as the aim was only to study the impact on the attention span and not the correlation in font size and font type. Next, the method used in this study is applicable to test the impact of eVDGs on ChADHD and generate a relevant, and valid set of VDGs for the content representation of digital platforms, and devices used by ChADHD.

## **5.4 Main Study**

### **5.4.1 Introduction**

This study (main study) is the extension of the pilot study. Here, we expand the our identification for a larger number of eVDGs for the content representation of the digital platforms, and devices used by ChADHD. In the pilot study 5.3 we identify that eVDGs have a positive impact on the attention span of ChADHD. Further, the method used is applicable for the testing of eVDGs with ChADHD. Thus, in this study we follow the validated method and identify a larger set of appropriate eVDGs for the content representation. The study identifies five major eVDGs namely - font type, font style, line spacing, background color, and picture type. These elements are adopted from expert recommended VDGs in Chapter 4.

## **5.4.2 Method**

### **5.4.2.1 Research Design**

This study is an extension of pilot study. This study refines the eVDGs used for the content representation of digital platforms, and devices used ChADHD. Study is the second part (1B) of first stage of the adopted NIH stage model as shown in Figure 2.1. It is a within-group study for identifying the appropriate combinations of the eVDGs - font type, font style, background color, color combinations, illustration style, and line spacing on the attention span of ChADHD. These variables are adopted from the Chapter 4. A different parametric combinations are generated to test the impact with ChADHD. This systematically combination of parameters study helped us to generate full factorial analysis table, which was randomized and administered to the participating ChADHD. The study includes three major stakeholders experts in special educational needs, designers, and ChADHD. The children are tested at their natural typical-learning environment at homes, schools, and remedial centers.

### **5.4.2.2 Variables and stimuli**

The combinations of expert recommended eVDGs variables reported in Chapter 4 were used to design the stimuli. These dependent, and independent variables are shown in Table 5.5. From Table 5.5, the standard variable refers to adopting the content representation styles/elements from the regular school textbook as it is in the digital form and comparing with the content representation elements identified in this research study. Next, the context-specific illustration style refers to design based on specific guidelines adopted from the expert recommended VDGs.

Author selected bionic reading as one of the parameter as it was suggested by Ren (2021) to enhance the attention span of Children living with Autism and further also can enhance the attention span of ChADHD. Next author also choose Peach to test in the background as researchers had observed that Peach background colour enhanced the reading of children with dyslexia Rello and Bigham (2017). The combination of variables in table 5.5 were used to generate the parametric combinations for stimuli design. The length of the stimuli was set between a word count of 200-250 words. The content was adopted from the English language

Table 5.5: Study Variable

<i>Variable Type</i>	<i>Variables</i>	<i>Levels</i>	
Independent	Font type	Mali	Standard (Times)
	Font style	Bionic	Without Bionic
	Background color	Peach	White
	Picture type	Type-1	Type-2
	Line spacing	1.5	2
Dependent	Attention span (in seconds)	-	-

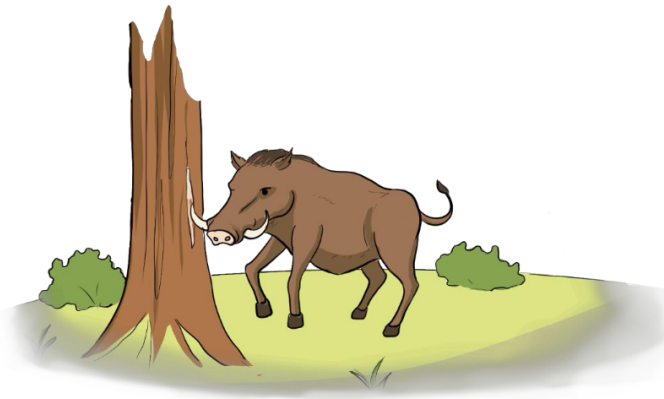
textbook of the class the child is studying. The designed stimuli were generated on a digital US letter-size page document. The margin was set to 2.5 cm from all the four sides. The design directions used in this study for the illustration design are – type-2 illustrations matching with the subordinate text, use of a maximum of three-color combinations in a single illustration, representing the characters in cartoonist form but replicating the real-world form, excluding the non-contributing elements and having warm colors in foreground.

The participating designer, designed these illustrations based on the guidelines adopted from the previous published studies, and the other two authors validated the illustrations. Figure 5.13 represents 'stimuli A', combination of font type mali, font style without bionic, line spacing 2, white background, and type-2 illustration style. Figure 5.14 represents 'stimuli B', a combination of standard font type, bionic font style, peach background, standard line spacing, and type-1 illustration style. In case of an opinion contradiction between the two validating authors, a third researcher was introduced to solve the contradiction. A randomized full factorial design of these variable combinations was tested for a standard running font size of 24pt, title or heading by 26pt, and footnotes 22 pt. Between title and running text- 1.0 cm, between running text and images- 1.35 cm, and images and running text - 1.35 cm.

#### **5.4.2.3 Participant Selection**

This study included two types of participants: (a) experts in special educational needs and clinical psychologist and (b) ChADHD. A total of two experts in special educational needs and 1 clinical psychologist were recruited for the study. These experts in special educational needs

## The Wild Boar and the Fox



One day, a wild boar was sharpening his tusks against the bark of a tree. He was doing it very carefully. There lived a fox in the same forest. He was always looking for a chance to make fun of other animals in the forest. When he

Figure 5.13: Stimuli A

and clinical psychologist have experience in testing and managing ChADHD for an average of twelve years. They assisted in estimating the attention span of ChADHD against each stimulus and recruiting ChADHD for this study.

## The Legend of Marathon



**About two thousand and five hundred years ago, Persia was a mighty kingdom. Their large army had landed in the bay near the town of Marathon. Their target was Athens, a city state in Greece. Athens had a small army compared to the Persian one. But the Athenian soldiers were very brave. They had faced the Persians before, but they needed help from**

Figure 5.14: Stimuli B

A total of twenty-four children were recruited for this study. The equation 5.3 states the formulae for sample size selection (Sharma et al. (2020)).

$$s = z^2 * P * (1 - P) / M^2 \quad (5.3)$$

- $Z = z$  score at 95% confidence intervals.
- $Z = 1.96$
- $P =$  Population size of ChADHD between age group of 5-14 years.
- $P = 1.25\%$
- $M =$  margin of error.
- $M = 0.05$

$$s = (1.96)^2 * 0.0125 * (1 - 0.0125) / (0.05)^2 \quad (5.4)$$

$$s = 3.841 * 4.9375 \quad (5.5)$$

$$s = 18.96 = 19 \text{ChADHD} \quad (5.6)$$

The criteria for inclusion of these children were – The child should have one of the three types of ADHD, within an age group of 5-14 years, and be able to read English language textbooks. The criteria for exclusion of the children were – should not have another physical or mental disability or disorder (other than ADHD and acceptable comorbid conditions). Acceptable comorbid conditions are Autism spectrum disorder, Learning disorder, Opposition defiant disorder, behavioral disorder, and characteristic anxiety. For the verification of ADHD in the recruited child, these children were retested for ADHD using the Vanderbilt teacher and parent rating scale. On the confirmation of the participation of the child, formal written consent was obtained from the parents. A verbal consent was also taken from the child. A verbal consent was also taken from the child. Assurance was given to the parents and children through the consent form and verbally that the data and personal information would be anonymous. An equal number of attention deficit type, hyperactivity type, and combinational type ChADHD were recruited in the study. Table 5.6 represents the details of the children participating in this study. The average age of the children was 10.4 years.

Table 5.6: Profile of participating ChADHD

<i>Number of ChADHD participating</i>	<i>Average Age (Years)</i>	<i>ADHD Condition</i>	<i>Average Educational Level</i>
7	11.6	Attention deficit type of ADHD.	Class 4 <sup>th</sup>
9	10.5	Hyperactivity type of ADHD.	Class 5 <sup>th</sup>
8	9	Combined type of ADHD.	Class 4 <sup>th</sup>

#### 5.4.2.4 Experimental Setup

We tested each child at their respective homes, or schools, or remedial centers in a typical learning environment. The experimental setup consisted of an iPad Air M1 chip, a Sony camera, a tripod, and a chair table sitting arrangement where the children study at their respective learning arrangements. iPad was used as the reading device. iPad was also used as a screen recording device to check if the child was reading correctly. Sony camera was used for the frontal recording to check body or facial movements. The tripod was used to hold the camera and adjust the camera angles. In the chair table arrangement, the child could adjust the distance between the backrest and the table per their needs. The participating children also had the freedom to adjust the brightness and the magnification level of the iPad as per his/her needs. The level of brightness and magnification was observed for each of the runs. The English language content was provided to the child on the iPad. A new stimulus was presented for each unique variable combination. The variation was maintained to prevent the learning effect. The experimental setup of this study is shown in Figure 5.3.

#### 5.4.2.5 Protocol

Each child was tested for twenty days for thirty-two different stimuli. Seven hundred sixty-eight runs were conducted for Seven hundred sixty-eight distinct stimuli on twenty-four children. Each child was tested for two stimuli daily (one in the morning and one in the evening). Each child was observed for a single stimulus three times with an interval of five min between each observation. A total of three observations were recorded for each child. The average period needed for one experiment was thirty-five minutes, including the setup time. These observations

were performed in each child's respective study zones. Observations in the child's study zone created a natural learning environment for these children. These children were informed of their right to quit or stop if they felt to do so or in case of any unease or unrest. Children were recorded for their facial and body movements once they were ready for the experiment.

#### **5.4.2.6 Data Collection and Analysis**

Video recordings were used to estimate the attention span of the child for each of the stimuli run. A child psychologist performed these estimations with a professional experience of more than ten years. The average attention span for each of the runs was calculated. The outcomes were correlated with the significance of independent variables. A fit regression analysis model in Minitab software was used to identify the significance of the variables with the attention span.

#### **5.4.3 Results and Discussion**

This study followed a co-designing approach by engaging experts in special educational needs, clinical psychologists, and ChADHD to study the impact and identify appropriate elements of identified independent eVDGs on the attention span of ChADHD. To study the impact and identify the relevant eVDGs a NIH stage model methodology was followed. One might ponder the reason behind using clinical methods and medical experts in this study. Further, a designer can argue for only including design methods while designing and testing ChADHD and not including the clinical trial methods. Nevertheless, while designing a behavioral modification method, tool, and technique, it is a must to follow a prescribed set of rules and techniques so that it does not create a negative impact on the individual living with a disorder or disability.

The inclusion of experts in special educational needs and clinicians becomes helpful in managing and testing the children effectively. The NIH stage model and study by Cibrian et al. (2022) show the necessity of using clinical trials and co-designing approach for identifying the relevant eVDGs. Thus, this study follows the NIH stage model and includes clinical psychologist, experts in special educational needs, ChADHD, and designers to identify effective and relevant eVDGs for the curriculum-based content design of digital devices and platforms used by ChADHD. The study recruits equal number of children living with each of the three dif-

ferent types of ADHD to avoid biases or errors. Study follows the stage 1 of the NIH stage model. The stage 1 of NIH model states the steps for the identification and modification of behavioral management ways. Here, the identification of the eVDGs is a part of developing a behavioral modification tool. Thus, the study identifies the eVDGs by following the NHI stage 1 methodology by working with experts, designers and children in a real learning environment.

The table 5.7 presents the results of analysis of variance (ANOVA). This helped in the assessment of the significance of the factors influencing the attention span of ChADHD. The table includes the sources of variation, degrees of freedom (DF), the adjusted sum of squares, adjusted mean squares, F-value, and corresponding p-values. The regression model, including Line Spacing, Child Samples, Picture Type, Background Color, Font Style, and Font Type, significantly affected the attention span of ChADHD. The model explained a substantial proportion of the variance, with an adjusted sum of squares of 483,652 and an adjusted mean square of 17913 (483652/27).

Table 5.7: Analysis of Variance

<i>Source</i>	<i>DF</i>	<i>Adjusted Sum of Squares</i>	<i>Adjusted Mean of Squares</i>	<i>F-Value</i>	<i>P-Value</i>
Regression	27	483652	17913	23.14	0.000
Line Spacing	1	11369	11369	14.69	0.000
Font Type	1	71902	71902	92.89	0.000
Font Style	1	101790	101790	131.51	0.000
Background Color	1	96054	96054	124.10	0.000
Pictures	1	872	872	1.13	0.289
Children Participants	22	202099	9186	11.87	0.000
Error	709	548788	774		
Lack-of-Fit	708	548276	774	1.51	0.584

From the table 5.7, it appears that the regression model, along with individual variables like "Line Spacing," "Font Type," "Font Style," "Background Color," and "Child Samples," are

statistically significant contributors to the variation in your dependent variable. On the other hand, "Pictures" does not seem to be statistically significant based on the p-value of 0.289. Further, the adjacent p-value for the lack-of-fit p-value greater than the significance level (typically 0.05) indicates that the model fits the data well. From table 5.7, the p-value for lack-of-fit is 0.584, suggesting that the model fits the data adequately. The model is a good fit for the relation between the independent variables, and attention span. To identify the impact of each independent variable we identify the relative percentage contribution of each independent variable to the regression model. The relative percentage contribution of the variables can be obtained from the equation 5.7:

$$\text{Relative percentage contribution} = (\text{AdjSS for variable}) / (\text{Total AdjSS}) * 100 \quad (5.7)$$

Table 5.8: Relative percentage contribution

<i>Variables</i>	<i>Relative percentage contribution</i>
Line spacing	2.35
Font type	14.84
Font style	21.05
Background color	19.86
Pictures	0.18
Children participants (collectively)	41.72

Note the relative percentage contribution provides a relative measure of the importance of each variable in explaining the variation in the dependent variable (see table 5.8).

Figure 5.15, figure 5.16, figure 5.17, and figure 5.18 represents the residual plots for the attention span estimated in seconds. The saturation of the attention span along the straight line in the first chart, saturation of the points between 30-90 in chart two, and the formation of the bell shape around 0 suggest the model is a good fit. The residual plot observations align with table 5.7. The model's shift is positive as it states that under certain conditions, the attention span tends to enhance. This observation very well defines the impact of independent variables on the dependent variable, and a specific combination of independent variables can significantly

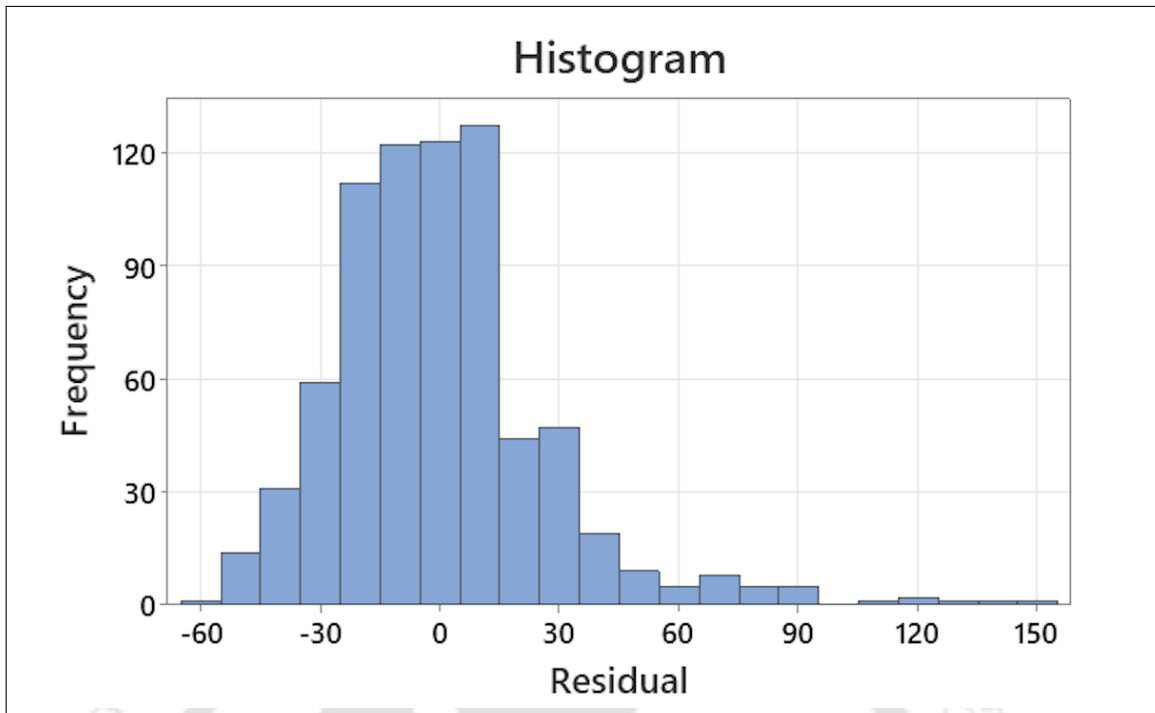


Figure 5.15: Histogram for attention span (in seconds).

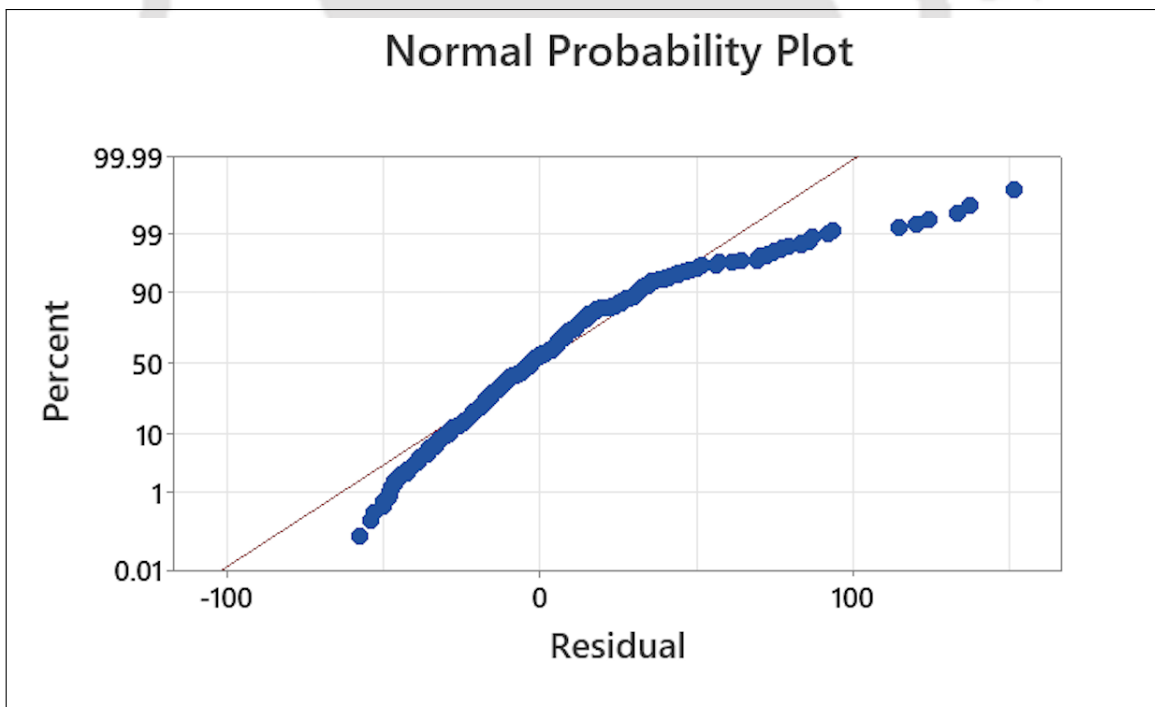


Figure 5.16: Normal probability plot for attention span (in seconds).

enhance the attention span of ChADHD.

Here, we conclude that the identified independent variables significantly impact the attention span of ChADHD. However, the specific conditions which enhance the attention span

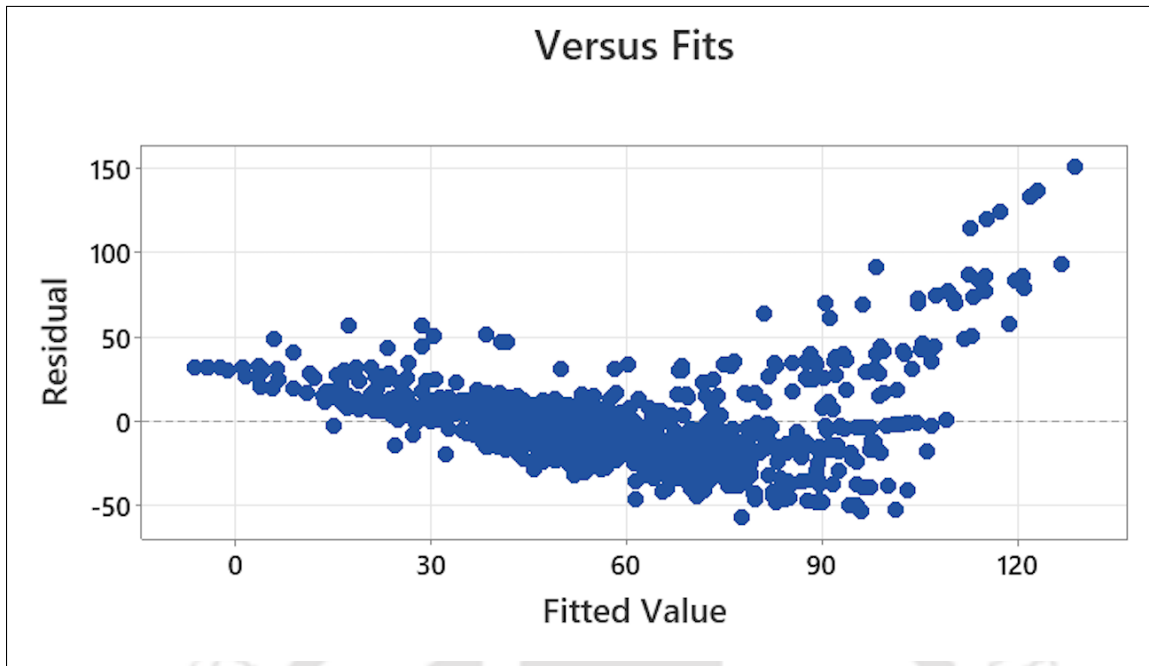


Figure 5.17: Versus fit plot for attention span (in seconds).

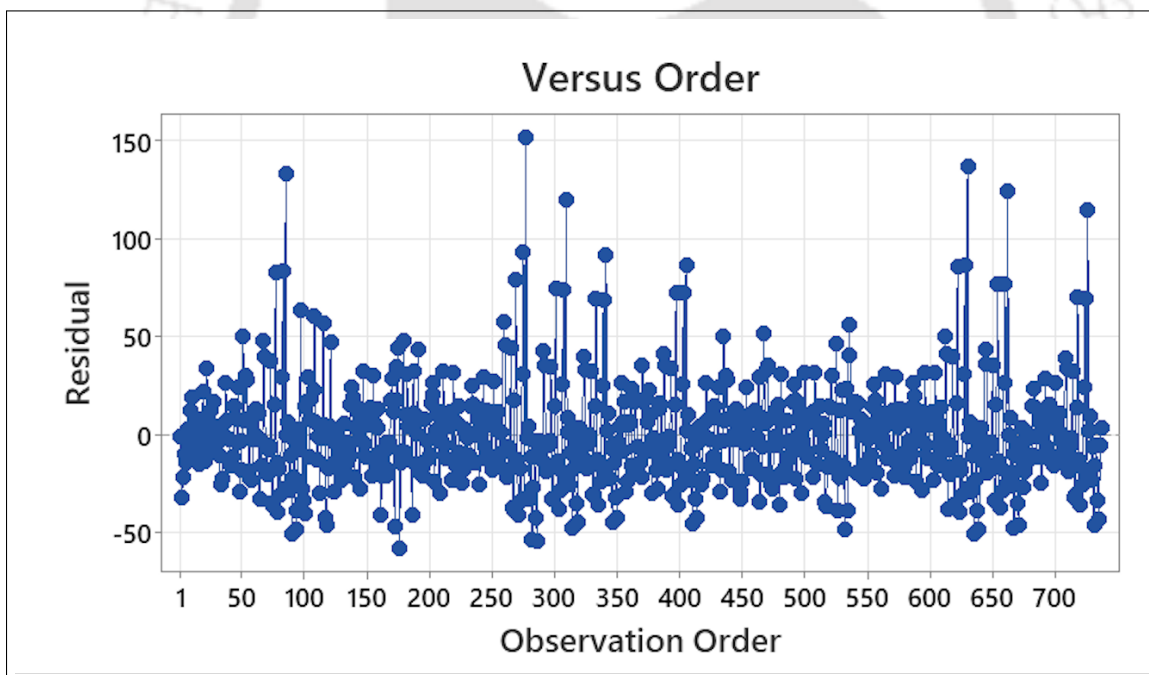


Figure 5.18: Versus order plot for attention span (in seconds).

can only be observed through the descriptive statistics. From the interaction plot and the main effect plot, we can observe that these variables have a particular impact on the attention span of ChADHD. Further, the descriptive statistics also help us to understand how each variable impacts the attention span of ChADHD. Figure 5.19 and figure 5.20 shows the descriptive statistics in the form of an interaction plot and a main effect plot.

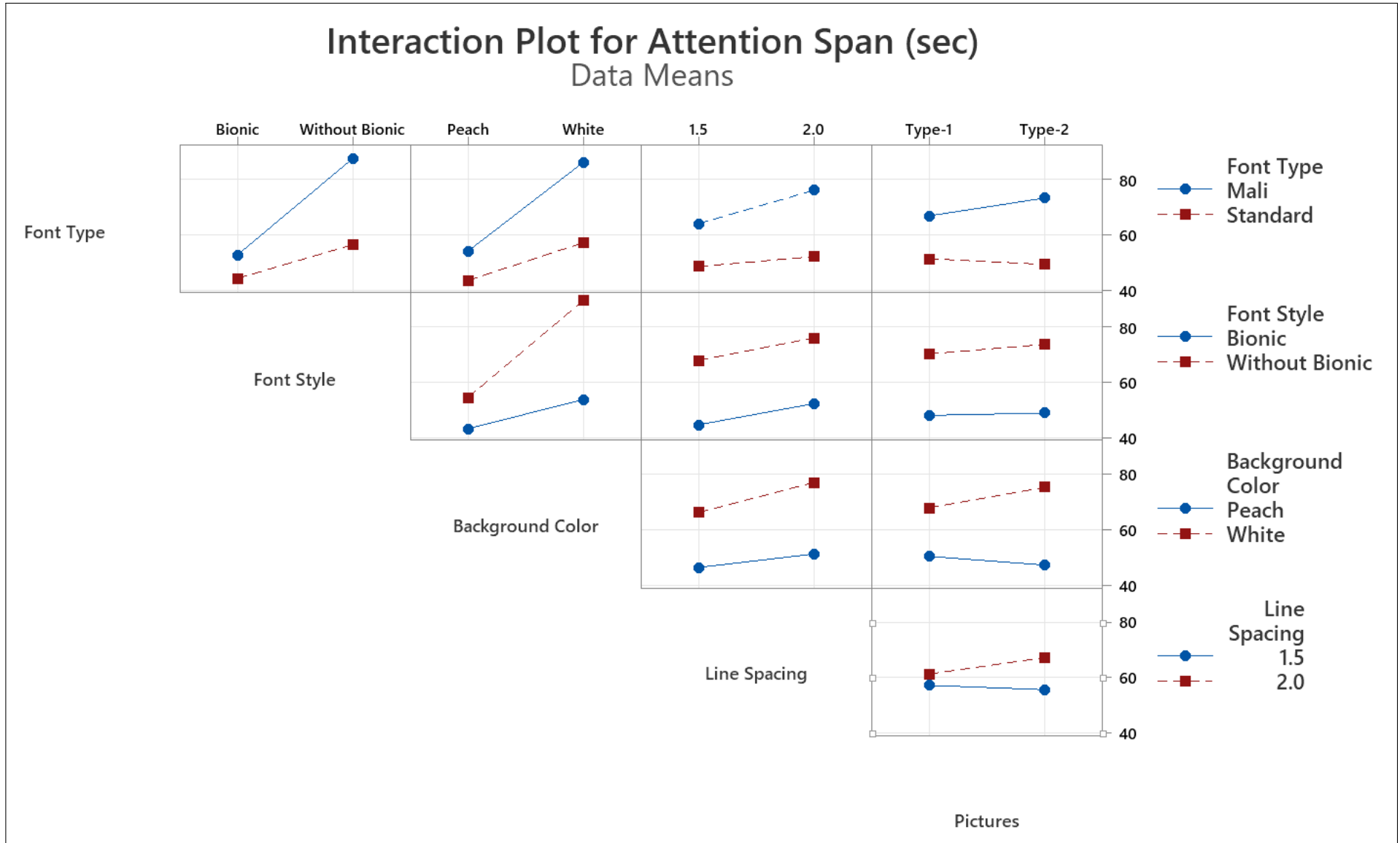


Figure 5.19: Interaction Plot for attention span (in seconds) with respect to study variables

# Main Effects Plot for Attention Span (sec)

Data Means

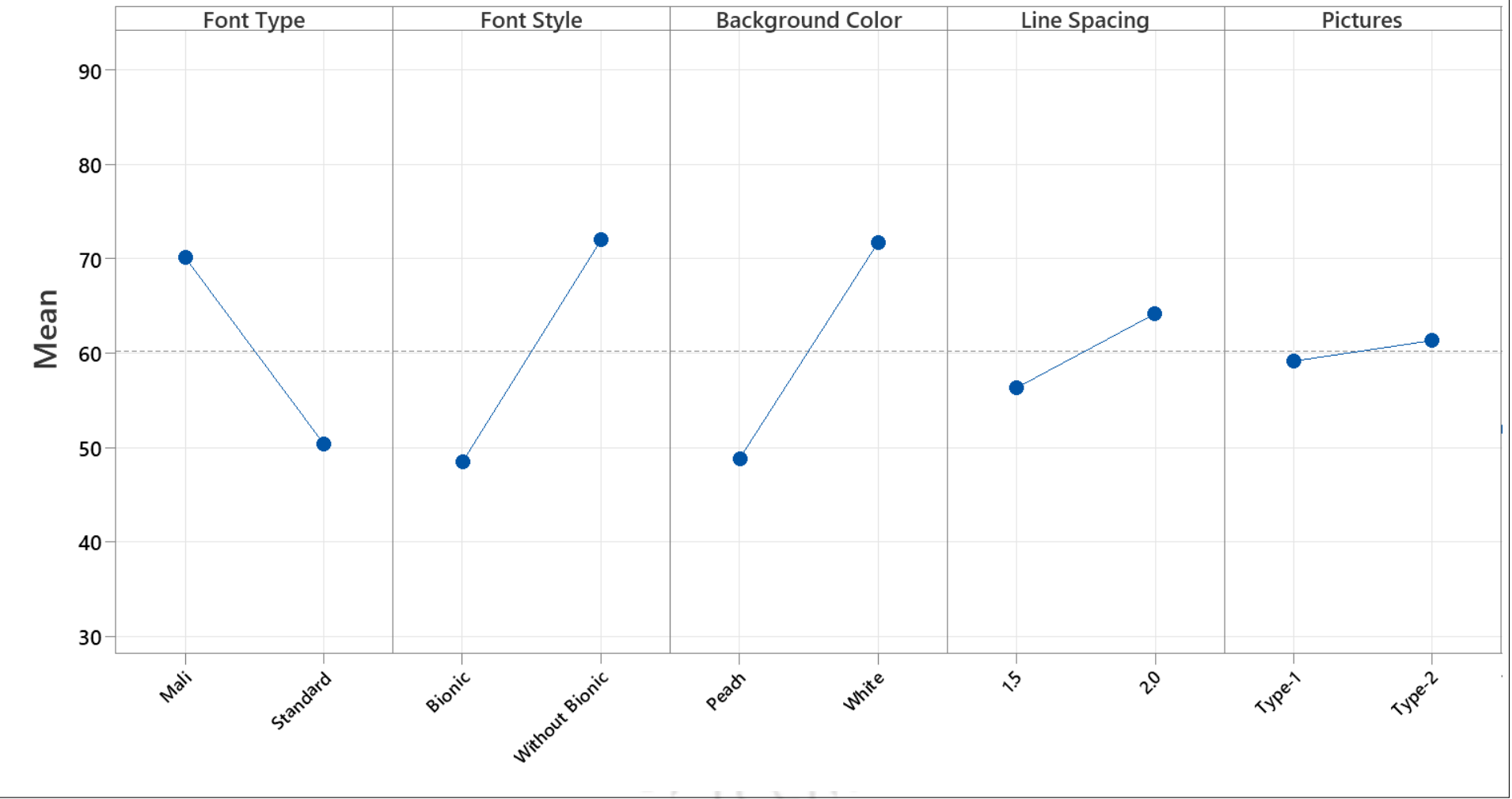


Figure 5.20: Main effects Plot for attention span (in seconds)

From the descriptive plots (figure 5.19 and figure 5.20), it is evident that a combination of specific font-type, font-style, background color, line spacing, and picture type has the maximum attention. A variation in these variable combinations results in a decline in the attention span of ChADHD. Mali font-type enhances the attention span compared to the standard font-type used in the school textbooks. Bionic reading, which is said to enhance the reading of children living with Autism, reduces the attention span of ChADHD. The white background color has a better impact than the Peach color. A double line spacing for the text provides a better reading and attention span. Type 2 picture, which were developed based on the specific guidelines adopted from chapter 4, had a better impact as compared to the illustrations present in the school textbook.

In this study, we identify that the eVDGs - font type, font style, and background color significantly impact the attention span of ChADHD. A combination of font type Mali, font style without Bionic reading, double line spacing and white background results in maximum attention span in the case of all three children. In the contradiction, a standard font size used in school textbooks in combination with Bionic reading and Peach background color resulted in the least attention span. When the line spacing was 1.5, children had difficulty reading the sentences, but on changing the line spacing to double, ChADHD could easily read the sentence. We could not increase the line spacing further because it increased the page length, and also, children needed help following up with the sentences. This case was prominently observed while using the Bionic font style. Children misread the words using the Bionic font style. For instance, in stimuli, the word was ‘**sharpening**’; as the first four letters were bolded, the child only read ‘**sharp.**’ We observed multiple such instances that resulted in misreading or missing out on the words by ChADHD. Another instance was in the case of a single or two-letter word; the child connected the word with the subsequent word or completely missed the word. For instance, the sentence was ‘**if he was really,**’ the child could not read the sentence and skipped the whole line. Thus, Bionic reading was supposed to help ChADHD enhance its reading flow. However, it had a counter impact on the reading ability of ChADHD. Thus, we cannot implement the tools, techniques, and methods that are useful to children living with Autism or similar disorders for ChADHD. Systematic research is a must while designing and developing any management method for children living with each type of disorder or disability.

Regarding picture type, eVDGs did not significantly impact the attention span of ChADHD. Picture representation had a lower percentage of contribution to the attention span of ChADHD.

Thus, the impact of pictures is difficult to judge. However, from descriptive plots and table 5.7, it can be inferred that this eVDGs do have a certain kind of impact on the attention span of ChADHD. The interaction plot clearly shows that the attention span increases with the use of type-2 picture type. A few reasons suggest the reason behind the insignificant impact of picture type. One such reason is that the number of images needed for a composition is under researched. The placement and the alignment of the pictures should be studied. Also, the text contributes to the significant content of the composition. Thus, from these observations, we can infer that the picture has a lower impact and, therefore, the picture type has a lesser significance. Future researchers can dig deeper to identify the relevant placement and number of images necessary for a particular composition. These reasons are the major causes that we speculate on the insignificant impact of pictures on the attention span of ChADHD. Thus, an optimal combination to have a maximum attention span of ChADHD in a typical learning environment is font-type Mali, 24 pt. font size, double line spacing, standard font style, white background, and type-2 picture for illustrations on a digital US letter size sheet. Using this combination of eVDGs to design the curriculum-based content of digital devices and platforms can help to enhance the attention span of ChADHD.

Further, from table 5.7, we can infer that font style has the maximum impact on the attention span, followed by background color and font type. Picture type has the least impact on the attention span of ChADHD. From Figure 5.19 and Table 5.7, we infer that each child sample has a different level of attention span, and the magnitude of visual stimuli is also different. The brightness level of the reading devices set by all three children was 40-50% of the total screen brightness. Further, the magnification was a 100% fit. Here, we identify the same results as identified in the pilot study.

#### **5.4.4 Summary**

This study identifies the relevant visual design element to represent the curriculum-based content of digital platforms, and devices applications used by ChADHD in a typical learning environment. The study presents a novel work by identifying eVDGs for content representation of digital platforms, and devices used by ChADHD through co-designed research work with experts in special educational needs, clinical psychologists, medical experts, and ChADHD fol-

lowing a standard NIHSM methodology, and protocols. Using these eVDGs will help enhance the attention span of ChADHD. Further, it will help designers, educators, and experts in special educational needs to design curriculum-based content for ChADHD. This study's scope is limited to identifying relevant and effective eVDGs. These identified eVDGs need further validation, through a long term testing with ChADHD before stating them as the valid VDGs for the content representation of digital platforms, and devices used by ChADHD. The study conducted in the next Chapter 6 validates the identified eVDGs with ChADHD in their natural typical-learning environment.

## **5.5 Chapter Summary**

This chapter was divided into two relevant studies pilot study, and the main study. In the pilot study we validated the applicability of our research method for testing the eVDGs with ChADHD. Also, we tested if eVDGs used for content representation of digital platforms, and devices has a potential impact. To which we conclude that our method is applicable for testing the eVDGs, and the expert validated eVDGs have an impact on the attention span of ChADHD. In the main study we refined our VDGs, by testing with ChADHD, following the valid method established in the pilot study. The outcomes are novel, and relevant. However, need a longitudinal testing before deploying them in the daily use applications. The next chapter evaluates the potential set of eVDGs identified in this chapter, through a long term deployment with a small number of ChADHD in real-time environment.



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## **Chapter 6**

# **Longitudinal Assessment of eVDGs**

The previous chapter reveals a set of refined eVDGs. It is necessary to test their impact before considering them as an established set of eVDGs. This chapter tests the impact of the eVDGs by testing them with ChADHD in real time for a span of nine months and comparing them with the existing treatments and management techniques used by participating ChADHD. The results show that the identified set of eVDGs have a significantly positive impact in enhancing the attention span of ChADHD when used in the representation of digital content on digital devices and platforms used by ChADHD. Thus, the chapter presents the novel and established set of eVDGs for the representation of digital content on digital devices and platforms used by ChADHD.

### **6.1 Introduction**

This chapter evaluates the impact of the relevant eVDGs identified in the previous chapter to represent the curriculum-based content of digital platforms and devices used by ChADHD in a typical-learning environment. While designing behavioural modification mediums for

ChADHD it is necessary to test the impact of such medium with the users for a minimum of six to nine months Gevensleben et al. (2010). In this chapter author evaluates the impact of such eVDGs on ChADHD for the span of nine months in a real time typical-learning environment. It is identified that the elements like font size, font type, line spacing, background colour, alignment and illustrations have an impact on the attention span when appropriately used. However, it is necessary to follow certain set of standard procedures while testing the mediums.

In this study to evaluate the impact of eVDGs and generate relevant eVDGs author combines the third stage of NIHSM with the co-design approach. A total of thirty-six ChADHD, their parents, experts in special educational needs, clinical psychologist, designers and caregivers were involved. The thirty-six children were randomly divided into two categories control group and treatment group. Author, recorded and estimated the attention span of these children pre-intervention and post-intervention with the assistance of experts in special educational needs and child psychologist. Post the analysis author identifies that intervention has a significantly positive impact in enhancing the attention span. Thus, the use of VDGs used in representation of e-content helps in positive behavioural modification of ChADHD by enhance the attention span. The VDGs presented in this study are novel and of greater value adding knowledge to the management community of ChADHD.

The rest of the chapter is divided across four standard sections - method, results, discussion and conclusion. The next section states the detailed methodology used in this study to evaluate the impact of VDGs on the attention span of ChADHD. The result section presents the results and analysis of the impact of the VDGs. In the discussion phase the author discusses the results and observations in detail and also provides the qualitative feedback obtained from different stakeholders. In the last section author concludes the study by briefing the outcomes, novelty, limitations and future scope for the study.

## **6.2 Chapter Objectives**

1. Recruit ChADHD, estimate their attention span, and randomly categorize in treatment, and control group prior to the intervention.
2. Regular designing, and supply of stimuli to the treatment group for a span of nine months,

3. Estimate the attention span of ChADHD of treatment group, and control group post nine months.
4. Analyse the estimations, and observations to generate a relevant, and valid set of VDGs.

## **6.3 Method**

### **6.3.1 Research Design**

This chapter of the study is a between group study to evaluate the impact of the eVDGs deployment over a longitudinal time span. thirty-six ChADHD were randomly divided in two groups treatment and control group. It was assured that the study included equal number of deficit type, hyperactive type and combined type of ChADHD. All the children were evaluated for their attention span pre-intervention. The experts in special educational needs and clinical psychologist estimated their attention span. The children with treatment group were received the specifically designed stimuli for the span of nine months. At the end of the study the attention span of both the groups were estimated following the standard procedure and the impact of the eVDGs was evaluated comparing both the groups. The pre and post attention span of ChADHD from both the groups was estimated against the stimuli designed using appropriate eVDGs.

### **6.3.2 Stimuli**

The stimuli were designed by adopting the appropriate eVDGs identified in the detailed Study of identifying the appropriate eVDGs. Figure F.2 of appendix F shows one of the sample of test stimuli. See that it is an adapted form of the conventional lesson plan from the state board text book (see figure F.1 of appendix F). These stimuli were prepared for a span of nine month for the children participating on the treatment group. The eVDGs combination included - Mali font type, Running font size 24 pt., title and heading font size 26 pt. and footnotes 22 pt., Standard font style, between title and running text- 1.0 cm, between running text and images- 1.35 cm, and images and running text - 1.35 cm, Double line spacing, White background and a specific

designing of the illustrations. The specific designing of illustrations included - context-specific illustrations matching with the subordinate text, use of a maximum of three-color combinations in a single illustration, representing the characters in cartoonist form but replicating the real-world form, excluding the non-contributing elements and having warm colors in foreground and warm colors in the background. The combination of these variables was used to generate the parametric combinations for stimuli design. The length of the stimuli was set between a word count of 200-250 words. The content was adopted from the English language textbook of the class the child is studying. The designed stimuli were generated on a digital US letter-size page document. The margin was set to 2.5 cm from all the four sides. One stimuli per child of the treatment group were presented for the span of nine months. A total of 208 stimuli were designed for each child over the span of nine months.

### **6.3.3 Participant Selection**

This part of the study onboards all the five categories of the stakeholders - one clinical psychologist, two experts in special educational needs, two designers, participating schools with teachers and parents, and thirty-six of ChADHD. The clinical psychologist and the experts in special educational needs on-boarded have individual experiences of more than ten years in managing ChADHD. These experts assisted the researcher in recruiting ChADHD. These experts further assisted in the evaluation of the potential children participants and estimation of the attention spans of each participant child. Also, these experts guided and assisted in the successful deployment of the stimuli for the span of nine months. The two designers, responsible for designing test stimuli, were the students of Master of Design (M. Des.) at the Department of Design, Indian Institute of Technology Guwahati. One of them had a background in Design, and the other one had the same in Architecture at their bachelor/ undergraduate level. They were selected after reviewing their design portfolios and their experience. It was also expected that they had an interest in designing for special needs and are volunteering for the assignment. For the selection of ChADHD the primary criteria were that the child should have ADHD, be between 7-14 years of age, and should be able to read English language books. The children should not have any physical or mental (other than ADHD and inclusive comorbid conditions) disability. The inclusive comorbid conditions were autism, learning disabilities, oppositional

defiant disorder, behavioral disorder, and characteristics of anxiety. After identification of such children with the help of experts and participating schools and teachers, the experts in special educational needs assisted in the retesting of these children for the type of ADHD, severity, and comorbidity using the Vanderbilt teacher and parent rating scale. A formal written consent was obtained from the parents of the children whose parents and children themselves accepted to be the part of this study post the briefings of this study.

### **6.3.4 Longitudinal Engagement of ChADHD**

The parents and the experts were guided and trained about the presentation of the stimuli to the participating treatment group children during the study period. The parents of these children and the experts in special educational needs monitored and assisted the child during the regular reading sessions. The parents also observed and monitored the development of these children over the nine months and reported their feed back at regular intervals over WhatsApp or the call.

### **6.3.5 Experimental Setup**

Each child was recorded to estimate the attention span at his/her respective homes, or schools, or remedial centers in a typical learning environment. The experimental setup consisted of an iPad Air M1 chip, a Sony camera, a tripod, and a chair table sitting arrangement where the children study at their respective learning arrangements. iPad was used as the reading device. iPad was also used as a screen recording device to check if the child was reading correctly. Sony camera was used for the frontal recording to check body or facial movements. The tripod was used to hold the camera and adjust the camera angles. In the chair table arrangement, the child could adjust the distance between the backrest and the table per their needs as shown in figure 5.3. The participating children also had the freedom to adjust the brightness and the magnification level of the iPad as per his/her needs. The level of brightness and magnification was observed for each of the runs. The English language content was provided to the child on the iPad. A new

stimulus was presented for each unique variable combination. The variation was maintained to prevent the learning effect.

This setup was deployed for the recording of both control group and treatment group for the pre-intervention and post-intervention. For the treatment group participating children had to read the stimuli sent over the WhatsApp regularly in the presence of the remedial expert or parent or caregiver. These children generally used mobile phones to read the stimuli.

### **6.3.6 Protocol**

Attention span of each child from the control group and treatment group was estimated pre-intervention and post-intervention. Three sets of videos were recorded for each of the child for a specific content to estimate the attention span at both the instances. The average period needed for the recording of single child was thirty-five minutes, including the setup time. These observations were performed in each child's respective study zones. Observations in the child's study zone created a natural learning environment for these children. These children were informed of their right to quit or stop if they felt to do so or in case of any unease or unrest. Children were recorded for their facial and body movements once they were ready for the experiment. All the recording were conducted under the supervision of a remedial expert and the presence of the child's parent or caregiver. For the children in the treatment group the stimuli was regularly delivered over WhatsApp (five days a week) for a span of nine months. This stimuli was delivered on the phones of the parents or caregivers. Precaution was taken that their regular activities including the treatment of ADHD was altered or affected. All the school and educational activities continued the same way as prior to participation if ChADHD in this study. A regular feedback was obtained from the parents and caregivers of each child over the WhatsApp and call about the developments in the children of treatment group over an interval of five weeks. Authors, only provided one stimuli per-day and did not interfere or conducted a change in their daily activities and accessories.

### 6.3.7 Data Collection and Analysis

The attention spans were estimated at two intervals of time (a) pre-intervention and (b) post-intervention. A standard procedure was used to estimate the attention span under the supervision of experts in special educational needs and in the presence of child's parents. In this procedure the child was recorded while reading the specifically designed stimuli using the identified eVDGs. The recordings were then evaluated by the experts in special educational needs and clinical psychologist to estimate the attention span of ChADHD. The estimated attention span were then analysed for the normality of the data. Further, unpaired t-test statistics was conducted for the four combinations of the pre-intervention and post-intervention of the estimated attention span of treatment and control group. Also, the attention spans were represented through the line charts to visually analyse the impact of the stimuli on the attention span of ChADHD.

## 6.4 Results and Discussion

Appendix F shows the estimated attention span of each ChADHD of control group and treatment group. The pre-intervention column represents the estimated attention span (seconds) prior to the intervention deployment. The post-intervention column represents the estimated attention span (seconds) post the intervention deployment ie. after the treatment span of nine months.

From appendix F it can be inferred that the attention span remained constant or withing a variation of  $\pm 5$ sec for the control group children. On the contrary the attention span has increased in case of most of the treatment group children. Thus, it can be inferred that the VDGs do have a positive impact on the attention span of ChADHD.

We conducted Shapiro-Wilk normality test to verify the normal distribution among all the estimated attention span. We choose this test as our sample size is less than 50 samples (Mishra et al. (2019)). In the normality test, we gain a p-value greater than 0.05 for all the four groups (see table 6.1). Thus, the estimated attention span for the pre-control, post-control, pre-treatment and post-treatment pass the normality test and can further be analyses using the

unpaired t-test.

Table 6.1: Normality testing of estimated Attention Span (in seconds)

<b>Shapiro-Wilk test</b>				
	<b>Pre_Control</b>	<b>Post_Control</b>	<b>Pre_treatment</b>	<b>Post_Treatment</b>
<b>W</b>	0.8972	0.8990	0.9505	0.9583
<b>P value</b>	0.0513	0.0553	0.4323	0.5683
<b>Passed normality test (<math>\alpha=0.05</math>)?</b>	Yes	Yes	Yes	Yes
<b>P value summary</b>	not significant	not significant	not significant	not significant

Table 6.3, table 6.5, Table 6.2 and table 6.4 present the following the unpaired t-test analysis between the different observations of children's attention span. These observations are made across the four different groups - (a) pre-control, (b) pre-treatment, (c) post-control, and (d) post-treatment.

In table 6.2, the table depicting the comparisons between the pre-control and pre-treatment groups suggests a p-value of 0.19 ( $>0.05$ ). Thus, there is no significant difference in the estimated attention span of the pre-control and pre-treatment. This means that all the thirty-six children have shown nearly the same impact of ADHD on their attention spans.

In table 6.3, the table depicting the comparison between the pre-control and post-control groups suggests that there is no significant change in the attention span of the ChADHD in the control group across the duration time of nine months (p-value= 0.9).

In table 6.4, the table depicting the comparison between the pre-treatment and post-treatment groups suggests that there is a significant difference with a p-value of 0.0351 ( $<0.05$ ). It can therefore be inferred that the eVDGs do have a significant impact on the attention span of ChADHD after receiving the design intervention across a time of nine months.

Similarly, in table 6.5, the table depicting the comparison between the post-control and post-treatment groups suggests a significant difference with a p-value of 0.007 ( $<0.05$ ). It can be stated that use of eVDGs in the design of digital devices and platforms have a significant

impact on the attention span of ChADHD.

To further analyse if the impact of the use of eVDGs is positive or negative, it is necessary to study the descriptive statistics. Figure 6.1 represents the line graphs of the attention span of control and 6.2 represents for treatment groups respectively. In both the figures the X-axis represent the individual child in each of the group respectively and the Y-axis represents their corresponding attention spans. The Orange line represents the pre-intervention estimated attention span, while the Grey line represents the post-intervention estimated attention span in both the figures.

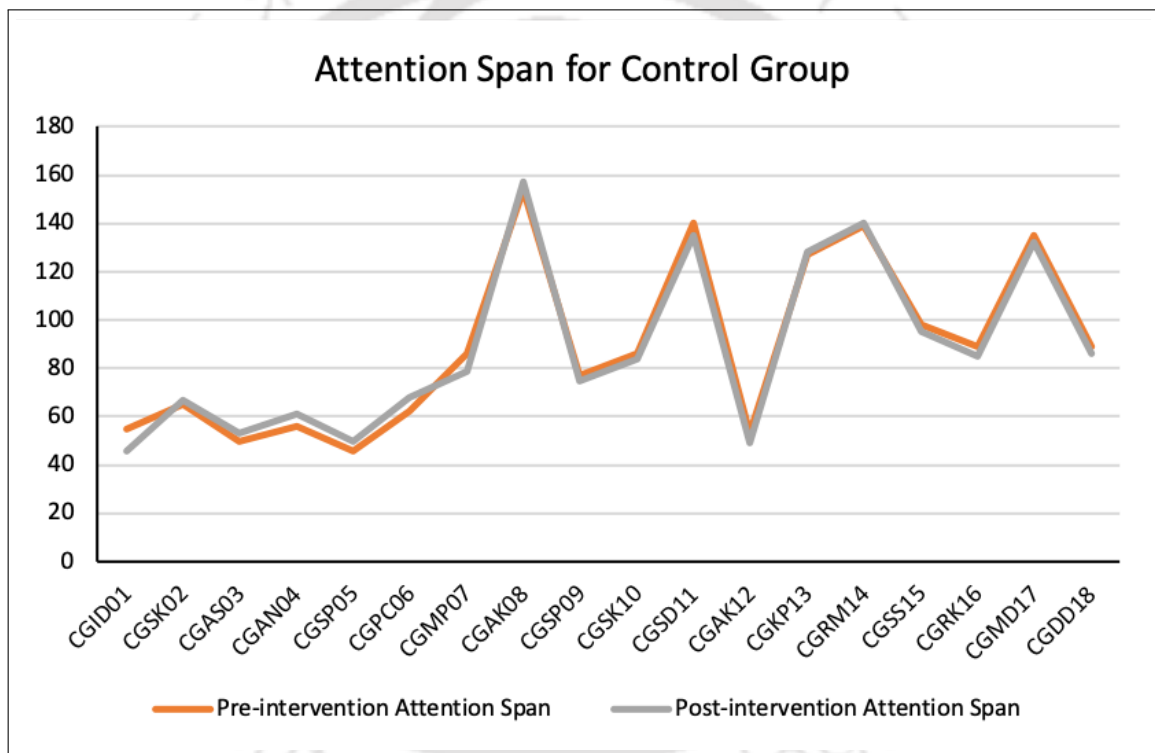


Figure 6.1: Attention spans (in seconds) of control group

From the figure 6.1 and figure 6.2 author infers that the attention span of the control group remains constant in most of the cases. In some of the cases the attention span was seen to reduce, this showed that there isn't much impact on the control group ChADHD. However, in the case of treatment group children it can be seen that the attention span increased in all the cases except for the two cases where the attention span remained constant. The analysis from the inferential statistics match with the analysis of the descriptive statistics ie. the VDGs have an impact on the attention span of ChADHD. Now, to study if the impact is positive or negative

Table 6.2: Unpaired T-test for Pre-control and Pre-treatment

<b>Column A</b>	Pre_Control
<b>Column C</b>	Pre_Treatment
<b>Unpaired t test</b>	
<b>P value</b>	0.1959
<b>P value summary</b>	not significant
<b>Significantly different (P &lt; 0.05)?</b>	No
<b>One- or two-tailed P value?</b>	Two-tailed
<b>t, df</b>	t=1.319, df=34
<b>How big is the difference?</b>	
<b>Mean of column A</b>	89.28
<b>Mean of column C</b>	110.1
<b>Difference between means (C - A) ± SEM</b>	20.83 ± 15.79
<b>95% confidence interval</b>	-11.26 to 52.93
<b>R squared (eta squared)</b>	0.04869
<b>F test to compare variances</b>	
<b>F, DFn, Dfd</b>	2.576, 17, 17
<b>P value</b>	0.0590
<b>P value summary</b>	ns
<b>Significantly different (P &lt; 0.05)?</b>	No
<b>Data analyzed</b>	
<b>Sample size, column A</b>	18
<b>Sample size, column C</b>	18

Table 6.3: Unpaired T-test for Pre-control and Post-control

<b>Column A</b>	Pre Control
<b>Column B</b>	Post Control
<b>Unpaired t test</b>	
<b>P value</b>	0.9365
<b>P value summary</b>	not significant
<b>Significantly different (P &lt; 0.05)?</b>	No
<b>One- or two-tailed P value?</b>	Two-tailed
<b>t, df</b>	t=0.08023, df=34
<b>How big is the difference?</b>	
<b>Mean of column A</b>	89.28
<b>Mean of column B</b>	88.33
<b>Difference between means (B - A) ± SEM</b>	-0.9444 ± 11.77
<b>95% confidence interval</b>	-24.87 to 22.98
<b>R squared (eta squared)</b>	0.0001893
<b>F test to compare variances</b>	
<b>F, DFn, Dfd</b>	1.013, 17, 17
<b>P value</b>	0.9783
<b>P value summary</b>	ns
<b>Significantly different (P &lt; 0.05)?</b>	No
<b>Data analyzed</b>	
<b>Sample size, column A</b>	18
<b>Sample size, column B</b>	18

Table 6.4: Unpaired T-test for Pre-treatment and Post-treatment

<b>Column C</b>	Pre_Treatment
<b>Column D</b>	Post_treatment
<b>Unpaired t test</b>	
<b>P value</b>	0.0351
<b>P value summary</b>	*
<b>Significantly different (P &lt; 0.05)?</b>	Yes
<b>One- or two-tailed P value?</b>	Two-tailed
<b>t, df</b>	t=2.195, df=34
<b>How big is the difference?</b>	
<b>Mean of column C</b>	110.1
<b>Mean of column D</b>	156.1
<b>Difference between means (D - C) ± SEM</b>	46.00 ± 20.96
<b>95% confidence interval</b>	3.407 to 88.59
<b>R squared (eta squared)</b>	0.1241
<b>F test to compare variances</b>	
<b>F, DFn, Dfd</b>	1.445, 17, 17
<b>P value</b>	0.4558
<b>P value summary</b>	ns
<b>Significantly different (P &lt; 0.05)?</b>	No
<b>Data analyzed</b>	
<b>Sample size, column C</b>	18
<b>Sample size, column D</b>	18

Table 6.5: Unpaired T-test for Post-control and Post-treatment

<b>Column B</b>	Post_Control
<b>Column D</b>	Post_Treatment
<b>Unpaired t test</b>	
<b>P value</b>	0.0007
<b>P value summary</b>	***
<b>Significantly different (P &lt; 0.05)?</b>	Yes
<b>One- or two-tailed P value?</b>	Two-tailed
<b>t, df</b>	t=3.740, df=34
<b>How big is the difference?</b>	
<b>Mean of column B</b>	88.33
<b>Mean of column D</b>	156.1
<b>Difference between means (D - B) ± SEM</b>	67.78 ± 18.12
<b>95% confidence interval</b>	30.95 to 104.6
<b>R squared (eta squared)</b>	0.2915
<b>F test to compare variances</b>	
<b>F, DFn, Dfd</b>	3.772, 17, 17
<b>P value</b>	0.0091
<b>P value summary</b>	**
<b>Significantly different (P &lt; 0.05)?</b>	Yes
<b>Data analyzed</b>	
<b>Sample size, column B</b>	18
<b>Sample size, column D</b>	18

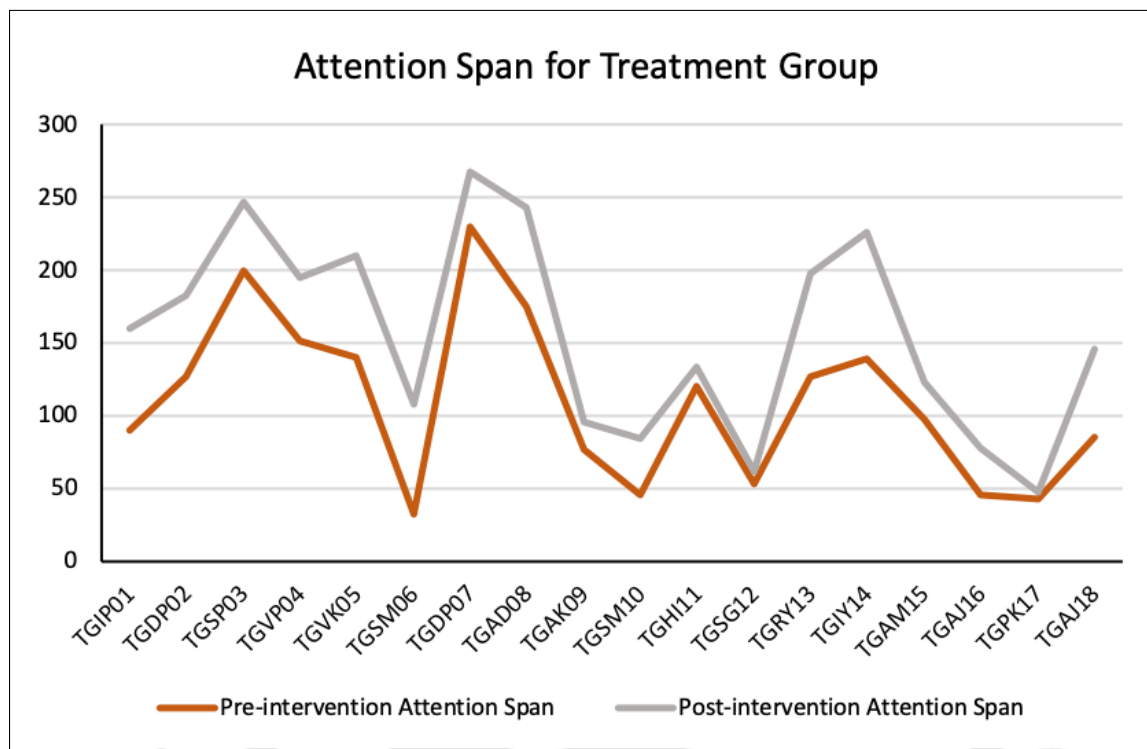


Figure 6.2: Attention spans (in seconds) of treatment group

we can infer from the descriptive statistics that the attention span increased when the treatment group received the stimuli for the span of nine months. Thus, the VDGs have a significantly positive impact on the attention span of ChADHD.

ChADHD by heredity find it difficult to sustain their attention span for a longer duration. The process of enhancing the attention span of ChADHD is the behavioural modification process. From the previous chapters it can be stated that the use of appropriate eVDGs have a positive impact on enhancing the attention span of ChADHD. Thus, the use of eVDGs bring about behavioural modification in ChADHD. Thus, while identifying or developing an appropriate set of eVDGs which are VDGs it is necessary to follow the NIHSM procedure. This chapter of the thesis is the Stage III of the NIHSM, which state to study the longitudinal impact of the behavioural intervention on the individual for a longer time span which can be between six to twelve months. Thus, in this chapter author presents the analysis of the impact of appropriate set of eVDGs used to represent the e-content of digital devices and platforms on the attention span of ChADHD for nine months.

The outcomes of this chapter are novel as they are applicable in the real world after testing for a span of nine months. When compared with the control group it can be inferred that the impact of the deployment of these VDGs is far better than the ongoing management mediums at schools, homes and remedial centers for ChADHD. These VDGs show no negative impact on ChADHD and can be deployed for the representation of all the possible interfaces used by ChADHD in their day-to-day life. Another major feedback was that the children, their parent and caregivers showed a positive approach toward the deployment of these stimuli for the span of nine months and requested for the full fledged deployment in the regular educational content. Thus, the full analysis and the stakeholders feedback infers that the VDGs developed in this thesis work have a strong and positive impact in enhancing the attention span of ChADHD.

## **6.5 Chapter Summary**

This study validates the impact of relevant eVDGs identified in the previous chapters to represent the curriculum-based content used by ChADHD in a typical learning environment by studying the long term impact for a span of nine months. The study validates this impact by comparing the pre-attention span and post-attention span of participating ChADHD by randomly distributing them in the treatment and control group. The study concludes that the deployment of eVDGs for a span of nine months enhanced the attention span of treatment group significantly and the control group shows no change. Thus, the appropriate set of eVDGs are the valid eVDGs which designers can use to represent the curriculum-based content used by ChADHD. The results are novel as these are the first ever appropriate set of eVDGs to represent curriculum-based digital content on digital devices and platforms used by ChADHD following an appropriate and valid methodology.



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## Chapter 7

# Summary and Conclusion

This chapter concludes the thesis by summarizing its contributions and design implications. In addition, this chapter presents limitations of the current research and further research opportunities in terms of future directions.

### 7.1 Introduction

Attention deficit hyperactivity disorder, popularly known as ADHD is a neurological disorder. It is generally observed in children at an early age Centers for Disease Control and Prevention (2023). ChADHD face several difficulties and challenges throughout their life span. These include difficulty in paying attention while performing tasks or activities, longer spans of sitting in a single place, waiting for the turn, missing out the details while performing a task or having a conversation. They face challenges in social interactions, academic activities, and inter-personal behaviour. Also, many of times ChADHD have comorbid conditions like Autism, Learning difficulties, Dyslexia, and Oppositions defiant disorder. ADHD negatively impacts the attention span of ChADHD (CDC (2022); Mayo Clinic Staff (2019)). The reduction in the attention

span negatively impact the academic performance of ChADHD. Thus, a need to enhance the attention span of ChADHD is necessary. Researchers and field experts design, develop, and use different ways to manage and enhance the attention span of ChADHD. One such way is the use of different assistive tools, devices and platforms (Sonne and Jensen (2016); Weisberg et al. (2014); Bul et al. (2015)). These digital tools, devices and platforms promise to enhance the engagement and attention of ChADHD. However, the authors of such researches pose the need of further research and need of design update to enhance the impact of such applications.

Further, we identify that use of relevant and appropriate eVDGs for content representation on digital devices and platforms have a positive impact in enhancing the attention span of ChADHD (McKnight (2010); Ben-Yehudah and Brann (2019); Jena and Devi (2020); Campbell (2020). However, a set of such relevant and validated eVDGs for the content representation remain absent or in a state of limited scope of application. Thus, through this thesis work researcher address the need of relevant set of eVDGs for the representation of curriculum-based content on digital devices and platforms used by ChADHD. Researcher conducts a planned and systematic research to establish these eVDGs by working with different stakeholder namely experts in special educational needs, clinical psychologist, teachers, designers, ChADHD and their parents and caregivers. He adopts a novel methodology by combining NIHSM and co-design approach in this study. The methodology adopted is very novel in the domain of design research and has proven to be effective in identification of eVDGs. In regards to the scope of this study considering the adoption of NIHSM this study limits to the stage III of the NIHSM. In the first part of stage 0 of this study researcher conducts a systematic review of the literature. Based upon this review he systematically builds his research methodology (see chapter 2) and theoretical background on the need of eVDGs (see chapter 3). Further, he presents the relevance of the aim and objectives of this study. However, he identifies a limited and non-valid set of eVDGs. Thus, in the second part of the stage 0 researcher engages with experts in special educational needs, clinical psychologist, teachers and designers to gain insights on the potential eVDGs for the content representation. Here the researcher conducts interviews, feedback surveys, design tasks and a validation survey with the participating stakeholders. This iterative method of generates a set of validated eVDGs which can potentially enhance the attention span of ChADHD. However, he knows that it is not possible to directly deploy these eVDGs in the digital devices and platforms used by ChADHD. Thus, he moves on the next stages to test the applicability of eVDGs with ChADHD. In the second stage of this study which is the stage I of

the NIHSM he identifies the relevant set of eVDGs. Researcher divides this study in two parts. In the first part he test two eVDGs font size and font type respective and also test the applicability of the testing methodology. He chooses the font type and font size because font contributes to the majority of the composition content. In this part we identify the font has an impact on the attention span of ChADHD. A specific combination of font size and font type enhances the attention span of ChADHD. Further, the method used to study the impact is reliable and applicable. Thus, in the next part of the study researcher refines other eVDGs namely font type, font style, line spacing, background colour, picture or illustration representation. On testing these element he identifies a specific combination of these eVDGs to enhance the attention span of ChADHD. Researcher conducts this study along with twenty four children and observes a similar pattern of effect on the attention span of all ChADHD for varying combinations. Thus, through this stage author identifies the a relevant set of eVDGs. The researcher skips the stage II of NIHSM. He states that as the stage I of NIHSM is conducted in the real-time and in natural setting NIHSM gives the privilege to skip stage II and proceed to stage III of the NIHSM. In the third stage he tests the identified eVDGs with ChADHD for a span of nine months. He include thirty six ChADHD and divide's them in two groups treatment and control. With the help of experts in special educational needs, parents and caregivers of ChADHD he studies the impact of eVDGs on the attention span. At the end of the study he compare the two groups and infers that the use of eVDGs significantly enhances the attention span of ChADHD. Thus, recommends the use of eVDGs identified in this study (refer eVDGs in section 7.2). These eVDGs are novel and relevant with the current needs of representing curriculum-based content on digital devices and platform used by ChADHD. The next section of that chapter states the contributions, and limitations of this study along with the possible future scope and opportunities.

## **7.2 Research Contributions**

This thesis work makes two major contributions:

1. Establishing a relevant and validated set of eVDGs for the curriculum-based content representation on digital devices and platforms which prove to enhance the attention span of

ChADHD in a typical-learning environment.

2. Delivering a novel design research methodology, an adoption of NIH stage model combined with co-designing approach, for the systematic establishment of relevant and valid set of eVDGs.

The eVDGs presented in this thesis work state the use a very specific set of element to represent the curriculum-based digital content. These element include:

1. Use of Mali as font type.
2. Use of 24pt. font size for running text, 26pt. font size for headers and title.
3. Use of regular or normal font style.
4. Use of double line spacing between the text. Further, we also suggest the use of 1.0 cm spacing between title and running text, 1.35 cm between running text and image.
5. Use of US letter page size layout with a border of 2.5 cm on all the four sides and a rectangular grid for positioning of the content.
6. Design and use of illustration (along with text) with themes that are mapped to the content of the curriculum.
7. Use of a maximum of three distinct color and their derivatives in terms of tints and shades, to represent a single frame.
8. Use of warm colors in foreground and cool colors in the background.
9. Use of cartoonish forms for the representation of concepts in pictures or illustrations, whenever needed.
10. Represent the context in illustrations depicting the real world.
11. Eliminate the non-contributing elements to reduce the clutter on the screen.

### 7.3 Implications for Design

In the present time the percentage of children living with ADHD is on a steep rise year by year (Centers for Disease Control and Prevention (2023)). Majorly these children face academic challenges due to the inherent condition of reduced attention. Researchers and experts in special educational needs are emphasising on the development of management interventions for ChADHD to enhance their attention span in the learning environments. Although the present management interventions have a positive impact in enhancing the attention span of ChADHD, their impact can be further enhanced through the systematic design of such interventions. Currently almost all these interventions are digital and screen based. To enhance the impact of such interventions it is necessary to systematically design these interventions. However, the guidelines or directions to design these screen based interventions are absent or sparse, inadequately tested with ChADHD or are just opinion based. Further, if we see the literature, we find that such guidelines are either not available or fail to offer useful interpretations. Even when we read the e-content design guidelines presented by Government of Indian, we don't find any mention of guidelines for ChADHD (Jayanthi Narayan et al. (2021)). Thus, designers face challenges in representing the digital curriculum-based content for ChADHD and increases the chances of interpretation the guidelines wrongly. An inappropriate interpretation of guidelines result in lesser/ negative impact designs or incomplete representation of the digital content. We do see such challenges faced by the designers in the re-design task activity of this research work (see Chapter 4). Further, the existing guidelines are not formally validated in real time, which raises the concern of using such guidelines to design for ChADHD. If such incomplete or wrongly designed curriculum-based content is provided to ChADHD it negatively impact the attention span of ChADHD (McKnight (2010); Cerezo et al. (2019)). To prevent such experiences for designers and ChADHD we establish a relevant and valid set of eVDGs for the curriculum-based content representation of digital devices and platforms used by ChADHD in a typical learning environment. Use of these guidelines by the designers will help in easy interpretation of representation strategies, reducing the misinterpretation and designing the curriculum-based content effectively.

Similarly, experts in special educational needs who design the digital curriculum-based content for ChADHD use specific representation strategies known from the literature or represent base

on their personal experiences. These, experts who have a vast experience find difficulties in designing specifically for ChADHD, as there are also children with other disorders and disabilities who are managed by these experts. Now, using our guidelines experts will need lesser efforts to design curriculum-based digital content for ChADHD. Further, it will reduce the chances of in-appropriate designing for ChADHD. Thus, these established set of eVDGs are not only helpful for designers but also for the experts and ChADHD by guiding to represent effective curriculum-based digital content for ChADHD.

This research study is novel in terms of its proposal for a set of eVDGs for the representation of curriculum-based digital content for ChADHD following a standard and systematic methodology. Although, researcher has not studied the impact on learnability and enhancement of the educational performance he has seen a significant improvement in the attention span of ChADHD in a learning environment. Thus, in future researcher can take these eVDGs and test the impact on learnability and the academic performance of ChADHD. Prior to this study all the suggestions and guidelines were either opinion based or non-formally tested for ChADHD. Thus, making this study very relevant in the present era. This study paves a path for future researchers to develop better digital interventions for ChADHD. If this study would have not been conducted then possibly such important finding and scope of further researcher would have remained unfolded. Thus, making this study a relevant posit in the current era.

## **7.4 Limitations and Future Directions**

In this research study we establish a relevant and valid set of eVDGs for representation of curriculum-based digital content on digital devices and platforms used by ChADHD. These eVDGs prove to enhance the attention span of ChADHD in a typical learning environment. However, we do state a few limitation which are seemingly important. These limitations are as follows:

- These eVDGs are identified and validated with and for ADHD children only. Thus, we propose the use of these eVDGs for ChADHD only and not for children with any other disorder or disability like autism, and learning disabilities.
- These eVDGs are identified and tested to represent the curriculum-based digital content

only. We are not sure on using these eVDGs to represent any other content other than the curriculum-based.

- These eVDGs are identified and tested to represent the content on digital devices and platforms only. We do not have an assurance on using these eVDGs to represent the curriculum-based content on print media.
- The identification, testing and validation of the eVDGs is conducted in mainland of India only. These eVDGs may or may not be applicable for ChADHD living in other parts of the globe.

With these limitations we also present certain future directions which are as follows:

- The future researchers can adopt and test these eVDGs for children with other neurological disorders like autism, learning disabilities. There is a perception that same intervention or techniques can be used for ADHD, autism or learning disabilities. However this case may not be true here, and thus to prevent the negative impact of these eVDGs it is necessary to test before implementing for children living with other neurological disorders.
- Researchers in future can add certain more eVDGs on formal testing with ChADHD, if they identify any.
- These eVDGs can be tested for content representation other than the curriculum-based content representation for ChADHD.
- These eVDGs can be tested for curriculum-based content representation on print media for ChADHD.
- Researchers can also study the impact of these eVDGs on learnability and behavioural change of ChADHD.
- While establishing the eVDGs researcher could not deploy a formative evaluation method like Heuristic Evaluation (HE). This happened for two main limitations - (a) no access to such digital artefacts, and (c) existing digital artefacts with no direct relevance for ChADHD. In future when such limitations disappear, the researchers can conduct include HE in their research and design methodology.

- These eVDGs can be tested in different countries, cultures, and communities.
- In future, researchers can also study the impact of other representation mediums like auditory and kinesthetic along with the use of these eVDGs to enhance the attention span of ChADHD.



# Acknowledgments

I write here to acknowledge efforts made by different individuals who have helped shape positively not only this research work but my own thinking towards the world around me as well. I am taking an opportunity here to express my sincere gratitude towards all such individuals, communities and institutions.

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Most importantly, I am very much thankful to my parents and my family for understanding my preoccupation with this work and foregoing their demands in my time. None of this presented till now and to be presented in future would be possible without the love and patience in them. I shall be grateful for being a constant source of love, concern, support and strength for all these years.

**Sandesh Sanjeev Phalke**

# Appendix A

## Feedback Survey

**Project Description:** Greetings! The current study focuses on developing assistive learning tool for children living with ADHD (ChADHD). The tool focuses on improving the concentration span, sitting time and basic learning skills of children with ADHD. The scope of the study limits to the Indian context, confined to English and Marathi language.

**Survey focus:** The survey strictly focuses on the generation of the educational content for the digital tools and the necessary features of the content. The flow of the questionnaire is on the basis of the guidelines laid by the government of India to develop the e-content. The four main formats for interaction with children include Auditory interaction, Visual interaction, Textual interaction, and Gamification.

Further the questionnaire also focuses on the major needs within the content need which are: ADHD children centric, Goal oriented, Safe and inclusive, Opportunities to socialize, and learning time.

The outcomes will help to build the tool that will bring change in the teaching methods (accommodation), different learning content (modification) and simplification of the treatment process. We limit the extent of the survey till its utilization for content development strictly from the trained experts. We shall use all the information collected through the questionnaire (both personal and professional) strictly for the content development and research purpose only.

**Please provide your profile details:** Your Name, Center/School Name, Position of Responsibility/Role

**Please help us with your informed consent:**

Did you understand the idea of the project based on the above introduction? - Yes, No, Maybe

What are your views on the project? - Text space provided

Would you like to be a part of the survey? - Yes, No

**Questions based on content design:**

1. Is the educational content given to the ADHD and neurotypical children the same?- Yes, No
2. How is the educational content for children with ADHD different? - Text space provided
3. What is the current educational content taught to the children with ADHD at the centres? - Text space provided
4. Should we use the same content or has it to be different than the current content?- Yes, No
5. If Yes, what should be added or given differently? - Text space provided
6. How do we classify the educational content, for the children with different age group, the class they study in or their IQ? - Text space provided
7. Which subject should we include in the tool for the children? - Text space provided
8. What should be type of content format? - Text space provided
9. What is the impact of audio and visuals on the ADHD children? - Text space provided
10. Audios should be provided? - Text space provided
11. What should be the quality and frequency of the audios? - Text space provided
12. What should be the type of videos given to the children with ADHD? - Text space provided
13. What should be the brightness level, speed of the video and color scheme? - Text space provided

14. Do type and features of the font has an impact on ADHD children?- Yes, No
15. If Yes, what is the impact of the font style and size? - Text space provided
16. Any suggestion on any specific font style and size? - Text space provided
17. How does the background and colors impact the children with ADHD? - Text space provided
18. Our literature study suggest the use of cartoons, what are your views on it? - Text space provided
19. What type of cartoons should be used? - Text space provided
20. Should we focus on historical cartoons (characters from epic like Hanuman, Ramayan) or on modern ones (like Doremon, Ninja hatori)? - Text space provide
21. Is it necessary to use images of real objects in illustrations?- Yes, No
22. What type of mini games should we include? - Text space provided
23. Should they be competitive within group or self-competitive? - Text space provided
24. How much should be the time given to the children at a single instant for the digital content? - Text space provided
25. Should there be intermediate evaluations?- Yes, No
26. What should be type of evaluations eg. quiz-based, drawing-based, or tracing-based? - Text space provided
27. Can you summarise the major topics and points while developing the digital content? - Text space provided
28. Anymore suggestions while the designing of the digital content? - Text space provided

**Thank you participant for your time and energy.**



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# Appendix B

## Feedback Form for Designers

### Consent form for Participant

---

I have been informed about the nature of the experiment. I understand that I have the right to withdraw from the experiment at any time. Any information/data about me will remain confidential. The experiment will be conducted so that I will not be demeaned in any way. I will be debriefed at the end, and have the opportunity to find out the results. Any information about project will remain confidential and will not be shared by any means.

I give my informed consent to participating in this experiment to the above conditions.

Name\_\_\_\_\_

Date\_\_\_\_\_

Contact number\_\_\_\_\_

\_\_\_\_\_  
Signature of the Participant

# Design Experiment

S/N

Participants Name: \_\_\_\_\_ Role: \_\_\_\_\_

Design Experience: \_\_\_\_\_

Querries:

## Feedback

Illustration

Font size & Font style

Colour

Frames

# Appendix C

## Validation Survey

**Suitable feature analysis survey for the content representation of digital devices used by ADHD children.**

Greetings! We value informed consents to participate. Kindly provide the same.

Do give you consent of participation?

**Choice 1:** I provide my consent to participate in this questionnaire.

**Choice 2:** I am not willing to continue further.

### **Profile details:**

*Please provide basic profile details to help us understand you as a respondent.*

Name, Centre/School name, Position of Responsibility/Role.

### **Syllabus and Tool Content:**

This part focuses on the educational syllabus for the tool which must be provided for the children living with ADHD.

*Report your opinion against the following statements.*

1. Educational syllabus/content for the ADHD children should be same as non-ADHD children of a particular class. - Yes, No, Maybe.
2. Lower class syllabus should be taught to these children along with their present studying class syllabus. - Yes, No, Maybe.
3. These children should be taught according to their mental age rather than their chronological age. - Yes, No, Maybe.
4. Children living with ADHD require longer learning time span than the non-ADHD children. - Yes, No, Maybe.

5. There is a need of Individual Educational plan (IEP) for these children. - Yes, No, Maybe.
6. Which of the following subjects would you prefer in an interactive tool to test the content representation? - Maths, Marathi (regional language), English, Environmental Sciences.

### **Interactions and Features of the Tool:**

*Report your opinion against the following statements.*

1. Cartoons, jingles, video based interactions, oral narrations, games and gamified flow has an impact on children living with ADHD. - Yes, No, Maybe.
2. Video speed should be 1X. - Yes, No, Maybe.
3. Pictures of everyday seen objects have better impact than unfamiliar in shape or animated object. - Yes, No, Maybe.
4. Maximum number of colours used in the single frame should be 3. - Yes, No, Maybe.
5. Which form of cartoon figures are preferred as effective interaction characters? - Human figured cartoon characters, Non-human figured cartoon characters.
6. There should be only 1 background colours in a single frame on screen? - Yes, only 1 background colour, No, More than 1background colour.
7. What should be preferred background colour? - White, Black.
8. Preferred colour combination for the animations, pictures and text in the tool. - A, B, C, D.
9. Font size on the screen should be equal to the font size used in four line notebook (32 pt.). - Yes, No, Maybe.
10. Which of the following font style is appropriate for ADHD children while using the application. - Cavolini, Lucida Handwriting, Mali, Chilanka.

### **Child Evaluation and User flow:**

*Report your opinion against the following statements.*

1. Preferable strategies during the evaluation stage for ChADHD (mark multiple choice if applicable).  
**Choice 1:** Objective evaluation based on Multiple Choice Questions (MCQ),  
**Choice 2:** Objective evaluation through questions designed in the form of Mini Games,  
**Choice 3:** Subjective evaluation based on assessing the drawing,  
**Choice 4:** Objective and Subjective evaluation through Verbal Quizzes.
2. In a single sitting session, how long should the tool be used by ChADHD? - 20-30 minutes, 30-40 minutes, 40-50 minutes, or 50-60 minutes.
3. How would you rate the division of learning session of 30 min as 10-5-5-5-5, where 10 min is teaching 5 min break, 5min reteaching, 5 min mini game, 5 min for evaluation? - 1 (Least likeable), 2, 3, 4, 5(Most likeable).
4. Mark the phases where parents can be involved (mark multiple choice if applicable).  
**Choice 1:** Learning phase,  
**Choice 2:** Child monitoring phase,  
**Choice 3:** During the completion of the homework,  
**Choice 4:** During the evaluation phase.

*Report your opinion against the following statements.*

1. Gamified user flow affects positively to enhance sitting time and attentions span? - Yes, No, Maybe.
2. Tool should be evaluated on a regular interval to keep it reliable. - Yes, No, Maybe.
3. Tool should be used for 5 days a week. - Yes, No, Maybe.
4. Parents should be engaged with their child during the usage of the tool. - Yes, No, Maybe.

Please mention any suggestion or recommendations. - Space to type text

**Thank you. We thank all the participant for their time and efforts.**



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## Appendix D

### Attention span estimation against font-type and font-size in the pilot study

Table D.1: Attention span against font size and font type

Std Order	Run Order	Pt. type	Blocks	Sample	Font Size	Font Type	Attention span (in seconds)
45	1	1	1	5	32	LH <sup>1</sup>	2
11	2	1	1	2	16	Cavolini	67
43	3	1	1	5	32	Mali	25
20	4	1	1	3	16	Cavolini	8
7	5	1	1	1	32	LH	28
40	6	1	1	5	24	Mali	91
9	7	1	1	1	32	Mali	15
41	8	1	1	5	24	Cavolini	70
36	9	1	1	4	32	LH	12
38	10	1	1	5	16	Cavolini	57
12	11	1	1	2	16	LH	48
6	12	1	1	1	24	LH	7
27	13	1	1	3	32	LH	6
10	14	1	1	2	16	Mali	102
3	15	1	1	1	16	LH	9
26	16	1	1	3	32	Cavolini	40
34	17	1	1	4	32	Mali	25

<sup>1</sup>LH stands for Font named Lucida Handwriting.

**Table D.1 continued from previous page**

<b>Std Order</b>	<b>Run Order</b>	<b>Pt. type</b>	<b>Blocks</b>	<b>Sample</b>	<b>Font Size</b>	<b>Font Type</b>	<b>Attention span (in seconds)</b>
5	18	1	1	1	24	Cavolini	45
22	19	1	1	3	24	Mali	72
18	20	1	1	2	32	LH	25
2	21	1	1	1	16	Cavolini	47
23	22	1	1	3	24	Cavolini	50
39	23	1	1	5	16	LH	21
32	24	1	1	4	24	Cavolini	46
4	25	1	1	1	24	Mali	56
24	26	1	1	3	24	LH	11
17	27	1	1	2	32	Cavolini	50
33	28	1	1	4	24	LH	25
44	29	1	1	5	32	Cavolini	28
25	30	1	1	3	32	Mali	50
14	31	1	1	2	24	Cavolini	60
1	32	1	1	1	16	Mali	42
8	33	1	1	1	32	Cavolini	49
35	34	1	1	4	32	Cavolini	35
16	35	1	1	2	32	Mali	104
29	36	1	1	4	16	Cavolini	48
31	37	1	1	4	24	Mali	71
15	38	1	1	2	24	LH	19
13	39	1	1	2	24	Mali	114
37	40	1	1	5	16	Mali	93
30	41	1	1	4	16	LH	32
28	42	1	1	4	16	Mali	48
19	43	1	1	3	16	Mali	47
21	44	1	1	3	16	LH	2
42	45	1	1	5	24	LH	42

Table D.2: General observation on magnification and brightness

<i>Sample No.</i>	<i>Brightness Level</i>	<i>Magnification Percentage</i>
1.	40-50% of the total brightness	100% fit
2.	40-50% of the total brightness	100% fit
3.	40-50% of the total brightness	100% fit
4.	40-50% of the total brightness	100% fit
5.	40-50% of the total brightness	100% fit





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## Appendix E

### Attention span estimation in the main study

Table E.1: Attention span against font size and font type

Run Order	Font Type	Font Style	Background Color	Line Spacing	Picture	Children Participant	Attention Span
1	Mali	Without Bionic	White	2	Type-2	K	190
2	Standard	Bionic	White	2	Type-2	E	37
3	Mali	Bionic	Peach	1.5	Type-1	S	29
4	Mali	Bionic	White	2	Type-1	J	52
5	Standard	Without Bionic	Peach	1.5	Type-1	Q	34
6	Mali	Without Bionic	White	1.5	Type-2	X	173
7	Standard	Without Bionic	Peach	1.5	Type-1	V	46
8	Mali	Without Bionic	Peach	2	Type-1	V	59
9	Mali	Without Bionic	Peach	1.5	Type-2	X	68
10	Standard	Without Bionic	White	1.5	Type-1	M	117
11	Standard	Without Bionic	Peach	1.5	Type-2	N	56
12	Standard	Bionic	White	2	Type-1	D	17
13	Standard	Bionic	White	1.5	Type-2	J	36
14	Mali	Without Bionic	White	2	Type-1	D	59
15	Mali	Without Bionic	White	2	Type-2	Q	46
16	Standard	Bionic	White	2	Type-1	A	48
17	Standard	Bionic	White	2	Type-1	C	56
18	Standard	Without Bionic	Peach	2	Type-2	F	55

Table E.1 continued from previous page

Run Order	Font Type	Font Style	Background Color	Line Spacing	Picture	Children Participant	Attention Span
19	Mali	Without Bionic	Peach	2	Type-2	T	62
20	Standard	Bionic	Peach	1.5	Type-1	A	31
21	Mali	Bionic	Peach	2	Type-1	O	57
22	Standard	Bionic	White	1.5	Type-1	D	25
23	Standard	Bionic	White	2	Type-1	G	30
24	Mali	Without Bionic	White	2	Type-1	E	45
25	Mali	Without Bionic	Peach	1.5	Type-2	W	69
26	Mali	Without Bionic	White	2	Type-1	R	51
27	Mali	Bionic	Peach	1.5	Type-2	U	37
28	Standard	Bionic	Peach	2	Type-2	U	26
29	Mali	Bionic	Peach	1.5	Type-1	F	67
30	Mali	Without Bionic	Peach	1.5	Type-2	I	85
31	Mali	Bionic	Peach	1.5	Type-1	N	39
32	Standard	Without Bionic	White	1.5	Type-2	W	39
33	Standard	Bionic	White	2	Type-1	V	57
34	Mali	Without Bionic	White	1.5	Type-2	D	68
35	Standard	Bionic	White	2	Type-1	O	56
36	Standard	Without Bionic	White	2	Type-1	H	45
37	Standard	Bionic	White	1.5	Type-2	S	32
38	Standard	Without Bionic	Peach	2	Type-1	K	23
39	Mali	Without Bionic	White	1.5	Type-2	U	186
40	Standard	Bionic	Peach	1.5	Type-1	G	25
41	Mali	Without Bionic	White	1.5	Type-2	T	201
42	Standard	Bionic	White	1.5	Type-1	L	40
43	Mali	Without Bionic	Peach	1.5	Type-1	B	48
44	Mali	Without Bionic	White	2	Type-2	R	61
45	Mali	Bionic	Peach	2	Type-1	G	27
46	Standard	Without Bionic	White	2	Type-2	G	34

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
47	Standard	Bionic	White	1.5	Type-1	O	59
48	Standard	Without Bionic	White	2	Type-1	P	51
49	Standard	Bionic	Peach	2	Type-1	O	90
50	Mali	Bionic	Peach	1.5	Type-1	T	66
51	Mali	Bionic	White	1.5	Type-2	X	64
52	Mali	Bionic	White	1.5	Type-1	H	52
53	Standard	Without Bionic	Peach	2	Type-1	F	39
54	Standard	Without Bionic	Peach	1.5	Type-1	A	28
55	Standard	Without Bionic	White	2	Type-1	W	85
56	Standard	Without Bionic	Peach	1.5	Type-2	W	56
57	Standard	Without Bionic	White	1.5	Type-1	T	133
58	Mali	Bionic	Peach	2	Type-1	M	68
59	Mali	Without Bionic	Peach	2	Type-2	C	80
60	Mali	Bionic	Peach	2	Type-2	C	37
61	Mali	Without Bionic	White	2	Type-1	P	63
62	Mali	Bionic	Peach	2	Type-2	N	61
63	Mali	Without Bionic	Peach	1.5	Type-1	R	45
64	Mali	Without Bionic	Peach	1.5	Type-1	O	54
65	Mali	Bionic	White	1.5	Type-2	C	73
66	Standard	Bionic	Peach	2	Type-2	B	47
67	Mali	Without Bionic	White	2	Type-2	V	86
68	Mali	Bionic	Peach	2	Type-2	M	33
69	Standard	Bionic	Peach	1.5	Type-1	L	48
70	Mali	Bionic	Peach	2	Type-2	H	51
71	Standard	Bionic	Peach	2	Type-2	T	29
72	Standard	Without Bionic	Peach	1.5	Type-1	G	25
73	Mali	Without Bionic	Peach	2	Type-1	F	34
74	Standard	Without Bionic	White	1.5	Type-1	H	74

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
75	Standard	Without Bionic	Peach	2	Type-1	Q	24
76	Standard	Bionic	Peach	2	Type-2	E	28
77	Standard	Without Bionic	Peach	1.5	Type-2	A	52
78	Mali	Without Bionic	White	1.5	Type-2	N	102
79	Mali	Without Bionic	Peach	1.5	Type-1	W	37
80	Standard	Without Bionic	Peach	2	Type-2	B	27
81	Standard	Without Bionic	Peach	2	Type-1	B	67
82	Mali	Bionic	Peach	1.5	Type-1	H	47
83	Standard	Bionic	White	2	Type-1	H	51
84	Standard	Bionic	Peach	2	Type-1	L	40
85	Standard	Bionic	Peach	1.5	Type-1	I	57
86	Mali	Without Bionic	White	2	Type-2	U	241
87	Standard	Bionic	Peach	2	Type-1	E	31
88	Mali	Without Bionic	White	1.5	Type-2	O	114
89	Mali	Bionic	White	2	Type-1	I	62
90	Standard	Without Bionic	White	1.5	Type-2	I	48
91	Mali	Without Bionic	Peach	1.5	Type-2	L	65
92	Mali	Bionic	Peach	2	Type-1	K	54
93	Mali	Bionic	White	2	Type-1	H	54
94	Mali	Bionic	Peach	2	Type-2	D	49
95	Mali	Without Bionic	Peach	2	Type-2	H	58
96	Standard	Bionic	White	1.5	Type-2	D	39
97	Standard	Without Bionic	Peach	2	Type-2	R	39
98	Mali	Bionic	White	2	Type-1	E	38
99	Standard	Without Bionic	White	1.5	Type-1	K	101
100	Standard	Bionic	Peach	1.5	Type-2	M	23
101	Mali	Bionic	Peach	1.5	Type-1	R	37
102	Mali	Without Bionic	Peach	1.5	Type-2	P	56

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
103	Standard	Bionic	White	2	Type-1	L	32
104	Mali	Bionic	White	2	Type-1	C	57
105	Standard	Bionic	White	1.5	Type-2	C	40
106	Mali	Bionic	White	2	Type-2	B	53
107	Standard	Without Bionic	Peach	2	Type-2	I	80
108	Standard	Bionic	Peach	1.5	Type-2	E	33
109	Mali	Without Bionic	White	1.5	Type-1	D	145
110	Mali	Bionic	White	2	Type-2	D	34
111	Mali	Bionic	Peach	2	Type-1	L	69
112	Mali	Without Bionic	Peach	1.5	Type-2	A	49
113	Standard	Bionic	White	1.5	Type-1	F	61
114	Standard	Without Bionic	White	2	Type-1	J	89
115	Mali	Bionic	White	1.5	Type-1	J	49
116	Mali	Bionic	White	1.5	Type-2	Q	66
117	Standard	Bionic	Peach	1.5	Type-1	U	50
118	Mali	Bionic	Peach	2	Type-2	F	42
119	Mali	Bionic	White	1.5	Type-1	L	52
120	Standard	Bionic	Peach	2	Type-2	C	28
121	Standard	Bionic	Peach	2	Type-2	H	41
122	Mali	Without Bionic	White	2	Type-1	I	220
123	Standard	Bionic	Peach	1.5	Type-1	E	29
124	Standard	Bionic	White	2	Type-1	W	50
125	Standard	Bionic	Peach	1.5	Type-1	T	53
126	Mali	Without Bionic	White	2	Type-1	B	93
127	Mali	Without Bionic	White	2	Type-1	G	38
128	Standard	Without Bionic	White	1.5	Type-1	O	64
129	Mali	Without Bionic	White	1.5	Type-1	N	113
130	Mali	Without Bionic	Peach	2	Type-1	N	71

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
131	Mali	Without Bionic	Peach	1.5	Type-1	M	37
132	Standard	Bionic	Peach	1.5	Type-2	J	24
133	Mali	Without Bionic	White	2	Type-1	Q	34
134	Mali	Without Bionic	Peach	1.5	Type-1	D	75
135	Standard	Without Bionic	Peach	2	Type-2	L	64
136	Mali	Bionic	White	1.5	Type-2	H	59
137	Standard	Without Bionic	Peach	1.5	Type-1	F	19
138	Standard	Bionic	White	1.5	Type-1	P	49
139	Mali	Without Bionic	Peach	1.5	Type-1	P	59
140	Mali	Bionic	Peach	1.5	Type-1	C	65
141	Standard	Without Bionic	Peach	1.5	Type-1	K	42
142	Mali	Without Bionic	White	2	Type-1	A	73
143	Mali	Bionic	White	2	Type-2	O	59
144	Standard	Without Bionic	Peach	2	Type-2	X	63
145	Mali	Bionic	White	2	Type-1	K	37
146	Mali	Without Bionic	Peach	1.5	Type-2	N	98
147	Standard	Bionic	Peach	1.5	Type-2	W	23
148	Standard	Bionic	White	1.5	Type-1	M	48
149	Mali	Bionic	White	2	Type-1	G	32
150	Standard	Bionic	White	1.5	Type-2	X	35
151	Mali	Bionic	Peach	1.5	Type-2	K	22
152	Mali	Without Bionic	White	1.5	Type-1	A	79
153	Standard	Bionic	White	1.5	Type-2	R	40
154	Standard	Without Bionic	White	1.5	Type-2	K	26
155	Standard	Without Bionic	White	2	Type-2	X	88
156	Mali	Bionic	Peach	1.5	Type-2	J	36
157	Standard	Without Bionic	White	1.5	Type-1	E	50
158	Standard	Bionic	Peach	2	Type-1	C	48

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
159	Standard	Bionic	White	2	Type-2	I	103
160	Standard	Without Bionic	Peach	2	Type-1	D	29
161	Standard	Without Bionic	White	1.5	Type-2	L	44
162	Standard	Without Bionic	White	1.5	Type-2	E	37
163	Mali	Bionic	Peach	1.5	Type-2	N	50
164	Standard	Without Bionic	Peach	1.5	Type-1	N	35
165	Standard	Bionic	Peach	1.5	Type-1	M	47
166	Mali	Bionic	White	1.5	Type-1	N	40
167	Mali	Bionic	Peach	2	Type-2	X	33
168	Standard	Without Bionic	White	1.5	Type-1	N	58
169	Standard	Without Bionic	Peach	2	Type-1	W	37
170	Standard	Bionic	White	2	Type-1	Q	54
171	Mali	Bionic	Peach	1.5	Type-1	M	58
172	Mali	Without Bionic	White	1.5	Type-1	S	42
173	Mali	Without Bionic	White	2	Type-1	U	192
174	Mali	Bionic	Peach	2	Type-1	A	37
175	Mali	Without Bionic	Peach	1.5	Type-2	T	78
176	Standard	Bionic	White	1.5	Type-2	I	44
177	Mali	Bionic	Peach	1.5	Type-2	T	40
178	Standard	Bionic	White	1.5	Type-1	K	34
179	Standard	Bionic	White	1.5	Type-2	L	29
180	Mali	Bionic	Peach	2	Type-1	J	70
181	Mali	Without Bionic	White	2	Type-1	W	180
182	Mali	Bionic	White	1.5	Type-1	O	44
183	Standard	Bionic	Peach	1.5	Type-2	K	10
184	Mali	Without Bionic	Peach	1.5	Type-1	S	36
185	Mali	Without Bionic	White	2	Type-2	E	53
186	Mali	Bionic	White	1.5	Type-2	E	41

Table E.1 continued from previous page

Run Order	Font Type	Font Style	Background Color	Line Spacing	Picture	Children Participant	Attention Span
187	Standard	Without Bionic	Peach	2	Type-2	O	30
188	Standard	Without Bionic	White	2	Type-1	B	44
189	Standard	Bionic	White	2	Type-2	S	33
190	Mali	Bionic	White	2	Type-2	N	53
191	Standard	Bionic	White	2	Type-1	R	40
192	Mali	Without Bionic	White	2	Type-2	P	72
193	Standard	Bionic	White	1.5	Type-1	N	53
194	Mali	Bionic	Peach	1.5	Type-2	C	39
195	Standard	Bionic	Peach	2	Type-1	T	49
196	Mali	Bionic	Peach	2	Type-1	Q	44
197	Mali	Bionic	White	1.5	Type-2	N	44
198	Standard	Without Bionic	Peach	1.5	Type-2	R	42
199	Standard	Bionic	Peach	2	Type-1	K	30
200	Mali	Without Bionic	Peach	1.5	Type-1	G	34
201	Standard	Without Bionic	Peach	2	Type-2	U	68
202	Mali	Bionic	Peach	2	Type-2	J	34
203	Standard	Without Bionic	White	2	Type-1	D	42
204	Standard	Bionic	Peach	2	Type-1	N	81
205	Mali	Without Bionic	White	1.5	Type-1	L	98
206	Standard	Without Bionic	Peach	2	Type-1	T	42
207	Standard	Bionic	White	2	Type-2	P	56
208	Standard	Without Bionic	Peach	1.5	Type-2	L	61
209	Mali	Without Bionic	White	2	Type-1	O	103
210	Mali	Bionic	White	1.5	Type-1	Q	37
211	Mali	Bionic	White	2	Type-1	R	43
212	Mali	Bionic	Peach	1.5	Type-2	F	43
213	Standard	Without Bionic	Peach	1.5	Type-2	P	56
214	Standard	Bionic	White	2	Type-2	D	50

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
215	Standard	Bionic	Peach	2	Type-1	H	48
216	Mali	Bionic	Peach	1.5	Type-1	Q	85
217	Mali	Bionic	White	2	Type-2	R	40
218	Mali	Bionic	Peach	2	Type-1	W	68
219	Standard	Bionic	Peach	2	Type-2	R	32
220	Standard	Bionic	Peach	2	Type-2	G	24
221	Standard	Without Bionic	White	2	Type-1	C	97
222	Mali	Bionic	White	1.5	Type-1	V	58
223	Mali	Without Bionic	Peach	2	Type-1	U	119
224	Standard	Without Bionic	Peach	1.5	Type-1	T	64
225	Standard	Without Bionic	Peach	1.5	Type-2	D	88
226	Standard	Without Bionic	White	1.5	Type-2	Q	70
227	Standard	Bionic	White	2	Type-1	M	50
228	Mali	Bionic	White	1.5	Type-2	B	44
229	Mali	Bionic	White	1.5	Type-1	X	47
230	Mali	Without Bionic	Peach	2	Type-2	O	64
231	Standard	Bionic	White	2	Type-1	B	51
232	Standard	Without Bionic	White	1.5	Type-2	B	49
233	Mali	Without Bionic	White	1.5	Type-1	J	148
234	Standard	Without Bionic	White	2	Type-1	M	87
235	Mali	Bionic	White	2	Type-2	F	35
236	Standard	Bionic	Peach	2	Type-2	P	46
237	Mali	Bionic	White	2	Type-2	M	124
238	Standard	Bionic	Peach	2	Type-1	F	40
239	Standard	Without Bionic	Peach	2	Type-2	E	36
240	Mali	Bionic	White	2	Type-2	E	33
241	Standard	Without Bionic	White	1.5	Type-2	S	34
242	Standard	Bionic	Peach	1.5	Type-2	X	23

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
243	Mali	Without Bionic	Peach	1.5	Type-1	F	43
244	Mali	Without Bionic	Peach	2	Type-1	J	116
245	Standard	Bionic	Peach	2	Type-1	G	28
246	Standard	Without Bionic	White	2	Type-2	I	110
247	Mali	Without Bionic	White	2	Type-1	F	20
248	Standard	Without Bionic	Peach	1.5	Type-2	G	31
249	Mali	Without Bionic	Peach	2	Type-1	S	33
250	Standard	Bionic	Peach	1.5	Type-2	C	26
251	Mali	Without Bionic	Peach	2	Type-2	E	40
252	Standard	Bionic	White	1.5	Type-2	P	55
253	Standard	Without Bionic	Peach	2	Type-2	T	73
254	Mali	Without Bionic	Peach	2	Type-2	G	35
255	Standard	Without Bionic	White	1.5	Type-2	X	39
256	Standard	Without Bionic	White	2	Type-2	S	36
257	Mali	Bionic	White	2	Type-2	G	30
258	Standard	Bionic	Peach	1.5	Type-1	O	55
259	Mali	Without Bionic	Peach	1.5	Type-2	D	52
260	Standard	Without Bionic	White	1.5	Type-2	G	32
261	Mali	Bionic	Peach	1.5	Type-2	H	52
262	Standard	Without Bionic	White	2	Type-1	A	36
263	Standard	Without Bionic	Peach	2	Type-2	C	72
264	Standard	Without Bionic	White	2	Type-1	T	99
265	Mali	Bionic	White	1.5	Type-1	B	40
266	Mali	Bionic	Peach	2	Type-2	O	68
267	Mali	Without Bionic	White	1.5	Type-1	Q	41
268	Mali	Without Bionic	Peach	2	Type-2	M	72
269	Mali	Bionic	Peach	2	Type-1	X	67
270	Standard	Without Bionic	White	1.5	Type-2	R	42

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
271	Mali	Without Bionic	Peach	1.5	Type-1	L	41
272	Standard	Bionic	Peach	1.5	Type-1	K	33
273	Standard	Bionic	White	1.5	Type-2	E	37
274	Standard	Without Bionic	White	2	Type-2	P	60
275	Standard	Without Bionic	Peach	2	Type-1	U	39
276	Standard	Without Bionic	Peach	1.5	Type-2	V	59
277	Standard	Bionic	Peach	1.5	Type-2	I	28
278	Mali	Bionic	Peach	2	Type-1	T	78
279	Mali	Bionic	White	1.5	Type-1	E	37
280	Standard	Without Bionic	White	1.5	Type-2	A	52
281	Standard	Bionic	Peach	2	Type-1	U	45
282	Standard	Without Bionic	Peach	2	Type-1	S	35
283	Mali	Bionic	Peach	2	Type-1	H	46
284	Standard	Without Bionic	Peach	1.5	Type-1	O	38
285	Standard	Without Bionic	White	2	Type-2	L	108
286	Standard	Without Bionic	White	2	Type-1	L	72
287	Standard	Without Bionic	Peach	2	Type-1	L	38
288	Mali	Without Bionic	Peach	1.5	Type-2	B	98
289	Standard	Without Bionic	White	1.5	Type-2	D	52
290	Mali	Without Bionic	Peach	1.5	Type-2	M	69
291	Mali	Bionic	White	2	Type-2	K	108
292	Mali	Without Bionic	Peach	1.5	Type-2	O	109
293	Standard	Bionic	White	2	Type-2	H	52
294	Mali	Bionic	Peach	1.5	Type-1	U	61
295	Mali	Bionic	Peach	1.5	Type-2	I	42
296	Standard	Bionic	Peach	1.5	Type-1	P	50
297	Standard	Bionic	White	1.5	Type-2	K	23
298	Mali	Without Bionic	Peach	2	Type-1	M	113

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
299	Mali	Without Bionic	White	1.5	Type-2	W	175
300	Mali	Without Bionic	Peach	2	Type-2	I	88
301	Mali	Bionic	Peach	2	Type-1	R	36
302	Standard	Bionic	White	1.5	Type-1	C	53
303	Mali	Bionic	Peach	2	Type-2	S	32
304	Standard	Without Bionic	White	1.5	Type-1	B	58
305	Mali	Without Bionic	White	1.5	Type-1	F	29
306	Standard	Bionic	Peach	1.5	Type-1	J	48
307	Standard	Without Bionic	White	2	Type-2	R	46
308	Standard	Bionic	White	2	Type-2	U	89
309	Mali	Without Bionic	Peach	2	Type-2	N	57
310	Standard	Bionic	Peach	1.5	Type-2	R	37
311	Standard	Bionic	White	2	Type-2	L	75
312	Standard	Without Bionic	Peach	2	Type-2	P	51
313	Mali	Without Bionic	Peach	1.5	Type-1	H	57
314	Mali	Without Bionic	White	1.5	Type-2	J	182
315	Standard	Bionic	White	1.5	Type-2	Q	57
316	Mali	Bionic	White	2	Type-1	O	92
317	Mali	Bionic	White	2	Type-2	J	127
318	Mali	Without Bionic	Peach	1.5	Type-1	T	42
319	Mali	Without Bionic	Peach	2	Type-1	Q	44
320	Mali	Without Bionic	White	2	Type-2	H	77
321	Standard	Without Bionic	Peach	1.5	Type-2	B	56
322	Standard	Bionic	Peach	1.5	Type-2	S	29
323	Standard	Without Bionic	White	1.5	Type-2	M	40
324	Mali	Bionic	White	1.5	Type-2	T	74
325	Standard	Bionic	Peach	2	Type-2	O	53
326	Mali	Without Bionic	Peach	2	Type-2	K	58

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
327	Standard	Bionic	Peach	2	Type-1	D	30
328	Standard	Bionic	White	1.5	Type-2	F	73
329	Mali	Without Bionic	White	1.5	Type-2	A	78
330	Mali	Bionic	White	2	Type-1	F	64
331	Mali	Without Bionic	Peach	2	Type-2	R	46
332	Mali	Bionic	White	1.5	Type-1	T	54
333	Mali	Without Bionic	White	2	Type-2	L	120
334	Standard	Bionic	White	2	Type-2	C	94
335	Mali	Without Bionic	White	2	Type-1	S	41
336	Mali	Without Bionic	Peach	1.5	Type-1	K	23
337	Mali	Without Bionic	Peach	1.5	Type-2	H	51
338	Mali	Bionic	Peach	1.5	Type-2	D	55
339	Mali	Without Bionic	White	1.5	Type-1	K	128
340	Standard	Bionic	Peach	1.5	Type-2	A	38
341	Mali	Bionic	White	1.5	Type-1	P	53
342	Mali	Without Bionic	White	1.5	Type-2	F	31
343	Standard	Bionic	Peach	2	Type-2	K	12
344	Mali	Bionic	White	1.5	Type-2	W	65
345	Standard	Bionic	White	1.5	Type-1	T	54
346	Standard	Without Bionic	White	2	Type-1	R	36
347	Standard	Bionic	White	2	Type-1	P	55
348	Mali	Without Bionic	White	2	Type-2	A	98
349	Mali	Bionic	White	1.5	Type-2	F	34
350	Standard	Bionic	Peach	2	Type-2	Q	42
351	Mali	Bionic	White	2	Type-2	S	32
352	Mali	Bionic	Peach	1.5	Type-1	O	44
353	Standard	Without Bionic	White	2	Type-1	F	37
354	Mali	Bionic	Peach	1.5	Type-2	O	56

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
355	Mali	Without Bionic	Peach	1.5	Type-1	N	48
356	Mali	Bionic	Peach	1.5	Type-1	P	53
357	Standard	Bionic	Peach	2	Type-2	X	25
358	Mali	Without Bionic	White	1.5	Type-2	E	46
359	Standard	Bionic	White	1.5	Type-1	V	51
360	Mali	Bionic	White	1.5	Type-2	R	47
361	Mali	Bionic	Peach	1.5	Type-2	Q	42
362	Mali	Without Bionic	Peach	2	Type-1	H	53
363	Mali	Without Bionic	White	1.5	Type-1	X	141
364	Mali	Without Bionic	Peach	2	Type-2	J	74
365	Mali	Bionic	White	1.5	Type-2	J	67
366	Standard	Bionic	White	1.5	Type-2	H	51
367	Standard	Bionic	Peach	1.5	Type-2	Q	28
368	Standard	Bionic	White	2	Type-2	R	41
369	Mali	Bionic	Peach	2	Type-1	S	29
370	Standard	Bionic	White	1.5	Type-1	B	53
371	Mali	Bionic	Peach	1.5	Type-2	X	34
372	Standard	Bionic	White	1.5	Type-2	W	36
373	Mali	Bionic	Peach	2	Type-2	L	37
374	Standard	Bionic	Peach	1.5	Type-2	G	28
375	Standard	Without Bionic	Peach	1.5	Type-2	Q	47
376	Standard	Without Bionic	Peach	2	Type-1	P	59
377	Standard	Bionic	Peach	2	Type-2	I	30
378	Mali	Without Bionic	White	2	Type-2	I	280
379	Standard	Without Bionic	Peach	2	Type-2	M	65
380	Mali	Bionic	Peach	2	Type-1	C	76
381	Standard	Bionic	Peach	2	Type-1	V	53
382	Standard	Without Bionic	Peach	2	Type-1	V	61

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
383	Mali	Without Bionic	White	2	Type-2	J	235
384	Mali	Without Bionic	Peach	1.5	Type-2	G	30
385	Standard	Bionic	Peach	1.5	Type-1	C	52
386	Standard	Without Bionic	Peach	2	Type-1	X	36
387	Mali	Bionic	Peach	2	Type-2	W	33
388	Mali	Bionic	Peach	2	Type-2	K	20
389	Mali	Without Bionic	Peach	2	Type-2	Q	46
390	Standard	Without Bionic	White	2	Type-2	C	100
391	Mali	Without Bionic	Peach	2	Type-2	X	70
392	Mali	Bionic	White	2	Type-1	Q	42
393	Mali	Without Bionic	Peach	1.5	Type-2	F	31
394	Standard	Without Bionic	White	2	Type-2	A	61
395	Standard	Without Bionic	White	1.5	Type-1	G	44
396	Standard	Bionic	White	1.5	Type-2	T	41
397	Standard	Bionic	Peach	1.5	Type-1	D	12
398	Mali	Bionic	White	1.5	Type-2	K	51
399	Mali	Bionic	Peach	1.5	Type-2	L	39
400	Mali	Bionic	White	1.5	Type-2	M	66
401	Standard	Without Bionic	White	1.5	Type-1	L	95
402	Standard	Bionic	Peach	1.5	Type-2	V	52
403	Standard	Without Bionic	Peach	1.5	Type-2	U	57
404	Standard	Without Bionic	Peach	2	Type-1	N	67
405	Standard	Without Bionic	White	1.5	Type-1	S	47
406	Standard	Bionic	White	2	Type-2	W	83
407	Mali	Without Bionic	Peach	1.5	Type-1	I	42
408	Mali	Without Bionic	White	2	Type-2	O	142
409	Mali	Without Bionic	White	2	Type-1	V	71
410	Standard	Bionic	White	2	Type-1	J	52

Table E.1 continued from previous page

Run Order	Font Type	Font Style	Background Color	Line Spacing	Picture	Children Participant	Attention Span
411	Mali	Without Bionic	White	1.5	Type-1	I	176
412	Standard	Bionic	Peach	1.5	Type-2	L	26
413	Standard	Bionic	White	1.5	Type-1	J	49
414	Standard	Bionic	White	2	Type-1	N	51
415	Standard	Without Bionic	White	1.5	Type-1	C	130
416	Mali	Bionic	Peach	1.5	Type-1	D	29
417	Mali	Bionic	White	2	Type-1	U	54
418	Standard	Bionic	White	1.5	Type-1	E	33
419	Mali	Without Bionic	White	2	Type-2	C	255
420	Standard	Bionic	White	2	Type-2	F	28
421	Standard	Without Bionic	White	2	Type-2	K	75
422	Mali	Bionic	White	1.5	Type-1	S	33
423	Standard	Without Bionic	Peach	2	Type-1	H	55
424	Standard	Without Bionic	White	2	Type-1	O	49
425	Mali	Without Bionic	White	1.5	Type-2	I	200
426	Mali	Without Bionic	Peach	2	Type-2	D	98
427	Standard	Bionic	White	1.5	Type-1	Q	32
428	Mali	Without Bionic	Peach	1.5	Type-1	Q	33
429	Mali	Without Bionic	Peach	1.5	Type-1	X	36
430	Mali	Bionic	White	1.5	Type-1	F	37
431	Mali	Bionic	Peach	1.5	Type-2	G	32
432	Standard	Without Bionic	Peach	1.5	Type-2	X	54
433	Standard	Without Bionic	White	2	Type-2	T	102
434	Mali	Bionic	White	2	Type-2	C	138
435	Mali	Bionic	White	1.5	Type-1	I	58
436	Standard	Bionic	White	2	Type-2	J	87
437	Mali	Bionic	White	1.5	Type-2	S	37
438	Mali	Without Bionic	Peach	2	Type-2	P	60

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
439	Standard	Bionic	White	2	Type-2	Q	88
440	Standard	Without Bionic	Peach	2	Type-1	J	38
441	Mali	Without Bionic	Peach	2	Type-1	O	80
442	Standard	Bionic	Peach	1.5	Type-1	V	48
443	Standard	Without Bionic	White	2	Type-2	D	43
444	Standard	Bionic	White	2	Type-1	X	49
445	Standard	Bionic	White	1.5	Type-2	V	56
446	Standard	Without Bionic	Peach	2	Type-2	W	64
447	Mali	Without Bionic	Peach	2	Type-2	W	71
448	Mali	Bionic	Peach	1.5	Type-2	B	50
449	Mali	Without Bionic	White	2	Type-2	N	127
450	Mali	Without Bionic	White	1.5	Type-2	V	74
451	Mali	Bionic	White	2	Type-2	A	45
452	Mali	Bionic	Peach	1.5	Type-1	G	28
453	Standard	Without Bionic	Peach	1.5	Type-2	H	53
454	Standard	Bionic	Peach	2	Type-1	A	41
455	Mali	Bionic	Peach	2	Type-1	I	77
456	Mali	Without Bionic	Peach	2	Type-2	F	39
457	Standard	Bionic	White	2	Type-2	N	63
458	Standard	Bionic	Peach	2	Type-1	J	44
459	Mali	Bionic	Peach	2	Type-1	D	42
460	Standard	Bionic	White	2	Type-1	E	35
461	Standard	Bionic	White	2	Type-2	K	70
462	Standard	Bionic	Peach	2	Type-1	S	30
463	Mali	Bionic	Peach	2	Type-1	E	30
464	Mali	Without Bionic	White	1.5	Type-2	G	39
465	Mali	Without Bionic	White	1.5	Type-1	P	66
466	Standard	Bionic	Peach	2	Type-1	M	43

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
467	Standard	Bionic	Peach	1.5	Type-1	R	34
468	Mali	Without Bionic	Peach	2	Type-1	I	135
469	Mali	Without Bionic	White	1.5	Type-1	C	160
470	Mali	Without Bionic	White	2	Type-2	B	127
471	Standard	Bionic	Peach	2	Type-1	W	43
472	Mali	Without Bionic	White	1.5	Type-1	T	163
473	Standard	Bionic	Peach	2	Type-2	D	48
474	Standard	Bionic	White	2	Type-2	B	63
475	Mali	Without Bionic	Peach	2	Type-2	U	75
476	Standard	Without Bionic	Peach	2	Type-1	O	75
477	Standard	Bionic	White	1.5	Type-1	W	47
478	Standard	Without Bionic	Peach	1.5	Type-1	S	26
479	Standard	Bionic	White	2	Type-1	T	57
480	Standard	Without Bionic	White	1.5	Type-1	I	143
481	Standard	Without Bionic	Peach	1.5	Type-1	E	28
482	Standard	Without Bionic	Peach	1.5	Type-2	K	41
483	Standard	Bionic	White	1.5	Type-1	S	28
484	Standard	Without Bionic	Peach	2	Type-2	N	27
485	Standard	Bionic	Peach	1.5	Type-1	W	46
486	Standard	Without Bionic	Peach	2	Type-1	E	39
487	Standard	Bionic	White	2	Type-2	G	31
488	Standard	Without Bionic	Peach	2	Type-1	C	41
489	Mali	Without Bionic	Peach	2	Type-1	R	42
490	Mali	Without Bionic	White	1.5	Type-1	W	142
491	Standard	Without Bionic	Peach	1.5	Type-1	U	59
492	Standard	Bionic	White	2	Type-1	I	62
493	Standard	Bionic	Peach	1.5	Type-2	B	25
494	Standard	Bionic	Peach	1.5	Type-2	F	54

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
495	Standard	Without Bionic	Peach	1.5	Type-1	H	42
496	Standard	Without Bionic	White	2	Type-2	O	70
497	Mali	Bionic	Peach	2	Type-2	V	57
498	Mali	Bionic	Peach	1.5	Type-2	E	36
499	Mali	Bionic	Peach	2	Type-1	V	51
500	Mali	Bionic	Peach	1.5	Type-2	V	58
501	Mali	Without Bionic	Peach	2	Type-1	E	35
502	Mali	Bionic	White	2	Type-1	P	58
503	Mali	Without Bionic	Peach	1.5	Type-2	V	57
504	Mali	Without Bionic	White	1.5	Type-2	K	160
505	Mali	Without Bionic	White	1.5	Type-1	B	113
506	Mali	Bionic	Peach	1.5	Type-2	P	57
507	Mali	Bionic	Peach	2	Type-1	F	32
508	Mali	Without Bionic	Peach	1.5	Type-1	C	41
509	Mali	Without Bionic	White	2	Type-2	S	48
510	Mali	Bionic	White	1.5	Type-2	A	63
511	Mali	Bionic	White	1.5	Type-1	R	41
512	Standard	Without Bionic	Peach	1.5	Type-1	D	53
513	Standard	Without Bionic	Peach	1.5	Type-1	I	65
514	Mali	Without Bionic	Peach	2	Type-2	V	64
515	Standard	Without Bionic	White	1.5	Type-2	P	57
516	Mali	Bionic	White	1.5	Type-2	U	69
517	Standard	Without Bionic	White	1.5	Type-2	N	49
518	Standard	Without Bionic	White	2	Type-1	S	28
519	Standard	Without Bionic	Peach	1.5	Type-1	R	33
520	Mali	Without Bionic	White	1.5	Type-2	R	52
521	Mali	Bionic	White	2	Type-2	U	130
522	Standard	Bionic	Peach	1.5	Type-1	X	46

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
523	Standard	Without Bionic	White	1.5	Type-2	T	45
524	Mali	Bionic	Peach	2	Type-2	I	40
525	Mali	Without Bionic	Peach	1.5	Type-2	U	73
526	Mali	Without Bionic	Peach	1.5	Type-1	V	63
527	Mali	Bionic	Peach	2	Type-1	B	51
528	Standard	Without Bionic	White	1.5	Type-1	U	123
529	Mali	Bionic	White	2	Type-2	I	151
530	Standard	Without Bionic	White	1.5	Type-1	R	59
531	Standard	Without Bionic	Peach	1.5	Type-2	O	63
532	Standard	Without Bionic	Peach	1.5	Type-2	S	33
533	Standard	Without Bionic	White	1.5	Type-1	A	94
534	Standard	Without Bionic	White	1.5	Type-1	F	81
535	Mali	Bionic	Peach	2	Type-1	N	51
536	Mali	Without Bionic	Peach	1.5	Type-1	E	38
537	Standard	Without Bionic	Peach	2	Type-1	A	55
538	Standard	Bionic	Peach	2	Type-2	F	25
539	Standard	Without Bionic	Peach	1.5	Type-1	B	35
540	Standard	Without Bionic	Peach	1.5	Type-2	I	67
541	Mali	Without Bionic	White	1.5	Type-1	G	40
542	Standard	Bionic	Peach	1.5	Type-2	P	52
543	Standard	Without Bionic	White	2	Type-1	N	44
544	Mali	Bionic	White	2	Type-1	L	56
545	Standard	Bionic	Peach	2	Type-1	P	52
546	Mali	Bionic	Peach	2	Type-2	T	38
547	Standard	Without Bionic	White	1.5	Type-1	Q	43
548	Mali	Without Bionic	Peach	1.5	Type-1	J	38
549	Mali	Bionic	White	2	Type-2	X	121
550	Standard	Without Bionic	White	2	Type-1	I	104

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
551	Mali	Bionic	Peach	2	Type-2	B	61
552	Mali	Bionic	White	1.5	Type-1	G	31
553	Mali	Without Bionic	White	1.5	Type-2	H	66
554	Mali	Bionic	White	1.5	Type-2	L	56
555	Standard	Without Bionic	White	2	Type-2	F	45
556	Standard	Bionic	Peach	1.5	Type-2	U	24
557	Standard	Bionic	White	1.5	Type-2	N	45
558	Mali	Without Bionic	Peach	2	Type-2	B	57
559	Mali	Bionic	Peach	1.5	Type-1	J	60
560	Standard	Without Bionic	White	2	Type-2	V	65
561	Standard	Bionic	White	2	Type-2	O	71
562	Mali	Without Bionic	White	2	Type-2	W	227
563	Mali	Without Bionic	White	2	Type-2	F	33
564	Mali	Without Bionic	White	1.5	Type-1	V	75
565	Standard	Without Bionic	Peach	1.5	Type-2	E	38
566	Standard	Bionic	White	1.5	Type-2	O	50
567	Mali	Bionic	White	2	Type-2	V	55
568	Mali	Without Bionic	White	2	Type-1	X	179
569	Standard	Without Bionic	Peach	2	Type-1	G	33
570	Standard	Bionic	White	1.5	Type-1	U	50
571	Standard	Without Bionic	White	1.5	Type-2	H	53
572	Standard	Bionic	Peach	2	Type-1	Q	47
573	Mali	Bionic	White	2	Type-2	Q	25
574	Mali	Without Bionic	Peach	2	Type-2	L	50
575	Standard	Without Bionic	Peach	2	Type-2	H	49
576	Mali	Without Bionic	Peach	2	Type-1	T	129
577	Standard	Without Bionic	Peach	2	Type-2	S	31
578	Mali	Bionic	Peach	1.5	Type-2	M	35

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
579	Standard	Without Bionic	Peach	1.5	Type-1	C	62
580	Mali	Without Bionic	Peach	1.5	Type-2	C	77
581	Mali	Bionic	White	2	Type-1	M	51
582	Mali	Bionic	White	1.5	Type-1	M	48
583	Mali	Without Bionic	Peach	2	Type-1	X	111
584	Mali	Without Bionic	White	2	Type-1	K	165
585	Mali	Bionic	White	2	Type-1	X	50
586	Mali	Without Bionic	Peach	2	Type-2	A	62
587	Standard	Bionic	Peach	2	Type-2	L	28
588	Mali	Bionic	Peach	2	Type-2	U	36
589	Mali	Without Bionic	Peach	2	Type-1	L	112
590	Standard	Bionic	White	1.5	Type-1	G	27
591	Mali	Without Bionic	White	2	Type-1	J	187
592	Standard	Without Bionic	Peach	1.5	Type-1	M	56
593	Standard	Bionic	White	2	Type-1	K	37
594	Standard	Bionic	Peach	1.5	Type-1	S	27
595	Mali	Without Bionic	Peach	1.5	Type-2	K	55
596	Mali	Bionic	Peach	2	Type-2	Q	55
597	Standard	Bionic	Peach	2	Type-2	N	47
598	Mali	Without Bionic	Peach	1.5	Type-2	E	35
599	Standard	Bionic	Peach	2	Type-2	S	25
600	Mali	Bionic	Peach	1.5	Type-2	S	32
601	Standard	Bionic	White	2	Type-2	V	58
602	Mali	Bionic	White	2	Type-2	H	50
603	Mali	Without Bionic	Peach	1.5	Type-2	J	71
604	Mali	Without Bionic	White	1.5	Type-1	U	151
605	Mali	Bionic	White	1.5	Type-2	V	66
606	Mali	Without Bionic	Peach	2	Type-1	K	98

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
607	Mali	Without Bionic	White	2	Type-1	H	64
608	Mali	Bionic	Peach	1.5	Type-2	R	41
609	Standard	Without Bionic	White	2	Type-1	E	30
610	Mali	Without Bionic	Peach	1.5	Type-1	U	38
611	Mali	Bionic	White	2	Type-1	T	58
612	Mali	Bionic	White	1.5	Type-1	U	50
613	Standard	Without Bionic	White	1.5	Type-1	D	15
614	Mali	Bionic	White	1.5	Type-1	W	47
615	Mali	Bionic	White	2	Type-1	V	60
616	Mali	Bionic	White	2	Type-2	L	95
617	Mali	Bionic	Peach	1.5	Type-1	E	32
618	Standard	Bionic	White	2	Type-2	A	49
619	Standard	Without Bionic	Peach	1.5	Type-1	X	55
620	Mali	Bionic	Peach	2	Type-2	E	34
621	Mali	Without Bionic	White	1.5	Type-2	Q	39
622	Mali	Bionic	White	2	Type-1	A	51
623	Standard	Bionic	White	1.5	Type-2	U	38
624	Standard	Bionic	Peach	1.5	Type-1	H	43
625	Standard	Without Bionic	Peach	2	Type-2	K	51
626	Standard	Without Bionic	Peach	2	Type-2	Q	56
627	Mali	Without Bionic	White	1.5	Type-1	O	126
628	Mali	Bionic	Peach	2	Type-2	R	40
629	Mali	Bionic	White	2	Type-1	D	23
630	Standard	Bionic	Peach	2	Type-2	J	26
631	Standard	Without Bionic	Peach	1.5	Type-1	L	62
632	Mali	Without Bionic	White	1.5	Type-2	S	41
633	Mali	Bionic	White	1.5	Type-1	K	34
634	Mali	Bionic	White	1.5	Type-2	P	60

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
635	Standard	Without Bionic	Peach	2	Type-2	A	43
636	Mali	Bionic	White	2	Type-1	S	34
637	Mali	Without Bionic	White	1.5	Type-1	M	144
638	Standard	Without Bionic	White	2	Type-2	B	63
639	Mali	Without Bionic	White	2	Type-1	L	116
640	Mali	Bionic	Peach	2	Type-1	P	52
641	Mali	Bionic	Peach	2	Type-2	G	30
642	Mali	Bionic	Peach	1.5	Type-1	I	71
643	Mali	Without Bionic	Peach	2	Type-1	A	51
644	Standard	Without Bionic	White	2	Type-1	G	27
645	Standard	Bionic	Peach	2	Type-2	M	25
646	Mali	Without Bionic	White	2	Type-2	M	199
647	Standard	Without Bionic	White	2	Type-2	J	92
648	Mali	Without Bionic	White	2	Type-1	T	207
649	Standard	Without Bionic	White	2	Type-1	Q	43
650	Mali	Without Bionic	White	1.5	Type-2	L	112
651	Standard	Without Bionic	Peach	1.5	Type-2	M	55
652	Mali	Bionic	White	1.5	Type-1	D	63
653	Standard	Bionic	Peach	1.5	Type-2	N	25
654	Mali	Bionic	Peach	1.5	Type-2	W	35
655	Standard	Bionic	White	1.5	Type-2	M	36
656	Standard	Without Bionic	Peach	1.5	Type-2	F	34
657	Standard	Without Bionic	White	1.5	Type-2	J	40
658	Mali	Bionic	White	1.5	Type-1	C	53
659	Mali	Without Bionic	Peach	1.5	Type-1	A	60
660	Standard	Bionic	White	1.5	Type-1	A	36
661	Standard	Bionic	Peach	2	Type-1	I	52
662	Mali	Without Bionic	Peach	1.5	Type-2	R	40

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
663	Standard	Bionic	White	1.5	Type-2	A	47
664	Mali	Bionic	White	2	Type-2	P	55
665	Standard	Without Bionic	White	2	Type-2	U	94
666	Standard	Bionic	Peach	1.5	Type-1	B	49
667	Standard	Without Bionic	Peach	2	Type-2	G	29
668	Standard	Without Bionic	White	1.5	Type-2	V	59
669	Standard	Without Bionic	Peach	2	Type-1	M	37
670	Mali	Bionic	Peach	1.5	Type-1	A	38
671	Standard	Without Bionic	White	2	Type-2	H	58
672	Mali	Without Bionic	White	1.5	Type-1	R	53
673	Mali	Bionic	White	1.5	Type-2	G	35
674	Standard	Without Bionic	White	2	Type-2	M	90
675	Standard	Without Bionic	Peach	2	Type-2	J	67
676	Standard	Without Bionic	White	1.5	Type-2	C	44
677	Standard	Bionic	White	2	Type-1	F	45
678	Mali	Without Bionic	Peach	2	Type-1	B	71
679	Standard	Without Bionic	White	2	Type-2	N	63
680	Mali	Without Bionic	White	2	Type-1	C	203
681	Standard	Without Bionic	White	2	Type-1	K	72
682	Mali	Without Bionic	White	2	Type-2	D	152
683	Mali	Without Bionic	Peach	2	Type-2	S	37
684	Mali	Bionic	Peach	1.5	Type-1	K	44
685	Standard	Without Bionic	Peach	1.5	Type-1	J	57
686	Standard	Without Bionic	Peach	1.5	Type-1	W	55
687	Standard	Bionic	Peach	1.5	Type-2	O	28
688	Standard	Without Bionic	White	1.5	Type-1	X	114
689	Mali	Without Bionic	Peach	1.5	Type-2	Q	32
690	Standard	Without Bionic	White	1.5	Type-1	V	83

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
691	Standard	Bionic	Peach	2	Type-1	X	42
692	Mali	Bionic	White	2	Type-1	B	82
693	Mali	Without Bionic	Peach	1.5	Type-2	S	32
694	Mali	Without Bionic	Peach	2	Type-1	D	26
695	Mali	Without Bionic	White	2	Type-1	M	182
696	Standard	Without Bionic	Peach	2	Type-2	V	54
697	Standard	Bionic	Peach	2	Type-1	R	38
698	Standard	Bionic	White	1.5	Type-2	B	45
699	Mali	Without Bionic	White	1.5	Type-2	M	177
700	Standard	Without Bionic	Peach	1.5	Type-2	T	62
701	Mali	Bionic	White	1.5	Type-2	D	58
702	Standard	Without Bionic	White	2	Type-2	Q	71
703	Standard	Bionic	White	2	Type-2	X	83
704	Standard	Bionic	Peach	1.5	Type-1	N	49
705	Mali	Bionic	Peach	1.5	Type-1	W	58
706	Mali	Bionic	Peach	1.5	Type-1	X	57
707	Mali	Without Bionic	Peach	2	Type-1	C	126
708	Mali	Without Bionic	White	2	Type-2	X	224
709	Mali	Without Bionic	White	2	Type-1	N	93
710	Standard	Without Bionic	Peach	2	Type-1	I	45
711	Mali	Bionic	White	2	Type-2	W	123
712	Standard	Bionic	Peach	1.5	Type-1	Q	50
713	Standard	Without Bionic	Peach	2	Type-2	D	55
714	Mali	Bionic	Peach	2	Type-1	U	72
715	Standard	Bionic	Peach	2	Type-2	V	45
716	Mali	Without Bionic	White	2	Type-2	T	260
717	Mali	Bionic	Peach	1.5	Type-1	L	52
718	Mali	Bionic	White	2	Type-1	W	51

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
719	Standard	Bionic	White	1.5	Type-1	R	36
720	Standard	Without Bionic	White	1.5	Type-2	U	42
721	Standard	Without Bionic	White	2	Type-1	V	49
722	Standard	Without Bionic	White	2	Type-2	W	89
723	Mali	Without Bionic	Peach	2	Type-1	P	56
724	Mali	Bionic	White	1.5	Type-2	O	48
725	Standard	Bionic	Peach	1.5	Type-2	D	74
726	Mali	Without Bionic	Peach	2	Type-1	W	112
727	Mali	Bionic	Peach	1.5	Type-1	B	39
728	Standard	Without Bionic	White	1.5	Type-1	W	115
729	Standard	Bionic	White	1.5	Type-1	H	46
730	Standard	Without Bionic	White	2	Type-1	U	91
731	Mali	Without Bionic	White	1.5	Type-2	P	65
732	Standard	Without Bionic	Peach	1.5	Type-2	C	61
733	Standard	Bionic	White	1.5	Type-1	X	47
734	Standard	Without Bionic	White	1.5	Type-1	P	71
735	Mali	Bionic	Peach	1.5	Type-1	V	52
736	Standard	Bionic	White	2	Type-2	T	96
737	Standard	Bionic	Peach	2	Type-2	A	27
738	Standard	Bionic	Peach	2	Type-2	W	25
739	Mali	Without Bionic	White	1.5	Type-1	E	45
740	Standard	Without Bionic	White	1.5	Type-1	J	120
741	Standard	Bionic	White	1.5	Type-2	G	30
742	Mali	Without Bionic	White	2	Type-2	G	46
743	Mali	Without Bionic	White	1.5	Type-1	H	67
744	Standard	Without Bionic	Peach	2	Type-1	R	44
745	Mali	Without Bionic	White	1.5	Type-2	C	197
746	Standard	Bionic	White	2	Type-2	M	85

**Table E.1 continued from previous page**

<b>Run Order</b>	<b>Font Type</b>	<b>Font Style</b>	<b>Background Color</b>	<b>Line Spacing</b>	<b>Picture</b>	<b>Children Participant</b>	<b>Attention Span</b>
747	Standard	Without Bionic	Peach	1.5	Type-1	P	49
748	Mali	Bionic	White	1.5	Type-2	I	80
749	Standard	Without Bionic	White	1.5	Type-2	O	54
750	Mali	Bionic	White	2	Type-2	T	141
751	Mali	Bionic	Peach	2	Type-2	P	56
752	Standard	Without Bionic	White	1.5	Type-2	F	48
753	Standard	Bionic	Peach	1.5	Type-2	T	26
754	Standard	Bionic	White	1.5	Type-1	I	58
755	Mali	Without Bionic	Peach	2	Type-1	G	31
756	Mali	Bionic	Peach	1.5	Type-2	A	48
757	Standard	Bionic	White	2	Type-1	S	32
758	Mali	Without Bionic	White	1.5	Type-2	B	102
759	Standard	Without Bionic	Peach	1.5	Type-2	J	56
760	Standard	Bionic	Peach	1.5	Type-2	H	47
761	Standard	Bionic	White	2	Type-1	U	53
762	Mali	Bionic	White	2	Type-1	N	82
763	Mali	Bionic	Peach	2	Type-2	A	47
764	Mali	Bionic	White	1.5	Type-1	A	47
765	Standard	Without Bionic	White	2	Type-1	X	85
766	Standard	Bionic	Peach	2	Type-1	B	81
767	Standard	Without Bionic	White	2	Type-2	E	40
768	Standard	Bionic	Peach	1.5	Type-1	F	36

## Appendix F

### Attention span estimation in the longitudinal study

Child Code	Pre-intervention Attention Span	Post-intervention Attention Span
CGID1	55	46
CGSK2	65	67
CGAS3	50	53
CGAN4	56	61
CGSP5	46	50
CGPC6	62	68
CGMP7	86	79
CGAK8	154	157
CGSP9	77	75
CGSK10	86	84
CGSD11	140	135
CGAK12	53	49
CGKP13	127	128
CGRM14	139	140
CGSS15	98	95
CGRK16	89	85
CGMD17	135	132
CGDD18	89	86

<b>Child Code</b>	<b>Pre-intervention Attention Span</b>	<b>Post-intervention Attention Span</b>
TGIP01	90	160
TGDP02	127	183
TGSP03	200	247
TGVP04	152	195
TGVK05	140	210
TGSM06	33	108
TGDP07	230	268
TGAD08	175	243
TGAK09	77	96
TGSM10	46	85
TGHI11	120	134
TGSG12	53	62
TGRY13	127	198
TGIY14	139	226
TGAM15	98	123
TGAJ16	46	78
TGPK17	43	48
TGAJ18	86	146

## 19. The Ugly Duckling

Mother Duck was really proud of her six new ducklings. They were soft, fluffy and yellow. Such fine little ducklings! But the seventh one was very different. It was bigger and its feathers were gray and shaggy. It looked so ugly!

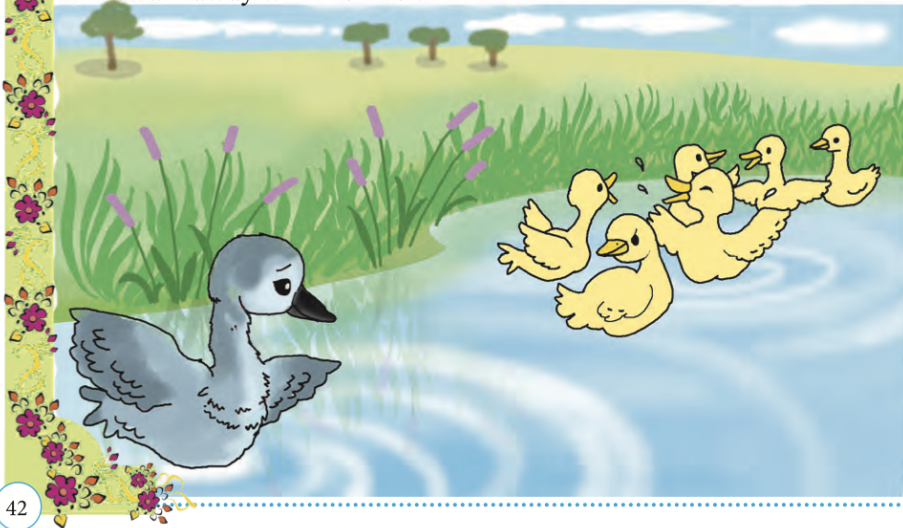


“All the same,” Mother Duck thought, “It’s my baby duckling.” She loved it dearly. But the other six brothers and sisters didn’t like the ugly duckling. When it waddled towards them, they turned their backs and ran away.

The little ducklings would go for a swim, every day, to a lake nearby. The ugly duckling wanted to join the others but they didn’t want him. They always swam away from him. He was left all alone.

The ugly duckling swam better than the other ducklings which did not please them at all. They teased him about his ugliness. His only friend was his mother. Other ducks told his mother, “All your ducklings are smart. But this big fellow looks so different. Why is he so ugly?” His mother only said, “He is mine, and I love him too.”

At last, feeling very lonely and sad, the ugly little duckling decided to leave the lake. He made his way to the river’s edge and swam away with the river.



42

Figure F.1: A typical lesson from the curriculum book titled, "English Balbharti Standard 4" (Gosavi (2021))

## **The Ugly Duckling – Part 1**

Mother Duck was really proud of her six new ducklings. They were soft, fluffy and yellow. Such fine little ducklings! But the seventh one was very different. It was bigger and its feathers were gray and shaggy. It looked so ugly!

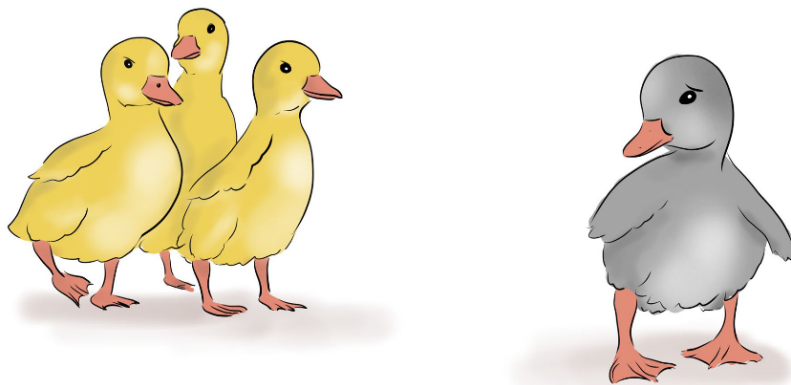


Figure F.2: Representation of lesson plan represented using the proposed eVDGs



## My Shadow

I have a little shadow that goes in and out  
with me,

And what can be the use of him is more  
than I can see.

He is very, very like me from the heels up  
to the head;



Figure F.3: Example of representation of lesson plan represented using the proposed eVDGs

## Hiking

For summer fun I like to hike.  
Off I hurry down the pike.  
To a country road I turn,  
And soon am thick in brush and fern.  
Oh, the secrets that I find  
If I have more than half a mind!  
For winter fun I like to hike.  
Yes, that's exactly what I like



Figure F.4: Example of representation of lesson plan represented using the proposed eVDGs

## Three Sacks of Rice: Part 1

You may have read many stories about three brothers. Usually, two of them - the elder ones are strong, clever but unkind. They laugh at the youngest one because he is too simple and softhearted. Our

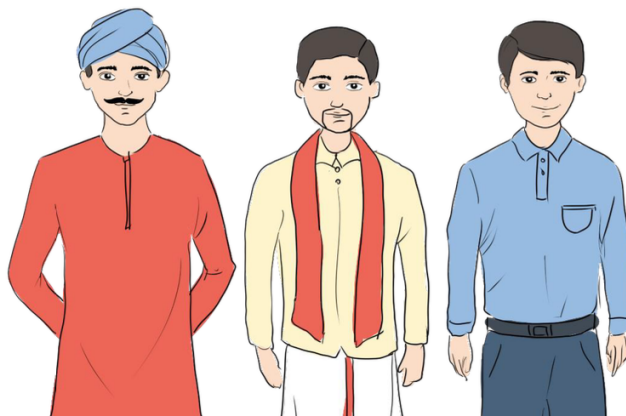



Figure F.5: Example of representation of lesson plan represented using the proposed eVDGs

# Appendix G

## Approvals and Collaborations



## G.1 Ethical Approval


 INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
Guwahati, Assam, India, Pin - 781039  
G

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**Certificate of Approval/Clearance**

**Institute Human Ethics Committee Approval**

The chair and the members of Institute Human Ethics Committee of Indian Institute of Technology Guwahati have considered the project titled **“Design and Development of Assistive Teaching Tool for Children Living with ADHD”** in the meeting convened on 26<sup>th</sup> February 2021 and given its approval for the same.

  
1.12.21

**Prof. Vimal Katiyar**  
**Deputy Chairperson of IHEC**  
**Dean R&D, IITG**


संकायाध्यक्ष, अनुसंधान एवं विकास  
Dean, Research and Development  
भारतीय प्रौद्योगिकी संस्थान गुवाहाटी  
Indian Institute of Technology Guwahati  
गुवाहाटी-781039  
Guwahati-781039

Figure G.1: Institute Ethical Committee Approval

## G.2 Collaboration Letters

### G.2.1 Gulmohar Remedial Center Satara

SURVEY NO. 12, CHINTAMANI PRIDE, 4TH FLOOR, NEAR CITY PRIDE.  
KOTHRUD, PUNE 411 038. MAHARASHTRA (INDIA)  
TEL : +91 (020) 66424600 FAX : +91 (020) 66424666  
CIN NO. : U27310PN1980PTC023353

 **PARANJAPE  
AUTOCAST  
PVT. LTD.**

10<sup>th</sup> May 2021

To,  
Dr. Abhishek Shrivastava,  
Assistant Professor,  
Department of Design, Indian Institute of Technology Guwahati,  
Guwahati, Assam, India-781039.

**Sub:** Confirmation to collaborate on the Research Project for children living with ADHD.

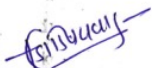
Dear Sir,

As a part of its CSR activity, Paranjape Autocast Pvt. Ltd. has been running Gulmohar Remedial Centre for children with Learning Disability in Satara district of Maharashtra state.

We have read your research proposal on "**Developing Gamified teaching tool for children with ADHD**". During our conversations with your student, Mr. Sandesh Phalke we found the project to be quite interesting. As such we are willing to be a part of your study and contribute in the development of the tool.

**We hereby grant our confirmation to be a part of this project.** We will be ready to help openly from our side, subject to the consent from parents as and when the centre reopens after the Covid pandemic subsides.

Yours faithfully,  
For Paranjape Autocast Pvt. Ltd.


  
Authorised Signatory

WORKS : Satara 1. H-19, M.I.D.C., Satara - 415 004, Maharashtra (India) Tel.: +91 (02162) 244436 / 244438 Fax : +91 (02162) 244494  
2. J-15/16 Additional M.I.D.C., Satara - 415 004, Maharashtra (India) Tel.: +91 (02162) 240351 / 240380 Fax : +91 (02162) 240350  
Shirwal : Jawale Road, Zagalwadi Phata, Village Sanghvi Post Naigoan, Via Shirwal. Dist. Satara - 412 801.  
Tel. : +91 (02169) 244246 / 244247 Fax : +91 (02169) 244226.

Figure G.2: Gulmohar Participation approval

## G.2.2 Manoved Foundation Satara, and Pune

**Mrs Pranoti Tilak**  
(M.A. Clinical Psychology, P.G.D.C.P, P.O.D.I.C , P.G.D.C.C)  
RCI-79526-A, Reg.no.CPTT18964240



Manovedh Foundation Operated  
(Govt. Reg. No: MAHA/17037/SA)

To,

Dr Abhishek Shrivastava,

Assistant Professor,

Department of Design, Indian Institute of Technology Guwahati,

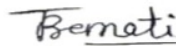
Guwahati, Assam, India-781039.

**Subject:** Confirmation to collaborate on the Research Project for children living with ADHD.

Dear Sir,

I have read about you research proposal on “**Developing Gamified teaching tool for Children with ADHD**”. Even during the conversations with your student, Sandesh Phalke I found the project quite interesting. I wish to be a part of your study and help you to analyses and develop your tool in the whole process. I would be glad to work along with you and your team.

**I grant my complete confirmation to be a part of this project.** I thank you for this opportunity and will be pleased to help openly from my side. I wish we have a healthy collaboration and develop a well-designed application for the children and contribute to the society.



**Mrs. Pranoti Tilak**  
M.A Clinical Psychology  
(P.G.D.C.P, P.G.D.I.C, P.G.D.C.C)  
RCI NO-79526-AReg.no.CPTT18964240

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**Manovedh Foundation operated Manovedh Counseling Center**  
Shop-114, R-Cube Opp. to Vinayak Hospital,  
Near Mumbai Bangalore Highway, Warje Pune.  
Mobile No. 8796179000

Figure G.3: Manoved Foundation Participation approval

## G.2.3 Hope Neurodevelopment Institute and Autism center, Guwahati

	<h3>HOPE Neurodevelopmental Institute and Autism Centre</h3> <p><i>(An ISO 9001-2015 Certified Organization)</i>          Contact No: 0361-3511421/9706035539/9707733330; Email: <a href="mailto:hopeassam13@gmail.com">hopeassam13@gmail.com</a>,          Website: <a href="http://www.aldrchope.org">www.aldrchope.org</a></p>	
<p><u>OUR SERVICES</u></p> <p>Bio Medical Consultation          Hyperbaric Oxygen Therapy (HBOT)          Applied Behaviour Analysis (ABA)          Sensory Intregation Therapy (SI)          Occupational Therapy (OT)          Physiotherapy (Paediatric)          Oral Placement Therapy (OPT)          Speech &amp; Communication Therapy          Special Education          Autism Movement Therapy (AMT)          Psychological Assessment &amp; Test          Parents Counselling &amp; Guidance          Cognitive Behaviour Therapy          Art Based Therapy          Diet &amp; Nutritional          Handwriting          Vocational Training</p> <p><u>OUR PROGRAMME</u></p> <p>CHILD DEVELOPMENT &amp; LIFE SKILLS          CENTRE for 5+Age group (A Day Care          Centre)          SCHOOL READINESS PROGRAMME          (2Yrs to 5 Yrs)          EARLY INTERVENTION PROGRAMME          (0 to 3 Yrs)          REMEDIAL CLASS (I to VII)          SOCIAL SKILLS PROGRAMME</p> <p><u>DEALS IN/          CONSULTATION FOR</u></p> <p>Delayed Developmental Milestone          Autism Spectrum Disorder          ADHD          Cerebral Palsy          Down Syndrome          Speech Impairment/Disorder          Learning Disability          Intellectual Disability          Multiple Disability          Slow Learner          All Psychological &amp; Behaviour          Disorder</p>	<p>Reg. No: HOPE/2021/377/210</p> <p>Date: 05/05/2021</p> <p>To,          Dr. Abhishek Shrivastava          Assistant Professor          Department of design          IIT, Guwahati, India          Assam-781039</p> <p>Sub: Collaboration for conducting research project on Designing and development of assistive teaching tool for the children living with ADHD.</p> <p>Respected Sir,</p> <p>I am happy to inform you that we will be glad to have collaboration in Designing and development of assistive teaching tool for children with ADHD.</p> <p>In this regard, we would like to confirm our participation and support of assistance for completion of your research project.</p> <p>Thanking you,</p>	<p>Yours Faithfully,</p> <p>          DR. LAKSHYAJIT DAS (PT)          Managing Director          Dr. Lakshyjit Das (PT)          Managing Director          CRR No. A19051</p>
		
<p>MAIN CENTRE: H/No:07, Rukmininagar, Housing Colony, Rangamancha Path, Near Old Passport Office, Guwahati          DAY CARE CENTRE: Puberun Path, Bagharbari, Sathgaon Road, Guwahati, Assam          DIBRUGARH CENTRE: Milanpur, Opposite E Lane, Dibrugarh, Assam</p>		

Figure G.4: Hope Neurodevelopment Institute and Autism center Participation approval



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# List of Publications

## International Journals

1. Phalke, S. S., Shrivastava, A., & Sahgal, P. (2023). Identification of Digital Font Size and Font Type to Enhance the Attention Span of Children Living with ADHD in a Typical Learning Environment. *International Journal of Visual Design*, 17(1), 43-60.

## International Conferences

1. Phalke, S. S., & Shrivastava, A. (2022, December). HI Applications for ADHD Children: A Case for Enhanced Visual Representations Using Novel and Adapted Guidelines. In *International Conference on Trends in Electronics and Health Informatics* (pp. 207-226). Singapore: Springer Nature Singapore.
2. Phalke, S. S., Shrivastava, A., & Phukon, M. (2023, January). Auditory Interactions: A Potential Way for Managing the Children Living with ADHD. In *International Conference on Research into Design* (pp. 751-759). Singapore: Springer Nature Singapore.

## Book Chapters

1. Phalke, S. S., & Shrivastava, A. (2023). Directions to Design Assistive Digital Aid for the Children Living With Attention Deficit Hyperactivity Disorder. In *Exergaming Intervention for Children, Adolescents, and Elderly People* (pp. 93-107). IGI Global.
2. Phalke, S. S., & Shrivastava, A. (2024). HI Applications for ADHD Children: The

Graphic Design Perspective. *In Brain-like Super Intelligence for Bio Electromagnetism.*  
Studies in Rhythm Engineering, Springer Nature [Accepted].

