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P(L)AY ATTENTION! Co-Designing for and with Children with Attention Deficit Hyperactivity Disorder (ADHD)

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Abstract. In recent years, children’s mental health problems, including Attention Deficit Hyperactivity Disorder (ADHD), have been a growing phenomenon. However, there are limited examples of designing for and with children with ADHD. This work views conditions such as ADHD through the lens of neurodiversity as different cognitive styles, focusing on *capabilities* and enhanced competences instead of *disabilities*. This paper explores how to engage children with ADHD in co-design activities. Taking the Diversity for Design (D4D) framework as a starting point, an adaptation of the framework for ADHD was first driven by theoretical considerations and three expert interviews, followed by an empirical study consisting of three co-design workshops with four male participants (aged 7-10). Based on observations and audio recordings from the co-design workshops, a qualitative analysis was carried out. Our results show that when their needs, preferences, and individual desires are taken into account, children with ADHD can be meaningfully engaged in co-design activities. By offering an adapted version of the D4D framework tailored for ADHD, designers can structure the environment and provide scaffolds so that children with ADHD can become active participants in co-design workshops. This research informs the design community on how to engage and involve children with ADHD into the design process.

Keywords: Co-Design · children · ADHD · diversity for design · D4D.

1 Introduction and Related Work

Children’s mental health, as well as social and emotional well-being are a growing concern in today’s society. The number of individuals requiring diagnosis and treatment is expected to rise in the near future. Besides anxiety and depression, numerous young people are affected by Attention Deficit Hyperactivity Disorder (ADHD), approximately 7-10% of the global population [10]. ADHD in children is often treated with psychostimulants, which has been proven to reduce playfulness [24]. Play improves self-control and attention, while reducing the symptoms of hyperactivity, therefore research suggests that it could be applied as prevention in some cases of ADHD [27].

Prior studies have noted the importance of looking at different cognitive styles from a critical perspective, through the lens of neurodiversity [2]. Accordingly, this study focuses on *coolabilities* [13] and enhanced competences instead of *disabilities*. While many studies have focused on involving children with Autism Spectrum Disorder (ASD) in the design process, there are limited examples of designing for and with children with Attention Deficit Hyperactivity Disorder (ADHD) [5].

The advantages technology can bring in the context of neurodiversity are broadly recognized by the Child-Computer Interaction (CCI) community [5]. A growing number of projects focus on involving children with special needs into the design process through participatory design activities, with different levels of involvement [11], [14]. Previous studies have explored the possibilities to include children, also with special needs and conditions, into the design process. One of the most influential scholars in designing with children is Allison Druin, who identified four levels of involvement regarding the role of children in designing technology [8]. To involve children with special needs in designing technology, Guha and colleagues created a three-layer-model [14]. Still, these researchers mainly focus on how to conquer difficulties in involving children into the design process. More recently, attention has focused on the shift of viewing disability from another perspective, and adapting the neurodiversity mindset. Dalton [7] proposes the development of new design methods for participatory design in the context of neurodiversity. In their systematic literature review, Borjesson and colleagues [5] present three examples of involving children with ADD/ADHD in the technology design process [1], [12], [29]; all addressing matters that individuals with ADHD have difficulties with, and varying in the level of user involvement. While children with Autism Spectrum Disorder have been frequently involved in the design process, little attention has been paid to children with ADHD [5].

Participatory design can be defined as the practice of *collective creativity* between participants. The designer acts as facilitator, and supports participants in idea generation and other activities by supplying different tools for expression [25]. Co-design (or collaborative design) [26] is rooted in participatory design (PD). It usually describes an activity where target users are engaged in contributing and creating their ideas in different design situations. As a result, novel solutions can be created together, not only with adults, but with children as well, based on the knowledge-sharing and experiences of the participants [28]. Personas can be used in the design process, for instance in envisioning fictional use-cases [6]. Co-created personas have been tested with participants with diverse needs, and have been found to be an empowering and effective way to generally engage people in participation [23].

This paper explores how to engage children with ADHD in co-design activities. Building on previous research regarding the Diversity for Design Framework (D4D) framework [3], this study attempts to apply and further develop a framework of methods in theory and practice in the context of ADHD through an empirical case study. Co-design workshops were organized to develop tools

Associated characteristics	ADHD	
<small>= strength</small>	<small>= difficulty</small>	
Spontaneous and high energy/Restless	■	■
Divergent or innovative thinkers	■	
Creative (in specific areas)	■	
Risk-takers/Impulsive	■	■
Attention to details or high precision	■	
High focus (related to interests)/Distractible	■	■

Fig. 1. Characteristic strengths and difficulties related to ADHD [3].

and methods for engaging children in meaningful participation in co-design. The outcomes of the workshops were used to provide the basis for adapting and extending the D4D framework to ADHD. The updated framework can be used to design digital services (apps) or toys that take the needs of children with ADHD into account and support their development. Such apps or toys could further be used for therapeutic purposes.

2 Background

2.1 ADHD and Creativity

A large amount of research is focused on disabilities and the negative effects of being diagnosed with ADHD. However, from a designer's point of view, the perspective needs to be shifted into looking at strengths when involving people with ADHD in design activities. Neurodiversity attempts to change how conditions are perceived by suggesting that they establish alternative cognitive processing styles appearing along a broad spectrum. The term Neurodiversity indicates several neurological conditions, such as Autism Spectrum Disorder, ADHD, dyslexia, anxiety, and intellectual disabilities, among others [2]. Grundwag [13] proposed the term coolability instead of disability regarding enhanced abilities and competences. An overview of characteristic strengths and difficulties related to ADHD can be found on Figure 1.

Many children with ADHD have difficulties to sit still for extended periods of time, following rules, and consequently are sometimes unable to perform well in a traditional school system. Certain characteristics that modern society believes to be disabilities (such as impulsivity and distractibility) in fact provide a high degree of adaptability; this was extremely useful for our hunter-gatherer ancestors, and eventually led to forming a unique DNA cluster, the so-called Edison gene. Thom Hartmann describes this gene in his book *The Edison gene: ADHD and the gift of the hunter child* [16]. He portrays Thomas Edison - the inventor of the phonograph and many other things - as an easily distractible person. Edison had many projects proceeding at the same time, and would work on one

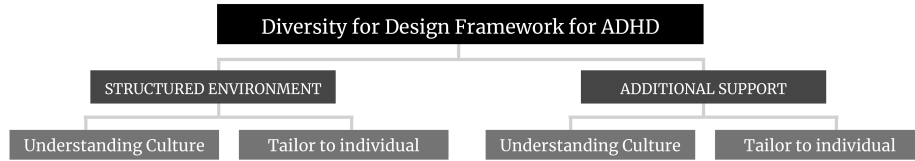


Fig. 2. The Diversity for Design (D4D) framework by Benton et al. [3]

until new inspiration struck or until he got bored. This means that a distractible person can be flexible, which is a key in innovation [17]. People with ADHD can move on quickly from negativity if the setting or activity changes. They are also very adaptive, and tend to get forgetful and disorganized in everyday situations. Consequently, they must learn how to solve particular problems creatively, becoming damage control experts (as Mahamane reported in his TEDx talk, in 2015). If they can control their attention by concentrating on what is interesting to them, they can be productive in their careers, for example in creative or other fields [9], such as the well-known chef Jamie Oliver.

2.2 The Diversity for Design Framework (D4D)

The Diversity for Design (D4D) framework was established by Benton et al. [3] with the objective of discussing challenges and strategies for facilitating participatory design activities with neurodiverse children. In the context of neurodiversity, the whole construction of the activities and the design environment becomes even more relevant due to their influence on how creativity is manifested. Therefore, in the D4D framework, the focus is both on the structured environment and on activities supporting strengths, while difficulties are balanced out structuring the environment and providing support (Figure 2). The general characteristics of neurodiverse conditions should be considered, in addition to the abilities and talents of individuals participating in the workshops: understanding culture and tailoring to the individual. Even though the two case studies presented in Benton’s article were based on Autism Spectrum Disorder (ASD) and dyslexia, it discussed characteristics of ADHD, and the framework was proposed to be applied to and further expanded to ADHD. The D4D is intentionally named a framework instead of a strict method - it is intended to be applied as a flexible set of tools that enables neurodiverse populations in meaningful participation.

Two additional approaches were taken into consideration in the case study, namely Universal Design for Learning (UDL) approach and growth mindset [21]. These theories are both looking at strengths and difficulties from the lens of neurodiversity, and therefore their perspective is in line with the D4D Framework. The three principles of UDL are established on giving multiple ways of engagement, representation, action and expression to provide an optimal learning experience that builds on flexibility and choices. Children with ADHD are reported to have lower self-esteem than average [15]. Looking at everyday setbacks as

challenges that can create opportunities for building skills that help overcome difficulties; adopting and training a growth mindset can empower children with attention issues, and develop their resilience [21].

3 Methods and Data Collection

The D4D Framework is adapted to ADHD in two steps. First, a theory- and expert-informed version is established based on insights from literature, and two expert interviews (Figure 3). 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 neuropsychologist, 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.

Second, a practice-informed version is developed by testing the framework during three co-design workshops (Figure 9). Three experts (i.e., two psychologists and a social worker) helped plan and provided 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.

4 Adapting the D4D Framework to ADHD

While the theoretical foundations have been laid to include neurodiverse population in the D4D Framework, there has been a lack of practical guidelines for involving children with ADHD in co-design activities. Therefore, we explored how the D4D framework could be adapted to children with ADHD. The first step was to search the literature and look for characteristics of ADHD; these helped in identifying the basis of the theoretically-inspired methods of the framework. Since some typical characteristics overlap for different neurological conditions [20], some of the features can be transferred from Benton’s two case studies. On Figure 3, these features are annotated with the letters “A” from the ASD, and “D” from the Dyslexia case studies [3]. Furthermore, insights from expert-interviews are marked with the letter “E”, while features confirmed from the UDL approach are annotated with the letter “U”. Features were added as boxes

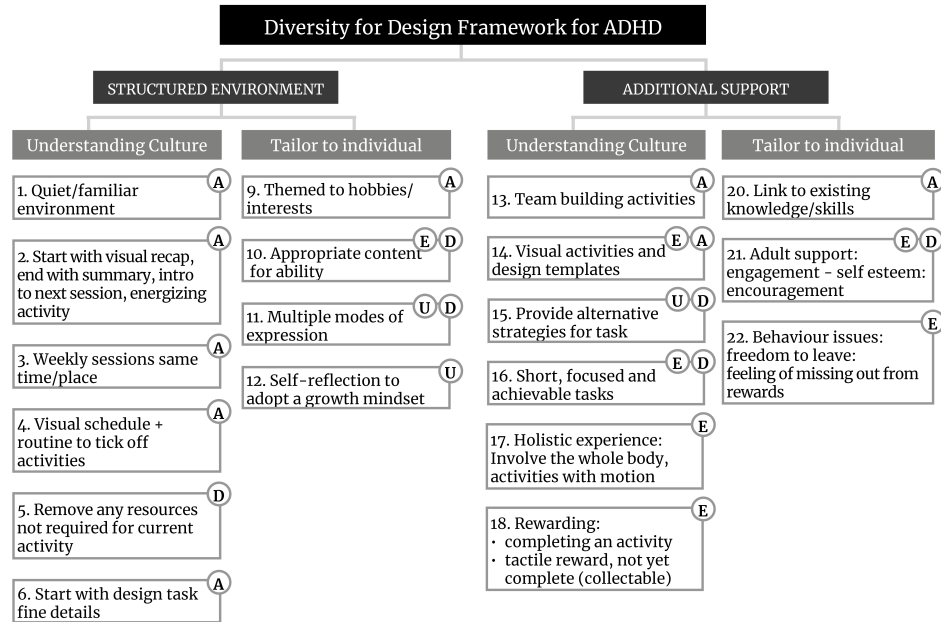


Fig. 3. The theory- and expert-informed version of the Diversity for Design (D4D) framework adapted for ADHD. Features on how to tailor activities to the individual and how to structure the environment to encourage participation were added as boxes, and labeled: “A” for ASD, “D” for Dyslexia, “E” for expert-interviews, and “U” for the UDL approach.

in the four categories, on how to tailor activities to the individual, and how to structure the environment to encourage participation.

4.1 Tailor to Individual

The D4D framework highlights the need for tailoring design activities to individuals, considering their skills and competences [3]. To execute this, a questionnaire should be sent out to parents before the first of three co-design workshops. Questions should be aimed at understanding children’s *hobbies and interests*, as they might be engaged more, and could possibly reach a deeper focus regarding these particular topics. The findings from the survey should then be used in motivating children in different activities, for example through embedding them in a story that is relevant for a particular child. Furthermore, strengths and potential difficulties should be assessed through the questionnaire to provide *appropriate content for ability*, to help reduce the risk of failure for the children. This feature was confirmed by the two experts as well. In addition, the feature *multiple modes of expression* from the Dyslexia study is in accordance with the findings from the UDL approach. Participants are encouraged to select from different methods

that fit their personal interest, to express themselves. Various tools are available for them as long as they are completing the session goals [21].

When providing support for each individual, Benton proposes in the ASD study that children's *existing knowledge* could be integrated into the composition of the design activities [3], which might be possible after the first workshop. Considering that some children also have low self-esteem [15], *adult support*, and engagement for each individual is essential. This feature was present also in the Dyslexia Study [3], while it was confirmed by experts too. An additional feature was added on the basis of the interviews: in case of behavior problems, researchers should offer the participant the *freedom to leave*. In most cases, children are expected to come back as the feeling of missing out from rewards might be stronger.

4.2 Structuring the Environment and Providing Support

Creating an environment where children can be themselves, without the feeling of being pressured, is essential because it can enhance collaboration, as individuals feel confident in sharing meaningful and creative ideas [25]. The crafting of the design environment, using appropriate methods and providing support, is even more critical in the context of (young) people with ADHD, considering their easy distractibility.

Focusing on children's interest, helping them to reach a state of deep focus is important to augment their creativity. Children who are easily distractible will pay attention to other things in the environment, such as other events, thoughts, or experiences. However, that is in fact a key aspect of creativity as well. It happens for example when mixing ideas together from different areas, that are not related to each other at first glance [17]. Furthermore, materials and tasks are also intended to invite and encourage participants in idea generation and exploration [19]. Hence, *removing any resources not required for the current activity* is suggested, similarly to the Dyslexia case study. Based on the findings of the ASD case study, at the beginning of each session, the structure and agenda are explained with a *visual schedule*, and the session is finished with a *visual summary and introduction to the next session* [3]. Building on children's strong visual skills, *visual design templates* are adopted, where, for instance, text is supported with pictograms. This feature was also supported by the expert interviews.

Adult support is also important: when children get distracted, the facilitator might intervene and provide inspiration. Similar to the Dyslexia Study [3], *short and well-structured tasks* were needed, because the attention-span of children with ADHD is shorter than average. Usually no longer than 10-15 minutes for each task, as it was suggested in the interviews. In addition, energizing activities that involve the *whole body in motion* are advised, to provide a holistic experience.

Rewarding is essential for children with ADHD. Research shows that the constant need for rewards has a biological background in their brain, causing deficits in their motivational system [15]. In one of the expert interviews, it was suggested to spark the interest of the children with a *tangible reward that is not*

yet complete that they can take home, such as an individual personal workshop diary. The diary would be a place where rewards (such as stickers) could be collected when tasks are completed.

Building on the UDL approach presented earlier, the methods for the workshops were further improved and clarified. At the end of each session, guiding questions aid self-reflection: in realizing the participant’s own strengths and challenges, reflecting on their own strategies for each activity to adopt the basics of growth mindset [21], and increasing the motivation for participation. In addition, it was suggested by one of the experts to support texts visually with small icons or pictograms for each question, as some children are stronger in visual skills than reading plain text. The first version of the theory- and expert- informed D4D Framework inspired the next research phase, namely the co-design workshops.

5 Co-Design Workshops

To investigate how children with ADHD can be engaged in co-design activities, a series of three workshops was conducted in Budapest, Hungary during three consecutive weeks in May 2018. Rather than producing refined artifacts, the main purpose of these workshops was to create an environment where children with ADHD could try different methods and tools in a co-design context.

5.1 Participants

Four children (all male, aged 7-10) were recruited from a local Montessori primary school. The Montessori educational approach [22] supports children in self-initiated discovery, and learning through interaction with the constructed environment, rather than following direct instructions. All participants had received a diagnosis of ADHD, except for one who was under assessment for ADHD and dyslexia as a co-morbidity. Written consent was obtained both from the school’s principal and the children’s parents, who were otherwise not involved in the co-design sessions. Although we see potential benefits in involving other stakeholders in co-design (e.g., parents and other school staff), we decided it was important to build trust and engage with children first, and make sure they would not act differently in the presence of their parents (e.g., acting shy or overplaying themselves).

5.2 Setting

Before the first workshop session, an online survey assessed children’s *hobbies, interests*, which were integrated in the form of rewards and reflective diaries. Based on the answers from parents, four workshop diaries were created with different themes (i.e., Minecraft, cars, bicycles, soccer) for each participant (see Figure 5, left).

Workshop 1: Present	Workshop 2: Past	Workshop 3: Future
Introduction		
Icebreaker		
Instructions		
Day in the Life Exercise	Favourite Toy/ Game Collage	Brainstorming Activity
Energizing Activity		
Instructions		Buddy Brainstorming
Play Bank	Play Mapping (Persona)	Group discussion
Debriefing		Presentation and Wrapping up

Fig. 4. The main structure of the three co-design workshops. Workshop sessions consisted of different activities and had a particular theme for each day (i.e., *Present*, *Past* and *Future*).

In preparing the workshops, it was important to find a *quiet/familiar environment*. The sessions took place in the afternoon in a classroom at the children’s school. To separate the workshops from the school setting, the environment was divided into zones. Similar to the dialogue-labs method [19], each task was set up at a different location, to inspire children and encourage participants to move around the area.

5.3 Procedure

The general structure of the three workshops followed the path of expression [25]. Each workshop session started with a concise visual *introduction* where participants were told about the structure of the session, followed by an *ice-breaker*. Two design-related activities per session (i.e., session 1: a *day in the life*, *play bank*; session 2: *collage*, *persona*; session 3: *brainstorming*, *buddy brainstorming*) formed the basis of the sessions, divided by an *energizing activity* (i.e., session 1: Switch places, if you have...; session 2: Secret Conductor; session 3: chair battle). The activities were all *short and focused*, each within a time frame of maximum 10 minutes (+ explanation). The duration of each workshop was one hour. After each activity, participants ticked off boxes on a *visual schedule*, which engaged children in volunteering, even before accomplishing the current task. The workshops were closed by a *debriefing* (outro), which provided a visual recap, and a summary of the session, and gave a brief introduction to the next session. An overview of the structure of the three sessions is presented on Figure 4.

The theme of the first session immersed participants in current experiences, by focusing on the *present*. The *day in the life* exercise (ibid.) helped children reflect upon their day, with the aim to prepare them for the generative session. In addition, this activity supported them in separating the levels of knowledge,

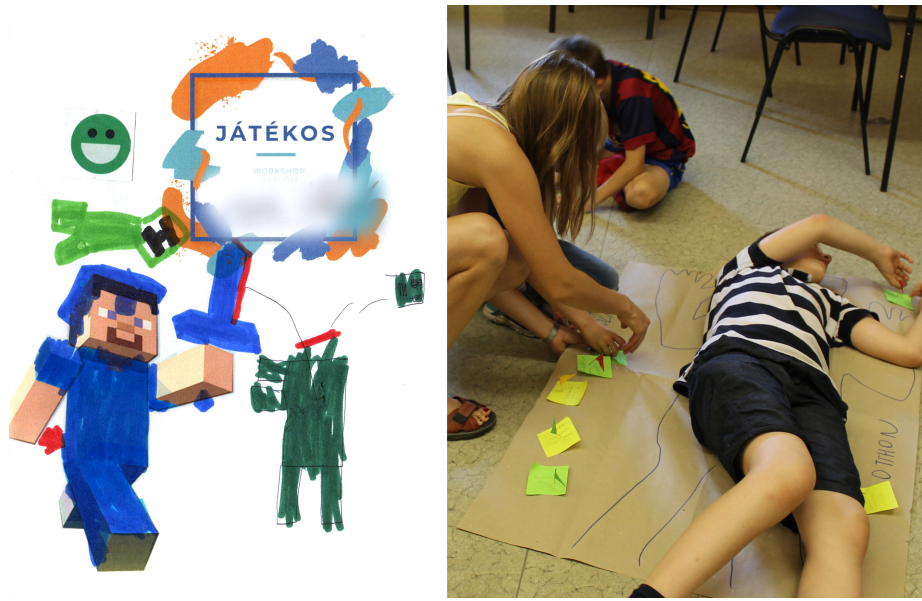


Fig. 5. Workshop diary with children’s customized drawings (left) and persona (right).

from stories to a description of their needs and values. The second design-related task (i.e., *play bank*) aimed to collect as many play activities as possible in form of a competitive exercise, while facilitators documented the two teams’ ideas.

The second session intended to activate feelings and memories from the *past*. Consequently, generative methods facilitated the investigation of past experiences (ibid.) and participants were instructed to make a *collage* of their favorite toys or games. Next, for the second design-related activity, children created a *persona* [6]. The aim of this task was to investigate participant’s wants, hopes, and dreams for the future regarding play experiences. One of the participant’s body was drawn around as a silhouette, after asking him to lie down on a piece of wrapping paper (Figure 5, right). Next to the themes “school” or “home”, participants shared their associations on small sticky notes. To adapt the activity for children with ADHD, and make it a bit more engaging and rewarding, we used colorful cake topper flags, which participants had to pierce through the paper.

Finally, the last workshop invited children to dream about *future* possibilities. The intention was to facilitate a co-design activity to generate and express fresh ideas related to children’s ideal experiences, and thus shape the future of play [18] for children with ADHD. Children were invited to design their own game. The first step was to individually *brainstorm* and create a story. Characters were chosen from cartoon animals, and the participants had to fill in two sets of storyboards given to them using a set of other characters. The next step was intended to facilitate team work in a form of a *buddy brainstorming* session, as

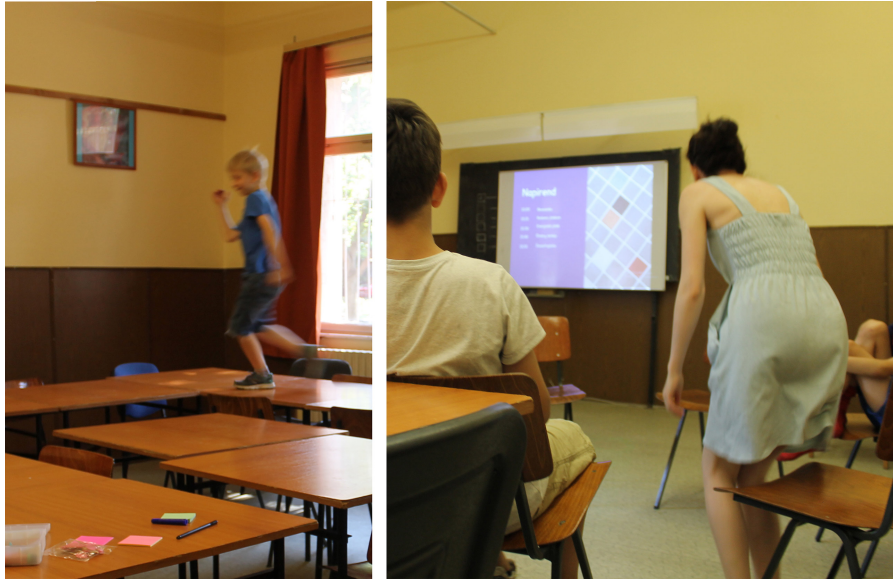


Fig. 6. Running on tables (left), and engaging others in playing “Chair Battle” (right).

well as a *group discussion* to evaluate ideas. Finally, for the presentation and wrapping up, parents were extended an optional invitation so they could see what had happened during the workshops.

The workshops were audio recorded, and pictures were taken with the permission from the parents. Analyzing the participants’ behavior during the co-designs sessions was beyond the scope of this study, thus there was no need to capture everything on video.

6 Findings

6.1 Workshop 1: Present

During the first workshop, children were invited to participate in a *day in the life* exercise, and were observed by the three facilitators. All of them appeared to be proactive, when something sparked their interest. After a small warm-up, children became engaged with the tools available. In spite of having strengths and weaknesses assessed by parents in the questionnaire beforehand, *appropriate content for ability* needed to be adjusted. Self-reflective questions were too abstract and beyond children’s ability to analyze their own performance.

Most of the *energizing games* were a great success, participants became engaged. Still, many rules were overwhelming for three children. Surprisingly, at the end of the first workshop one of the participants proactively suggested his own game-idea (musical chairs or “Chair Battle”) (Figure 6, right), and engaged others in play.

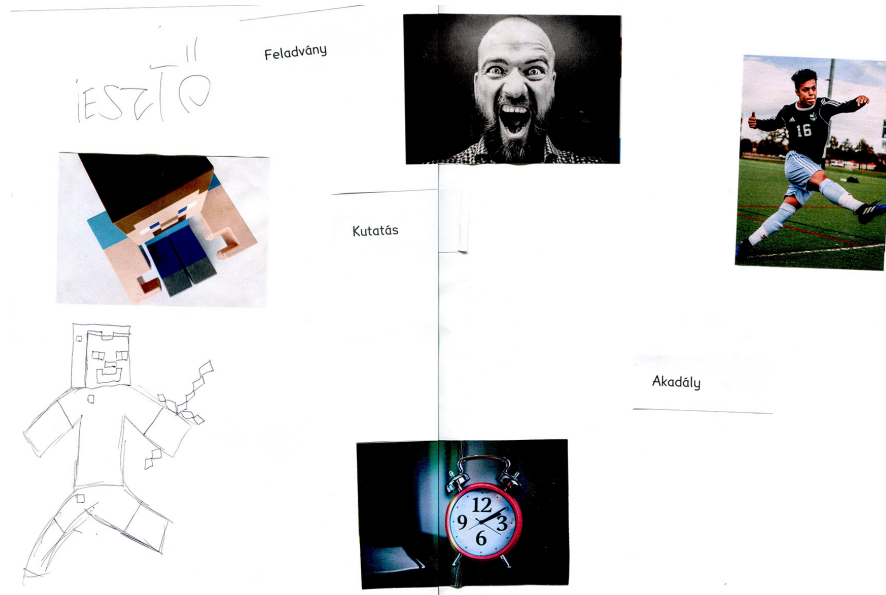


Fig. 7. A collage from the second workshop. Despite challenges in completing this task due to the large amount of materials available to children, this collage combines images, pre-defined words, drawings, and a handwritten word “*ijesztő*” or scary.

6.2 Workshop 2: Past

During the second workshop, children had to make a *collage* (Figure 10, left), and a *persona*, and were observed by the two female facilitators. Most of them could express their ideas most easily through their own drawing, in addition to describing orally what they were making. Making a *collage* was rather challenging, as participants seemed overwhelmed by the amount of materials presented to them [19], especially by the number of words.

One participant picked out words, and also images first, but at one point he decided to draw his favorite game instead, as sort of a comic strip. Another participant fully engaged with the task (Figure 7), as he was able to pick out more than one word, and pictures. Moreover, he proposed his own word (i.e., “*ijesztő*” or scary), as well as drew something on the paper. It was confirmed that *removing materials* for the current activity was important, otherwise children sparked interest towards everything. In addition, when introducing any new activity or tool, it was important to *communicate short, clear goals*, which might be at the expense of understanding the exact task sometimes.

If a participant struggled with an activity, an *adult* provided additional *support* (e.g., in reading), to help the child accomplish a task. A lot depends on the overall mood or having a good or bad day for individuals with ADHD, and taking their medication or not. Participants’ engagement and co-operative attitude varied during the workshops. For instance, based on one of the participant’s en-



Fig. 8. Storyboard of “Feri the cat and the Zombie attack” from the third workshop.

agement towards the energizing activity, the facilitators offered him the *freedom to leave* the workshop. Although it may seem like things got out of control, after a few minutes of energizing activities, running on tables and jumping (Figure 6, left), the workshop could still continue.

6.3 Workshop 3: Future

The last workshop invited children to *brainstorm* and design their own game story, while three facilitators were present making observations. When introducing characters or pictures, gluing could only be implemented with the help of the facilitators. On the other hand, stickers were always a great success as they were easy to install on the templates. The youngest participant interpreted the task slightly differently than others; his storyboard did not follow the template provided, but he was keen on explaining the story in detail. Another participant drew several different games in each frame, but also included the same controller for each of them. At the same time, the last participant created a full story for a lion, who at the end got scared. This detail was added later, when also discussing stories with other participants, whose story was drawn as a complete comic of “Feri the cat and the Zombie attack” (Figure 8). An overall impression was that children created anything beyond ordinary during the construction of the game story.

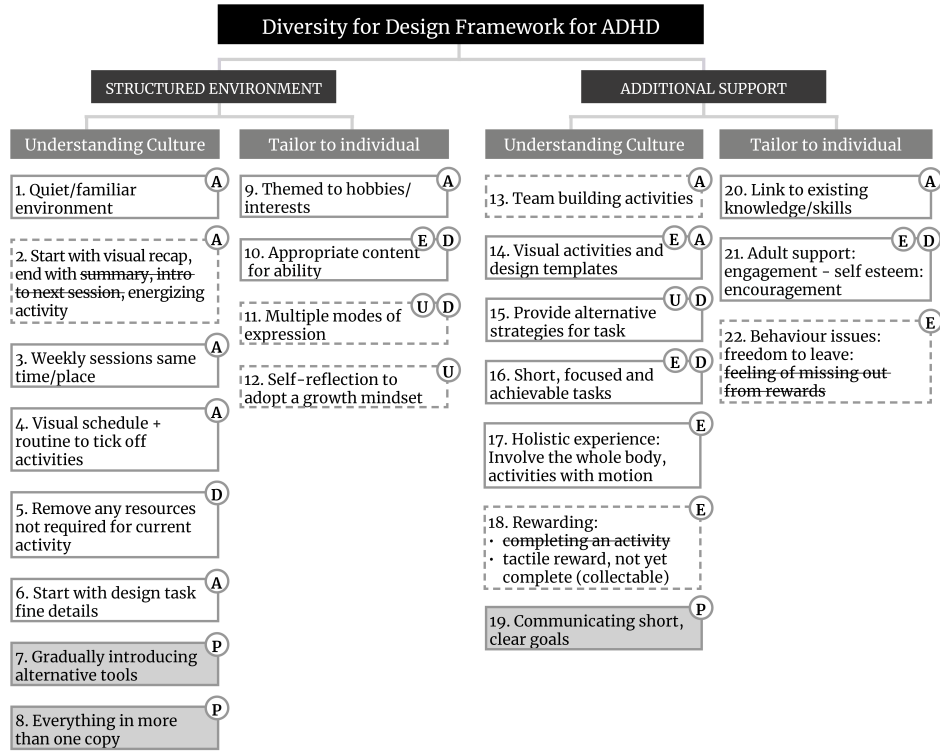


Fig. 9. The practice-informed version of the Diversity for Design (D4D) framework adapted for ADHD. Findings added after the methods were tested in practice with children with ADHD were added as gray boxes labeled "P". Revised aspects of the framework are illustrated with dashed lines.

Interestingly, the second phase of the ideation (*i.e.*, *buddy brainstorming*) was partly successful. One group was observed to be working together just fine, even though in previous sessions they did not get along well. The other group, however, could not finish presenting their stores to each other, as one of the participants left the room after the energizing activity. This was probably a result of personal differences between the children.

7 Discussion

7.1 Revised D4D Framework for ADHD

Based on our empirical findings, we have revised the D4D framework for ADHD. On Figure 9, boxes filled with gray and annotated with the letter "P" indicate findings added after the methods were tested in practice with children with

ADHD; these were reflected upon to further develop the framework. Some other aspects also needed to be revised, illustrated with dashed lines.

At the end of the first workshop, a participant proposed their own game, which left children energized. This was a better closing of the session, instead of having to concentrate on an *intro to the next session*. This might be important for children with ASD, but during the other workshops, we experimented with having an energizing activity at the end of the session instead, with successful results.

For the second workshop, regarding *self-reflection to adopt a growth mindset*, a more visual approach was selected. Smiley stickers were used to evaluate each activity, instead of writing answers to reflective questions. In addition, individually tailored workshop material also had its downsides. For example the *Minecraft* themed workshop diary was considered to be the coolest but only one copy was available (Figure 5, left). Therefore, it is important to have *multiple copies of tools* to avoid similar situations.

When introducing any new activity or tool, it is essential to *communicate short, clear goals*, which might be at the expense of understanding the exact task sometimes. Providing *multiple modes of expression* was useful in some cases, however in others, the variety of tools was rather overwhelming. Too many options can have a downside: due to lengthy explanations, children with limited attention span can lose track during the demonstration, and shift their interest to something else. Adopting the following strategy might be useful in these cases while *gradually introducing alternative tools*:

1. Explain briefly the goal of the activity, and provide one tool.
2. Participants start working and immersing into the topic.
3. Gradually introduce other options, and alternatives for expression.
4. Participants can now select their preferences.
5. Remove tools that are unnecessary.

During the collage task, words and images would have required more abstract thinking than participants' ability. It is advised not to include too many words and images, as children might quickly give up browsing through all of them. The blank A3-size paper can be overwhelming, as participants could not fill the whole page, therefore it is better to use pre-structured templates.

Even though rewarding is essential in the context of ADHD, it was not necessary to provide *small rewards after each activity*. In accordance with parents' observations, positive reinforcement, feedback and recognition were more important than snacks. Still, a *tangible reward that is not yet complete*, such as a sticker split into three parts, was successful. On the other hand, the feeling of missing out from rewards did not affect children's decision on whether they want to stay in the workshop or not.

Group work among individuals with ADHD was partly successful in its aims. The original intention was to facilitate co-design activities among the children. However, only one team succeeded in presenting their concepts to each other (Figure 10, right). While organizing co-design activities even with neurotypically



Fig. 10. Participants creating a collage during the second workshop (left), and presenting concepts to each other (right).

developing children, Vaajakallio, Mattelmäki & Lee observed similar challenges regarding creative collaboration, such as different group dynamics among the children, in addition to different abilities and skills, which is even more critical among neurodiverse children [28]. Hence, a greater flexibility from methods and facilitators is required than with adults or children, and *team building activities* should be reconsidered according to the needs of the group.

7.2 Limitations of This Study

One limitation regarding the methodology applied in the empirical case study is that the workshops included only four male participants, therefore the results cannot be generalized to all children with ADHD. It was not easy to find participants with the eligible criteria. In the school where recruitment took place, girls could not be found with ADHD. Thus, the outcomes might be one-sided due to gender preferences. This might be less of a problem because according to one of the experts, in childhood, the statistical rate in diagnosed cases is 4:1 in male vs. female (whereas in adulthood, it is 1:1). The small sample was chosen firstly because of the difficulty in recruiting helpers in facilitation, and the inexperience of the researchers with children with ADHD. For the purpose of this research, it was more important to gather qualitative data about testing design methods and involving children in the design process, rather than producing refined design artifacts. Nevertheless, increasing the number of participants would have improved the reliability of the study.

A further limitation is that no more than two in-depth interviews with experts from mental health care were conducted. This was a result of the limited time schedule and the difficulty to find relevant interviewees. Despite its limitations, the research reached its goal in informing the design community about engaging and involving children with ADHD into the design process.

7.3 Further Research

To develop a full picture of co-designing with children with ADHD, additional studies will need to focus on the dynamics of group work. In reality, collaboration between individuals with ADHD was partly successful. The findings suggest that inclusion might be a promising direction. Co-design sessions could involve several mixed teams with neurotypically developing children. Each of these teams could integrate children with ADHD who can be the catalyst of creativity in innovation.

The mapped experiences could be used not only when designing treatment games specifically, but in other games targeted at children with ADHD that they would be able to play for the sake of play [4]. The main goal is that play does not seem like homework for children, an extra obligatory task to carry out. By taking into account their experiences, it would be possible to leverage the potential of youngsters being *digital natives*, by taking advantage of their previous knowledge in games and other digital services.

One of the main findings from the expert interviews in this study was related to the important role of parents in therapy and development of their children. It was commented that *“parents are absenting themselves from play in the life of their child [...] nowadays.”* In the future, the next phase of research could gain valuable insights about involving parents and families in addition to teachers and commercial experts in co-design workshops.

8 Conclusions

This paper explored how to engage children with ADHD in co-design activities. The Diversity for Design (D4D) framework was adapted by first looking into theory, conducting expert interviews, and finally putting everything into practice during co-design workshops. Our results show that, when their needs, preferences, and individual desires are taken into account, children with ADHD can be meaningfully engaged in co-design activities. By offering an adapted version of the D4D framework tailored for ADHD, designers can structure the environment and provide scaffolds so that children with ADHD can become active participants in co-design workshops. The updated framework can be used to design digital services (apps) or toys that take the needs of children with ADHD into account and support their development. Such apps or toys could further be used for therapeutic purposes.

Consequently, together these results provide important insights about how to involve and engage children with ADHD in design activities. Reflecting on the theory-, expert- and practice-informed D4D in the context of ADHD, it is worth noting that involving and engaging children in design activities was successful. However, it was partly successful in building on collaboration between participants, which is a core element of co-design. Further research is needed on how to involve and engage participants in group work activities, where they are capable of building upon each other’s ideas. Firstly, among individuals with ADHD, and next in mixed teams to study how engagement and productivity would change.

This empirical case study aimed to reflect on the opportunities and challenges of involving children with ADHD in co-design, and thus is an important tool for the design community that contributes to collective knowledge of ADHD through its findings. Additionally, it represents one of the first investigations into involving children with ADHD in human-centered innovation. The study was carried out by exploring, testing and further refining the framework of already existing design methods. The article presented an adapted version of the Diversity for Design (D4D) framework for ADHD, including modified features and proposed additions. The theory- and expert-informed version was tested during three workshops, and by reflecting on the design practice, a practice-informed D4D was established. The second main contribution of this study was a research-informed, initial model of the design process when designing for children with ADHD.

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