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FRAMEWORK FOR ENHANCING ADHD CHILDREN ONLINE HOME LEARNING IN DESIGN ASPECT: A HONG KONG CASE

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Abstract

The COVID-19 pandemic has necessitated the adoption of distance learning as a new alternative educational approach globally, a shift that has persisted even to the post-pandemic period. Despite identifying online educational advantages in previous studies, the abrupt societal changes brought about by the pandemic have exposed disproportionate difficulties. This study aims to understand how attention deficit/hyperactivity disorder (ADHD) children and their parents are influenced by this educational pattern, and to outline a framework to improve their home-based learning environment from a design perspective. Following the Kolb's Experiential Learning Cycle (KELC), the research commenced with the analysis of ADHD children and online-schooling in Hong Kong. After problems are identified initially, the observational study of 32 school students with or without ADHD in a home-learning environment is conducted to interpret these problems. This process has identified the key issues of domestic distraction and the need for resource support. The study also provides a multi-functional table design as an initial direction for developing supportive frameworks. Then, another study is conducted with a total of 30 school students with or without ADHD and their stakeholders to assess the effectiveness of the design concept. Therefore, the study's findings provide a valuable insight for proposing the framework to improve the home learning experience via the working area for ADHD children. These research findings not only contribute to academic discourse for validating ADHD children challenges in distance education, but also facilitate ADHD parents, educators and designers to enhance the home learning environment by offering a structured design framework.

Keywords: *ADHD children, design education, distance education, Kolb's Experiential Learning Cycle*

Introduction

Research Background and Problem

Around 90% of school-aged children worldwide were affected by the school closure implemented to address the rapid spread of the coronavirus (COVID-19) (UNESCO, 2023). This had a devastating impact on children's academic performance and mental health. The United Nations Children's Fund research (2021) demonstrated that 214 million students ranging from pre-primary through to upper secondary missed at least three-quarters of their regular classroom instruction. This extensive long-term, home-based education has brought with it unprecedented challenges to schools, teachers, caregivers, and children. Due to the pandemic, online courses using internet and media-based technology were proposed and implemented worldwide. The advantages and disadvantages of online learning are continuously being discussed and debated. Polanczyk et al. (2007) believe that online learning and remote education enhance learning performance, interest in the courses, and interactions with teachers and classmates. Furthermore, many educationists and parents had negative and concerned attitudes about distance learning because of the behavioral problems and mental health issues

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of children. Some studies (Mukhtar et al., 2020; Panda et al., 2021; Hatton & Powell, 2022) have demonstrated that children with ADHD and their families face additional difficulties and challenges with home-based online learning.

Attention-deficit/hyperactivity disorder (ADHD) is generally defined as one of the most common mental health disorders among pediatric populations; the average prevalence rate is around 5% in children and adolescents nationwide, and it increased over time (Thapar & Cooper, 2016). Since this rising disorder is mainly characterized by inattention, hyperactivity and impulsivity (American Psychiatric Association, 2013; Cortese et al., 2020), it seriously affects individuals' quality of life (Peasgood et al., 2016), relationships with others (Grygiel et al., 2018), as well as school (Galéra et al., 2009) and work performance (Hechtman et al., 2016). Though symptoms decline with age, the early-age impact of ADHD is always irreversible and continues to influence individuals' subsequent quality of life (Klein & Mannuzza, 1991). Therefore, studies concerning children and adolescents with ADHD who are subjected to long-term quarantine and home-schooling are insufficient.

Research Aim and Research Focus

This research aims to explore the challenges faced by children with ADHD and their parents in distance learning environments while proposing a feasible framework from a design perspective to contribute to the educational issue of ADHD children in a home learning environment. Case studies mainly focus on Hong Kong as it offers unique opportunities to examine the effects of home-based learning: large-scale online teaching started in 2019, and its advanced technology infrastructure provided broad coverage of household internet necessary for remote teaching (Yeung & Yau, 2022). To study and enhance this home educational activity for ADHD children, the Kolb's Experimental Learning Cycle (KELC) is followed as a research methodology. The findings of this study have implications for ADHD parents, educators, designers, as well as ADHD children. It clarifies what are their challenges of remote education and how to improve their home learning environment by identifying a framework on ADHD children's working table. Thus, this research plays an important role in facilitating the future of ADHD children education due to the change of educational patterns among the worlds.

Research Methodology

Kolb's Experiential Learning Cycle (KELC)

Experiential learning (EL) refers to the semi-structured approach that requires cooperation between students and educators to "learn from one another through direct experiences tied to real world problems" (Bartle, 2015). Instead of traditional teacher-centered education, EL places students at the center of the learning process, and emphasizes continuous reflection, critical analysis and synthesis during this process. Kolb (2014) mapped the EL process into a four-stage cycle model composed of concrete experience, reflective observation, abstract conceptualization and active experimentation. Concrete experience is represented specifically by teaching activity, followed by reflecting, interpreting, and planning for action practice (Figure 1). The cycle is more like a spiral, with overall learning outcomes deepening during the process (Kolb & Fry, 1975). Following the KELC, the study systematically combined both primary and secondary data sources to attain clear understanding of ADHD children challenges by the remote education and improving their home-learning environment from the design perspective. The experiential learning cycle (KELC) model has been developed by researchers and educators as a framework to develop assessment strategies for design education (Shih & Sher, 2019).

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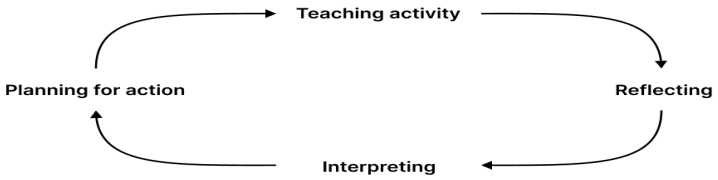
Figure 1
Kolb's Experiential Learning Cycle (KELC)



According to the KELC, the methodology of this study is divided into 4 steps, starting with the analysis of teaching activity (Figure 1). This study begins with the literature review of children's distance education and Hong Kong home learning environment (Step 1). Then, the reflection on the challenges faced by ADHD children in the online teaching is addressed (Step 2). Subsequently, it was interpreted whether those challenges were valid and reliable, and whether there was any design direction to improve by employing the observational and testing experiment (Step 3). Finally, the design direction is solidified and converted as an initial design concept for testing and collecting feedback (Step 4). Suggestions for the design framework studies are proposed based on insights from the final feedback.

Step 1: Teaching Activity: Distance Education in Hong Kong

Distance Education

Distance education (DE), or remote teaching (RT), is defined as "institution-based, formal education where the learning group is separated, and where interactive telecommunications systems are used to connect learners, resources, and instructors" (Schlosser & Simonson, 2009). This definition identifies four main characteristics that make DE distinctive: (1) it is conducted through institutions, (2) teachers and students are separated by geographical location, (3) teachers and students are connected by interactive telecommunications, and (4) a learning group or community is established through DE. The past two decades have witnessed a great deal of research attempting to examine the effectiveness of DE/RT compared to traditional face-to-face education (Means et al., 2013). Though some obstacles were identified, many researchers claimed that DE is effective in teaching and learning, since "…best practices in education are most often also directly applicable to distance education" (Simonson et al., 2011). Other researchers found that younger students needed a more structured environment like face-to-face classes to maintain learning efficiency (Li & Lalani, 2020). However, previous evaluation of DE effectiveness was based on circumstances when teachers and students were well-prepared for the learning sessions (Cowden et al., 2020). During the COVID-19 pandemic, the lack of infrastructure, facilities and resources to support DE resulted in a less-than-optimal situation (Hodges et al., 2020). These impacts intensified inequalities in the distribution of resources, as well as inequities referred to the learning ability and physical conditions (Tang, 2022). These factors suggest that remote education may have a more detrimental impact on students with ADHD. Despite the limitation of distance education, the trend of online classes is expected to continue and necessitates a greater focus in the future, even the end of the pandemic (Richards & Thompson, 2023).

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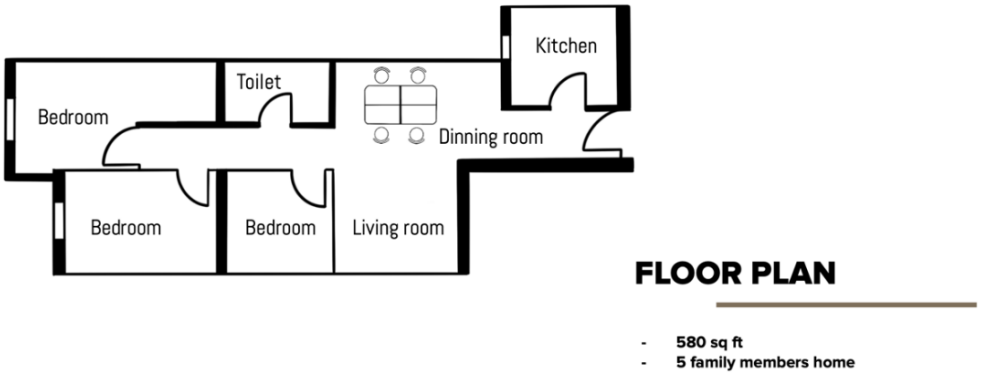
Hong Kong Home Learning Environment

Home-based learning also requires space to support learning activities, and the variety of home settings may discourage students' learning. For example, pets and family members may intrude on videoconferences (Manfuso, 2020), which is difficult to avoid because of the home layout. Yeung and Yau (2022) found that one of the biggest challenges Hong Kong students faced during online learning was limited space. Students complained about being distracted by noisy and crowded room environments. This phenomenon is especially severe in Hong Kong. Hong Kong's housing market continues to be the least affordable among the various metropolitan cities of the world (Chan, 2022). The median house size in Hong Kong was between 40-59 m^2 for public rental housing/subsidized sale housing and 60-79 m^2 for private housing, with a median of 3-5 people living in a house (Gou et al., 2018).

Figure 2
Typical Floor Plan for Family of 3-5 Members in Hong Kong



A typical floor plan for a 5-member Hong Kong family home is shown in Fig.2. On average, the dining area occupies less than 10 m^2. As online learning usually occurs in this space, Hong Kong students are easily distracted by the activities of other family members. Since ADHD students experience difficulties concentrating, home-learning presents additional obstacles for these students in Hong Kong.

Step 2: Reflection: Distance Education for Children with ADHD

Behavioral Problems

A majority of studies have found significant associations between the dominant symptoms of ADHD and the academic performances of children and adolescents (Daley & Birchwood, 2010; Morsink et al., 2021). Based on a study conducted by Shan He et al. (2021), approximately half of the parents surveyed reported a deterioration in attention by their children during online learning compared to their regular in-person schooling. A lack of a regular schedule, an immersive learning atmosphere, and specialized guidance purportedly weakened the bonds and interactions with teachers and peers. Distance learning approaches seriously

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challenge parents in managing children's home learning and home-school communications (Becker et al., 2020). Students are likely to perceive these activities as informal classes, or even as entertainment. A further complication is that home-schooling requires children to manage and balance their own learning progress rather than follow a structured routine. This is challenging for ADHD children. Their self-control is impaired, and they may present problematic behaviors during home-based learning activities. For example, they may encounter problems with time management and task prioritization. In line with a recent guideline proposed by Cortese et al. (2020), providing organized learning schedules and teaching structures are critical approaches to mitigate the sense of insecurity and anxiety pupils with ADHD experience.

Mental Health Issue

The long-term educational disruption resulting from the worldwide COVID-19 related school shutdown has not only adversely impacted children's academic achievements, but also their psychological well-being. For ADHD children, some studies have found a significant correlation between several negative emotions and lockdown (Jeffery et al., 2021; Brooks et al., 2020). These have exacerbated the difficulties ADHD pediatrics populations have experienced with online learning. There are two plausible reasons for these issues. Firstly, during the pandemic quarantines, requests for face-to-face psychological services soared and were abruptly transitioned to telehealth. This affected the quality of care as well as the efficacy of treatments. A study in 2021, primarily focusing on Australian children (Sciberras et al., 2022), demonstrated that approximately 13% of children with ADHD reported increasing difficulties accessing healthcare and psychological services. Furthermore, nearly half of the families who employed tele-medicine considered it to be of lower quality and efficacy than face-to-face care (Badawy & Radovic, 2020). In addition, increased levels of anger, anxiety and loneliness were most likely the result of changes in daily routine, class structures and social contact associated with pandemic restrictions. Another study of ADHD children examined the significant connections between professional care and guidance from teachers, as well as harmonious social relationships and positive emotions (Cortese et al., 2020). It may be presumed that the absence of a positive school atmosphere caused ADHD children to receive less timely and professional care than they would have in a traditional school setting.

Media Use and Physical Activities

Increased use of digital media and reduced physical activities, especially during the COVID-19 outbreak, are of concern for parents, especially for those with ADHD children. Some researchers have confirmed that one of the leading features of ADHD children is executive dysfunction (i.e. behavioral symptoms that disrupt abilities to manage thoughts, emotions and actions) (Barkley, 1997; Biederman et al., 2004). This may be the result of a lack of self-regulation and adaptive inhibition. Factors including long-term quarantine, online delivery, lack of positive school environments and professional supervisors during COVID-19 are likely to result in reliance on digital media (e.g., television, mobile phone, tablet, computer etc.). This is especially the case for ADHD children who are at high-risk of problematic digital media use (Kietglaiwansiri & Chonchaiya, 2018). Many parents have reported a growth in their children's use of digital media, as well as increasing difficulties in managing screen time during home-schooling (Zhang et al., 2020). Several studies have also confirmed the adverse effects of digital media use on the deterioration of ADHD-related symptoms, emotional states (Hoge et al., 2017), academic performance, and social interactions (Pluhar et al., 2019). In addition, another negative influence on ADHD children includes a reduction in physical activities and exposure to nature, which is considered a safe, inexpensive, effortless and widely accessible way of

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managing ADHD symptoms (Taylor et al., 2019). A growing body of evidence suggests a single bout of structured physical exercise is a worthwhile way of improving ADHD-related deficits, such as distraction, overactivity and lack of inhibition. Furthermore, Faber Taylor and Kuo (2009) emphasized the relevance of physical activities effectiveness and natural environments. They discovered that children with ADHD were more attentive after walking in a natural or green outdoor environment than after indoor activities or those conducted in artificial outdoor settings. This indicates that school closures have had a marked effect on regular physical education, and this has led to a surge of physically inactive students.

Step 3: Interpretation: Primary Study of ADHD children during Distance Education

The employment of observational study in student experience study encourages the observer to consider more physical environment and layout of the teaching space, enabling data to be collected on events occurring in a real-time and natural statement (Cotton et al., 2010). This research method facilitates the interpretation of challenges of ADHD children in distance education to become more reliable in Step 3. Apart from that, this step aims to explore the improvement of distance education at home from a design perspective via a quick test of panels, especially for the space where it is limited since Hong Kong is a major case study. Creating dedicated learning places could improve students' learning effectiveness (Keser Aschenberger et al., 2023) and blocking panels could be a suitable tool for small learning areas (Li & Gao, 2023). Nagasharmila and Hema (2018) also found that barriers installed around desks can improve the learning environment for students with ADHD.

Sample

This study was approved by the ethics committee of the Hong Kong Polytechnic University. 32 primary school students were invited to participate in this observational study. 24 students had no particular educational needs in contrast to the other 8, who were diagnosed with various levels of ADHD. At the time of the study, the age range of these participants was between 5 to 11 years old. This study was mainly conducted in participants' apartment in Hong Kong, where students had a distance education before. In terms of ethical considerations, an agreement for obtaining photographic records was provided to illustrate the test situations. Only two students, one with ADHD and one without, consented to the use of their photos without disclosing their names in the study. The remaining participants were not recorded by the researchers to prevent unnecessary exposure of their identities.

Procedures

During the implementation of distance learning, each student was required to prepare a series of study resources before the observational study and engage in a home-based learning activity in their home (Figure 3). Every observation consisted of 60 minutes during the phase of learning activities. It recorded various types of activities during each phase of student performance (Figure 3). In the quick test, 2 sets of panels with different numbers and sizes around students' desks are proposed and positioned on the participants' working table to test the level of openness supporting students' learning behaviors (Figure 4). To avoid certain distractions, both A3 (420mm x 297 mm) and A2 size (594mm x 420 mm) panels are prepared for the study.

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Figure 3
Record of Distance Learning Process of Students without (Top) and with (Bottom) ADHD

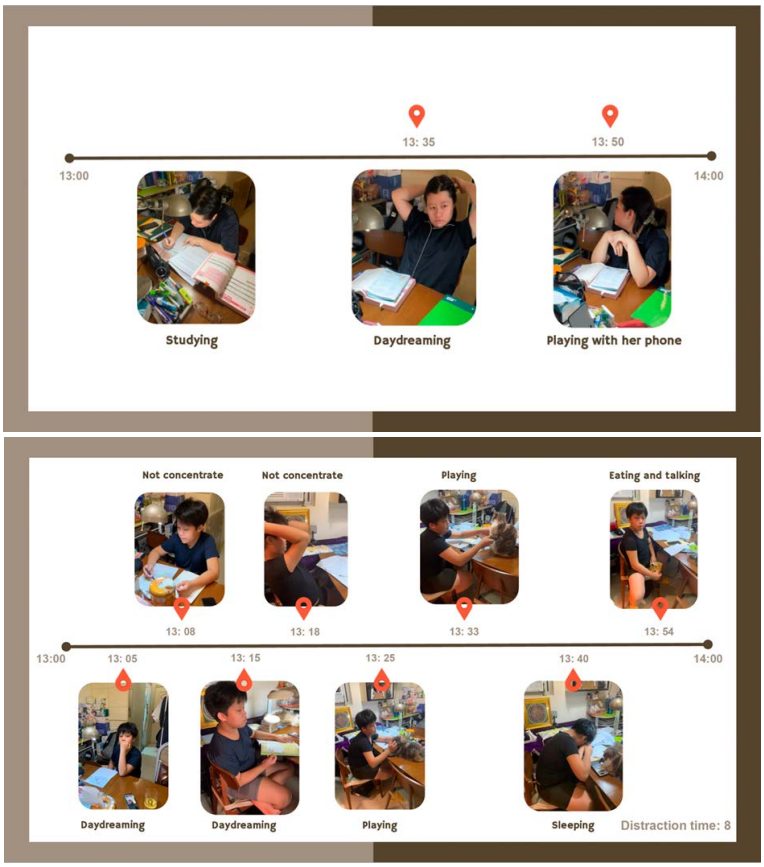

Figure 4
Testing the Effects of Different Ways of Facilitating Study Area Occlusion

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Data Analysis

In this study, the performance of both students with and without ADHD was analyzed using the above theoretical method, KELC. Step 3 in this cycle was focused on interpreting the reflection stage of distance education and enhancing the home-schooling environment by observing their learning processes and testing the effectiveness of the panel. In the result of observational study, students' learning processes were represented by two distinct behavior patterns, as shown in Figure 3. Students with ADHD focused on their studies for only about 20 minutes which was lower than the 50 minutes spent by the non-ADHD students. Their study area was relatively messier than others, both as a cause of distraction and because of lack of concentration. In the result of testing study, although participants have a positive attitude to the reducing distraction features of the panels, openness during home learning is also needed. For example, regarding a panel testing performed during the implementation of the observational study, one student reported: "*Front side single panel setting is preferred more than the one with 3 side surrounded because the 3 side panels setting bring a sense of oppression to me*".

Therefore, 4 basic outcomes were indicated and guided our data collection in the study:

1. Distance learning increases the chance of students with and without ADHD being distracted in home environment
2. Distance learning intensified the chance of students with ADHD being distracted at home
3. Panels can help students to reduce their distraction during learning
4. Single A2 panels in front of the users are more suitable for learning at home
5. Both the dining table and working desk are usual tools for students' distance learning due to the limited space

Step 4: Planning for Action: An Initial Design Concept for ADHD children in Distance Education

Based on the idea that the front-view occlusion with one panel helps improve students' home-based learning concentration, the following home-furniture improvement ideas are proposed: The activity challenges students to design a table that serves two purposes: it should support their home-based learning experiences and all within their working space. To reach the goal, several fundamental design elements were identified referred to previous studies from Step 1 to 3: (1) vertical panels should obstruct students' views, (2) a white board is needed for quick note-making, (3) pressure relief tools are required to allay the mental health issue, and (3) an organized area for learning material is required. By brainstorming and sketching, a traditional rectangular table was used to fit in typical room spaces (Figure 5). Movable white boards are then positioned on the table surface for activities such as time planning and study notes (Figure 6). The design of the panel provides a barrier to visual distractions and encourages to focus on learning activity. Additionally, a transparent glass window incorporated into the table surface should help students search items in the lower storage place, without distracting them.

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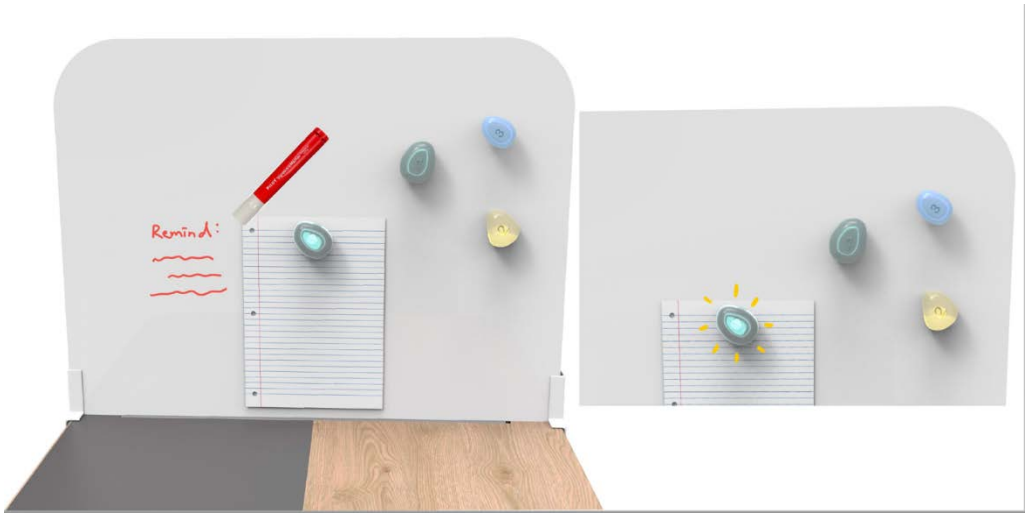
Figure 5
Multi-Functional Table Design

Stress and anxiety significantly affect students' attention span (Pacheco-Unguetti et al., 2010). This is more severe for students with ADHD, and pressure relief toys (Figure 6) are provided to help mitigate students' stress and keep them focused on their studies. One side of the toy is magnetic, enabling it to be used to stick notes on the white board.

Figure 6
Pressure Relief Lighting Toys and Managing Tools



Sample of Design Concept

To examine the potential of the table design above to help students with ADHD in home-based learning, an online survey is conducted. Out of 30 participants completed the questionnaire. Participants included students and adults with ADHD symptoms, parents of ADHD students and others who have been in contact with people with ADHD. The survey comprised 9 closed-ended questions (questions 1 to 8) and 2 open-ended questions (questions 9 and 10), as shown in Table 1.

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Table 1
Participants' Questionnaire and Answers (in %)

Q	Survey Items	Yes	No
1	Do you think having a personal space helps you concentrate in learning?	67.9	32.1
		Disagree	**Agree**
2	Do you think the design can help students with ADHD to reduce distraction and concentrate on learning? (Figure 5)	10.6	60.8
3	Do you think the table design should be effective in improving the learning concentration of ADHD students?	7.5	70.3
4	Do you think the toys can help decrease distraction experienced by ADHD students? (Figure 6)	3.6	64.3
5	Is this function suitable? (Figure 6)	7.1	67.9
6	Do you think providing a screen as a white board for timetabling purposes can help students with ADHD improve their time management abilities? (Figure 6)	7.1	67.9
7	Do you think adding a storage space can help ADHD students improve their organizing abilities?	3.6	75
8	Do you think the design can help improve ADHD students' time management skills?	3.6	64.3
9	Do you have ideas about other ways to help students with attention deficiency concentrate more on their learning?		
10	What do you suggest being added to or improved in the design of the table?		

Survey Results

The analysis of participants' feedback on the multi-functional table design intended to enhance the concentration of children with ADHD during distance education is presented in Tables 1, 2, and 3. As Table 1 shows, nearly 70% of participants had a positive attitude to the concept in various aspects. Answers from the first to third questions showed that more than half of the participants support the idea that the multi-functional table design with panel features could create personal space and improve the task focus for children with ADHD effectively. Answers from the fourth to fifth questions also support that interactive stress relief designs could reduce the users being distracted by surroundings at home, such as colorful and lighting objects. Answers from the sixth to eighth questions reflect that more than 60% of participants agreed that timetabling and storage features for the design could enhance their organizing abilities.

Table 2 presents the results of participants' responses regarding suggestions for improving home-learning concentration from a design perspective. 5 basic aspects are categorized in terms of rewards, space, interactions, calming and distraction. Apart from "space" mentioned in Table 1, most of the respondents noticed that designs for children with ADHD reducing distraction and calming mood during DE are important. In addition, certain interactions and rewards could trigger them to focus on longer periods of time.

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Table 2
Participants' Suggestions on Q9

Rewards	Space	Interaction	Calming	Distraction
Rewards for achieving goals	Separation from others Independent space Boards on both sides	Interaction via touching Interesting topics Lego and other games	Meditation Music	Less playing with phones and video games Less noise

Table 3 below gives the result of participants' responses to the suggestion of improvement of the multi-functional table design. 3 aspects are categorized in terms of appearance, ergonomics and functionality. Plenty of respondents addressed the color and adjustable features from the design, followed by the particle features. Following the theoretical methodology of Kolb's Experiential Learning Cycle (KELC) from Step 1 to 4, the next section is the result of enhancing the distance education at home for ADHD children.

Table 3
Participants' Suggestions on Q10

	Participants Comments
Appearance	- The color could be brighter. - More peaceful color could be used. - More choice on color. - The appearance could be more attractive. - The design should consider more about its environment. - Select better materials
Ergonomics	- The table should be height adjustable. - The seat should be height adjustable. - The storage place should only be able to be opened by parents. - The table should provide more occlusion by adding panels to both sides. - Add some pedals to the design so that students can exercise on it.
Functionality	- How the toy is used is not clear. - There could be a retractable cup holder. - More storage space would be better.

Research Results

According to the Kolb's Experimental Learning Cycle (KELC), each step of the research process contributes to the enhancement of home distance education for children with ADHD to establish more reliability and validity. The sequential approach to developing the distance education framework from the design perspective for them comprises 4 steps (Figure 1), including teaching activity (Step 1), reflecting (Step 2), interpreting (Step 3) and planning for the action (Step 4). Step 1 begins with the analysis of distance teaching activity via the literature review, referencing the case in Hong Kong. The result of the review identifies that distance education tends to be a new alternative educational method globally. However, it may emphasize

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inequalities to students, who lack resource support or with any disorders. Thus, Step 2 reflects the challenge of students with ADHD from distance education. The result of the reflection points out that students with ADHD may have faced increased behavioral problems and mental health issues during distance education, along with a reduction in their outdoor participation rates. In Step 3, two primary research studies are conducted, an observational study and a testing, to validate the findings from Step 1 and Step 2. From the interpretation of observational study, the learning statement of ADHD students was easily distracted by the surrounding compared to others without ADHD during the distance learning (Figure 3). The panel testing also indicates that positioning one panel in front of them improves their concentration the most in this phase of the study. Therefore, in Step 4, a multi-functional table was designed as an initial concept of distance education framework (Figure 5). It provides the feature of anti-distraction panels, interactive elements and organizing tools. To prove the effectiveness of the functionality of the design, online questionnaires are conducted (Table 1). The result of this survey supported that these design features are important to the children with ADHD. However, the respondents also emphasized the consideration of color, functional usage, and overall comfort as essential elements in the design.

As a result, these four steps of the KELC framework indicate that distance education can present learning challenges for children with ADHD. Redesigning their study environment, particularly the workspace, could enhance the effectiveness of home schooling. The details of this framework are summarized in Table 4, which illustrates the significant impact of the desk design on improving the learning environment for children with ADHD during distance education by incorporating table-mounted panels, stress-relief accessories, and learning assistance tools. In the panel design phase, a single front-sided panel is recommended for children with ADHD learning at home, as it not only blocks distractions from the surrounding environment but also mitigates the sense of confinement associated with three-sided panels, as indicated by the findings in Figure 4. This finding aligns with the survey results presented in Table 1, demonstrating a notable consistency in the assessment of strategies to improve the concentration of children with ADHD during distance education across these two primary research approaches. In the stress-relief accessories design phase, anxiety emerges as a significant issue for children with ADHD, as identified in the KELC study. Consequently, more than half of the survey respondents recognized the importance of fidget toys (Table 1) and indicated that “Calming” and “Interaction,” as cataloged in the findings of Table 2, are key elements for enhancing home learning for children with ADHD. In the learning assistance tools phase, the less-structured learning routine during distance education has been associated with behavioral problems for both students with and without ADHD, as shown in Figure 3. These observations correlate with the survey results from questions 6 and 8 in Table 1, highlighting the need for supportive learning tools. Thus, the challenges faced by children with ADHD during distance education and the framework for enhancing their home learning environments through suggested materials and features will be further discussed.

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Table 4
Major Framework of Improving Distance Education for ADHD Children at Home

Working Table Design Form & Features	Suggested tools or designs
A single white A2 or A3 size panel positioning in front of the users: (1) reducing the visual distraction from surrounding, (2) providing a new atmosphere for learning	White A2 or A3 size board
A placement of interactive stress relief accessories: (1) increasing user concentration (2) reducing the anxiety from the children with ADHD	Stress relief toys
A support of learning tools: (1) facilitating users' organizational ability (2) guiding user learning step by step	Learning timetable Task list

Discussion

This study comprehensively explores the influence of distance education on children with ADHD and develops a valid framework for improving their home learning environment from a design perspective. To analyze the relationship and challenges between distance education and children with ADHD, this study is informed by Kolb's Experiential Learning Cycle (KELC). By investigating distance teaching activities with Hong Kong as a case study, it is revealed that distance education has become the new normal due to the disruption caused by the COVID-19 pandemic (Chellathurai, 2020), and the limitations of home environments have negatively impacted students' learning performance (Beasy et al., 2021). These are affirmed as the basic understanding of distance learning activities. Reflecting on these complex backgrounds, severe behavioral problems, mental health issues, media usage problems and lack of physical exercise were identified as the major challenges of ADHD students and their parents during distance learning. The study's findings show that the home learning environment plays an important role in affecting the learning behavior of children with ADHD (Schmiedeier et al., 2014).

Taking Hong Kong as an exemplar site, the identified issues are incorporated into constructive design ideas. The results of the observational study and panel testing revealed that children with ADHD are significantly distracted during home distance education, and a certain level of study area occlusion is beneficial for enhancing their concentration. Korpa et al. (2021) also highlighted several concerns associated with home learning for children with ADHD, including distractions, anxiety, and excessive use of social media, which exacerbate the challenges of their educational experience. In this context, table-mounted partitions can provide separation, enhancing personal space and achieving the goal of reducing interference (Li & Gao, 2023). Building on this concept, a multi-functional table design featuring view occlusion boards, interactive stress relief toys, and organizational tools is proposed to support the framework aimed at increasing concentration and motivation among children with ADHD during home distance education from a design perspective (Figure 5).

Enhancement of Home Learning Environment for ADHD

The significant challenges faced by students with ADHD during home learning, as outlined in the literature review and observational study, indicate that the detailed features of the framework, in conjunction with the findings from testing and surveys, can enhance their concentration, reduce anxiety, and improve learning effectiveness during distance education.

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First, the inclusion of panel features on desks is essential for children with ADHD, as it not only blocks visual distractions at home but also helps to create a distinct learning atmosphere. Research by Keser Aschenberger et al. (2023) supports the notion that dedicated learning spaces within the physical home learning environment can lower students' stress levels and improve their overall well-being. Regarding materials and colors, warm wooden panels and bright colors, such as white acrylic boards, are suitable for panel designs in short-term and long-term activities, respectively (Li & Gao, 2023).

Additionally, providing fidget tools with interactive features for children with ADHD could reduce anxiety during home schooling. Lui et al. (2022) indicated that design elements incorporating interactive and stress-relief effects can also enhance learning performance and concentration. For instance, the lighting pressure relief toys illustrated in Figure 6 may serve this purpose. Some studies have identified that fidget toys, such as fidget spinners, can facilitate on-task performance and behavior for students with ADHD due to their interactive movement and habituation effect (Aspiranti & Hulac, 2022).

Furthermore, learning assistance tools presented to students with ADHD can improve their performance in distance learning by addressing their mental and behavioral challenges. Research by Meijer (2001) found that anxiety associated with ADHD is linked to deficiencies in the executive control network and an overactivation of the alerting and orienting networks, leading to difficulties in maintaining attention on tasks. This indicates that organizational tools, such as task lists and learning schedules, are necessary to support children with ADHD. Thennakoon et al. (2020) emphasized that supportive tools, like schedulers, are important for ADHD children and their parents, as they can help track a child's understanding of given instructions and guide parents in providing appropriate support.

In conclusion, those major features for redesigning their home learning environment contribute to the future distance educational development, facilitating ADHD parents, educators and designers to improve the learning experience at home.

Conclusions, Implications and Limitation

This study explored the challenges faced by children with ADHD and their parents during distance education, highlighting the trend of home schooling over recent decades. Utilizing Hong Kong as a case study, the research identified the issues of limited home floor space for learning and various domestic distractions, which create a non-learning atmosphere that significantly detracts from the focus of students with ADHD compared to their non-ADHD peers during home-based distance education. Furthermore, the study delineated a reliable framework aimed at enhancing the home learning environment for ADHD students, proposing the design of a multi-functional table as a key example. By employing the KELC methodology, this research suggests features to improve concentration and address mental and behavioral challenges faced by children with ADHD during distance education, specifically through the design of panels, stress relief tools, and learning support tools.

Thus, this study enriches the academic discourse by providing insight into the difficulties encountered by children with ADHD during the implementation of distance education. It underscores the potential for inequities to arise if students with physical disorders lack the additional resources necessary to support their online learning activities. The proposed framework also contributes to targeted parents, educators, and designers by providing the future direction of home learning environments design for ADHD children. For their parents and educators, some accessories could be applied to enhance the quality of home learning, such as the application of boards and timetables. For designers, this framework could serve as one of the design criteria for developing educational tools intended for ADHD children in a home setting. Since this study was conducted in Hong Kong, the results should be applicable to

similar large cities around the world. However, situations may be different in other places. For example, some cities may have been less affected by the pandemic, have more home floorspace than in Hong Kong, or have less advanced internet and online education infrastructure. These contextual differences suggest the need for more diverse investigation of the structural research methodology and broader research on the challenges of distance education in various situations. To conclude, this study still contributes a foundational understanding of the difficulties essential for children with ADHD to study at home. It also lays the groundwork for future investigations that, by adopting different methodological approaches, should provide a more holistic picture of home-learning issues for children with ADHD.

Declaration of Interest

The authors declare no competing interest.

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