Protocol

Examining the Effectiveness of a Dual Executive Function Training Package: Protocol for a Randomized Controlled Trial

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Abstract

Background: Executive function (EF) refers to the cognitive processes that enable goal-directed regulation of thoughts, emotions, and behaviors. Two interrelated domains are commonly distinguished: "cool" EF, which involves abstract cognitive processes, and "hot" EF, which involves regulation in emotionally or motivationally charged contexts. Children with special educational needs (SEN) frequently show difficulties across both domains, yet most interventions target one in isolation.

Objective: The present study aims to evaluate the effectiveness of a dual EF training package for 3 of the most prevalent SEN groups: attention-deficit/hyperactivity disorder (ADHD), specific learning difficulties (SpLD), and autism spectrum disorder (ASD).

Methods: A total of 288 primary school students aged 6 to 12 years with a diagnosis of ADHD, ASD, or SpLD will be recruited. Participants will be randomly assigned to either an intervention or a waitlist control group, stratified by diagnosis. Each intervention group (n=48) will receive the dual EF training program. Participants in the waitlist control group will continue to receive usual educational and clinical support (standard care) during the study period and will be offered the dual EF program upon completion of the study. Preintervention and postintervention assessments will include neuropsychological tests of EF, teacher- and parent-reported behavioral ratings, and measures of disability impact, school satisfaction, and social participation. Changes in outcome measures will be examined using a mixed-design analysis, with diagnosis (ADHD, ASD, and SpLD) and group (experimental vs waitlist control) as between-participant factors and time (pretest vs posttest) as the within-participant factor. Baseline scores will be included as covariates where appropriate. The analysis will assess overall intervention effects and whether changes over time differ by intervention condition and diagnosis, with significant interactions followed by appropriate post hoc comparisons.

Results: The study was funded by Advance Children Medical and Education Foundation Limited from September 2025 to December 2026 and received ethical approval. Recruitment commenced in early 2026, and 30 participants with ADHD, 30 with ASD, and 45 with SpLD had been enrolled by June 2026. Baseline assessments were completed for all participants. Further data collection and data analysis are scheduled for completion by early 2027, with the results to be submitted for publication thereafter.

Conclusions: This study will evaluate the effectiveness of a theme-based dual EF program that integrates hot and cool EF within a structured curriculum. Findings will provide evidence of the potential of this approach to support EF and related outcomes in children with SEN and may inform future research and inclusive educational practices.

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Introduction

Executive functions (EFs) are a set of higher-order cognitive processes that enable children to regulate their thoughts, emotions, and behaviors in pursuit of goals. Core domains include working memory, inhibitory control, and cognitive flexibility, often referred to as cool EFs because they are typically measured in abstract, decontextualized contexts [1]. Cool EFs are top-down cognitive processes that are logically based or mechanistic [2] and operate in affectively neutral contexts [3]. In contrast, hot EF refers to regulation in affectively or motivationally charged situations, encompassing delay discounting, affective/risky decision-making, and interpersonal and social behavior [3]. Both domains are crucial for children's learning, adaptation, and participation, but they rely on partially distinct neural systems and show different developmental trajectories [4]. Importantly, recent models emphasize that hot and cool EF should not be viewed as isolated constructs but rather as interconnected components along a continuum [3,5]. In real-world learning and social contexts, cognitive and affective demands are often intertwined. For example, sustaining working memory while managing frustration or planning actions while negotiating peer dynamics highlights the need for interventions that address both hot and cool domains simultaneously.

EF difficulties are particularly salient in the context of special educational needs (SEN). Children with SEN are disproportionately likely to present with impairments in both hot and cool EF, which underpin many of the learning and behavioral challenges they face in schools [6]. Among these, attention-deficit/hyperactivity disorder (ADHD), autism spectrum disorder (ASD), and specific learning difficulties (SpLD) are the 3 most prevalent conditions worldwide, and they are consistently associated with executive dysfunction [7,8]. ADHD, ASD, and SpLD are all characterized by combined hot and cool EF deficits. In ADHD, cool EF weaknesses in working memory, inhibition, and sustained attention [6,9] are compounded by hot EF problems such as poor delay of gratification, impulsivity, and emotional dysregulation [10]. ASD presents with cool EF impairments in flexibility, planning, and working memory [11,12]. It also shows hot EF deficits in emotion regulation, reward processing, and theory of mind [13,14]. SpLD is often framed as academic skill deficits. However, it also involves cool EF challenges in working memory, processing speed, and attention [15], as well as hot EF challenges related to frustration tolerance and motivation [8]. Despite this dual profile, many existing interventions have focused disproportionately on one side of the EF spectrum, typically emphasizing cool EF while neglecting hot EF. To provide meaningful support for children with SEN, a more comprehensive approach is needed, one that systematically integrates both domains.

Existing EF interventions provide partial solutions but leave important gaps. Cognitive training studies, such as Re et al [16], have demonstrated that children with ADHD symptoms can improve in attention, inhibition, and working memory following structured training. These domains reflect cool EF, and while the program successfully enhanced cognitive performance, the gains were largely confined to laboratory tasks, with modest evidence of generalization to socioemotional or classroom functioning. Hot EF, such as emotional regulation or social reasoning, was not directly addressed. A more ecological approach is seen in the cognitive-functional (Cog-Fun) intervention for ADHD [17]. Cog-Fun is an occupational therapy program that emphasizes metacognitive strategy use, planning, organization, and self-monitoring in daily life. Parents are also coached to support the application of strategies at home. While Cog-Fun is effective in improving organization, homework performance, and children's self-directed behavior, its focus remains on cool EF, with only indirect influence on hot EF domains such as emotional regulation and motivation through parent involvement.

More recent work has explicitly attempted to integrate hot EF. Shuai et al [18] developed an EF training package for children with ADHD that included not only core cool EF skills (working memory, inhibition, planning, flexibility, and verbal fluency) but also hot EF components such as emotional regulation. Their results showed improvements in both cognitive control and social understanding, underscoring the value of a dual-domain approach. However, the scope of hot EF was narrow, confined to theory of mind tasks and behavioral ratings of emotional control, and the program was delivered in a clinic-based format, limiting scalability and ecological validity in school contexts. Similarly, Jasni et al [19] implemented a psychosocial group intervention combining cognitive skills training with social skills and emotional regulation exercises. Although not framed explicitly in hot-cool EF terms, the program recognized the importance of targeting both domains. Children showed improvements in EF performance and social behavior. Yet the hot EF elements were integrated only loosely with cognitive training, and the lack of a systematic framework to connect the 2 domains limited the intervention's conceptual clarity and generalizability.

Research on EF interventions in ASD and SpLD reveals similar limitations. For ASD, interventions often focus on improving planning, flexibility, and organization through structured tasks or cognitive-behavioral strategies, targeting cool EF deficits [20]. Some studies incorporate social skills training, which overlaps with hot EF, but these are typically run as separate programs [21,22] rather than integrated EF training. This fragmented approach fails to address the interdependence of cognitive and socioemotional regulation, both of which are impaired in ASD [13]. In

SpLD, interventions predominantly target working memory, inhibition, or attention to support reading or mathematics performance. These cool EF-focused programs have demonstrated efficacy in improving task-related outcomes [23], but they neglect hot EF processes such as self-regulation, frustration tolerance, and motivational control, which are equally important for sustaining learning in students with SpLD [8]. The absence of a hot EF component leaves a gap in addressing the broader challenges faced by students with SpLD in daily classroom participation [24].

Together, these findings demonstrate that while ADHD, ASD, and SpLD are all characterized by combined deficits in hot and cool EF, most existing interventions are narrow in scope, either focusing almost exclusively on cool EF or including only partial and unsystematic coverage of hot EF. Furthermore, interventions are often delivered in clinical rather than classroom contexts, which constrains ecological validity and limits opportunities for students to practice EF in authentic academic and social environments. These limitations highlight the need for a comprehensive, classroom-based intervention that systematically integrates both hot and cool EF domains, such as the dual EF training package described in the present study.

Existing EF interventions have tended to adopt a fragmented architecture, with cool and hot EF components treated as separate strands rather than as interdependent processes. Cognitive training programs often prioritize laboratory-based tasks of working memory, inhibition, or flexibility, while socioemotional curricula focus on behavioral regulation or social skills, but the 2 are rarely integrated within a coherent structure. This separation is at odds with contemporary models conceptualizing EF as a continuum, in which cognitive and affective regulation are dynamically interlinked [3,5]. In everyday contexts, children must simultaneously hold information in mind, resist distraction, and adapt flexibly while also regulating frustration, negotiating peer relationships, and maintaining motivation. An intervention that addresses only one side of this continuum risks producing narrow, domain-bound effects with limited generalization.

Theoretical and empirical precedents suggest that integration is both necessary and feasible. Frameworks such as the expected value of control model [25] highlight how motivational and affective signals shape the allocation of cognitive control, underscoring the need to cotrain these systems within a unified framework. Similarly, approaches to self-regulated learning [26] and early childhood curricula such as Tools of the Mind [27,28] demonstrate the benefits of coupling cognitive strategies with emotion regulation and motivational scaffolding within the same area of focus. Yet, most existing efforts remain partial, addressing affect only indirectly or situating cognitive and affective training in parallel modules rather than within a unified sequence.

Taken together, prior studies demonstrate that EF is malleable and that both cognitive and socioemotional interventions can yield measurable benefits. However, they also reveal persistent limitations: most interventions either focus narrowly on cool EF or address hot EF only incidentally, and few are implemented in ecologically valid, classroom-based contexts. The current study seeks to evaluate the effectiveness of a dual EF training package designed to address these gaps by explicitly integrating cool and hot EF within a coherent, school-based curriculum. The program adopts a theme-based, paired structure in which each cool EF skill is systematically linked to its hot EF counterpart within the same chapter. To our knowledge, it represents the first intervention to use a systematically matched hot-cool EF design across an entire curriculum. This theoretically grounded and ecologically valid model is expected to yield improvements not only in core EF performance but also in broader functional outcomes most relevant to children with SEN.

Methods

Participants

A priori power analysis was conducted using G*Power (version 3.1.9.7; Heinrich Heine University Düsseldorf) to determine the required sample size for the planned analysis of the primary outcomes (ie, working memory, cognitive flexibility, and inhibition). The study will use a 2 × 3 × 2 factorial repeated-measures ANOVA, with intervention condition (experimental vs waitlist control) and diagnostic group (ADHD, ASD, and SpLD) as between-participant factors and time (pretest vs posttest) as the within-participant factor. The power analysis was therefore based on the planned factorial repeated-measures analysis rather than on a simple 2-group comparison. A medium effect size was assumed based on findings from Singh et al [29] concerning comparable EF interventions, with a 2-sided significance level of α=.05 and statistical power of 80%. Under these assumptions, the required sample size was estimated at 180 participants, with 90 participants in the experimental group and 90 in the waitlist control group. After adjusting for a clustering effect (assumed to be .01) and a 10% attrition rate, the total sample size required is 288 participants. The principal investigator will therefore recruit 288 children aged 6 to 12 years from 3 to 4 primary schools in Hong Kong, with each group containing 48 participants.

This study will be conducted across different primary schools, which will be randomly selected. Students will be invited to participate in the study if they meet the following criteria: (1) they are aged 6 to 12 years and (2) they have been diagnosed with ADHD, ASD, or SpLD. They will be randomly assigned to either an experimental group or a waitlist control group. Participants who have completed an EF training program will be excluded.

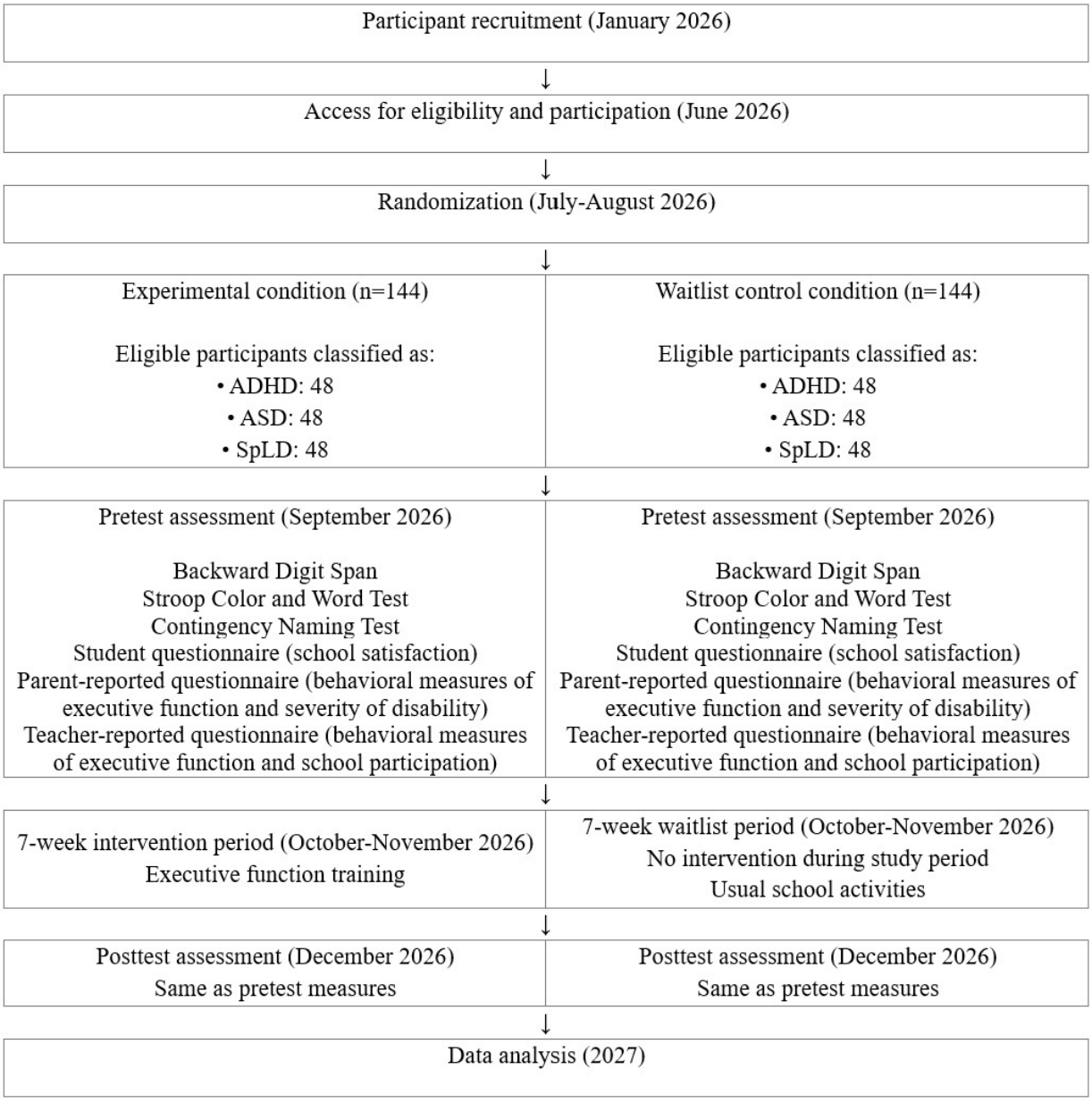
Study Design

A randomized waitlist-controlled design over 7 weeks will be used to examine the effectiveness of the dual EF training package for students with SEN. The 7-week duration was informed by previous research indicating that relatively brief, structured EF interventions can be implemented feasibly within this time frame. For example, Dyresen et al [30] designed a randomized controlled trial of executive control

training for students with ADHD involving weekly sessions over 7 weeks. Their outcome assessments included the use of the Behavior Rating Inventory of Executive Function (BRIEF) and neuropsychological tests (eg, working memory, inhibition, and attention span). Dovis et al [31] also demonstrated that repeated EF training sessions delivered over a relatively short intervention period can produce improvements in specific EF outcomes among children with SEN. The effectiveness of the intervention will be assessed through a pretest-posttest design, evaluated based on the degree of improvement in performance at the 2 time points. If any significant protocol modifications are made, all relevant parties will be informed, including the trial registry, the Human Research Ethics Committee, research team members, all participating students and their parents, the journal that publishes the study protocol, and the funding body.

The study will use a 2-arm design to evaluate the overall effectiveness of the integrated dual EF training program compared with a waitlist control condition. The combined intervention will be selected as the unit of evaluation because the primary objective is to assess the effectiveness of the program as an integrated intervention, rather than to determine the independent effects of individual EF components or the incremental benefit of combining them. A 2-arm design also permits evaluation across the 3 diagnostic groups while maintaining a feasible sample size and study implementation (Figure 1). This study protocol is reported in accordance with the SPIRIT (Standard Protocol Items: Recommendations for Interventional Trials) guidelines (Checklist 1) [32].

Figure 1. Flow diagram of the intervention procedures based on CONSORT (Consolidated Standards of Reporting Trials). ADHD: attention-deficit/hyperactivity disorder; ASD: autism spectrum disorder; SpLD: specific learning difficulties.



Ethical Considerations

Prior to data collection, institutional ethics approval has been obtained from the Human Research Ethics Committee of The Education University of Hong Kong (reference number A2019-2020-0477-01). Parents will be provided with project information and consent forms outlining the purposes of the study, data collection procedures, and measures to ensure confidentiality and anonymity. A parent of every student who volunteers for the study will be asked to sign a written informed consent form.

Participant data will be pseudonymized to protect privacy and confidentiality. Each participant will be assigned a unique research ID, which will be used to identify the participant in the research dataset. The questionnaires and consent forms linking research IDs to participant identities will be stored separately and will only be accessible to authorized members of the research team. The dataset will be stored securely on password-protected institutional systems, with access restricted to authorized study personnel. Identifying information will not be included in the dataset used for statistical analysis.

Procedures

The questionnaires will then be sent to schoolteachers, who will be asked to distribute them privately to the participating students. All assessments will be conducted individually for each student by independent assessors who are blinded to the treatment conditions. The research methods will be carried out in accordance with relevant guidelines and regulations.

Following recruitment and confirmation of eligibility, the participating schools will be allocated to either the experimental group or the waitlist control group using computer-generated random allocation. The stratified randomization based on age and school location will be performed using computer-generated random numbers by a trained research assistant who will be blinded to the identities of the participants. Students allocated to the experimental group will receive the EF training program first. Students assigned to the waitlist control group will receive this program after the experimental group has completed it. To improve adherence to the intervention, participants will be permitted to continue receiving their usual educational, therapeutic, and clinical services throughout the intervention period. These may include additional tutoring, psychological or behavioral interventions, and other support for attention, EF, or related skills. Relevant concomitant interventions, including their type, frequency, duration, and timing, will be recorded. These data will be used to describe additional support received by participants, assess comparability between study groups, and inform the interpretation of study findings. Where appropriate and supported by the available data, relevant concomitant interventions will be considered in sensitivity analyses.

The intervention period will last for 7 weeks, during which data will be collected using questionnaires and cognitive assessments administered before and after the intervention. The research assistant conducting the randomization will not be involved in any data collection. The entire process of data collection and intervention will be conducted by other trained research assistants who are blinded to the participants' group assignments.

Intervention

All students will participate in a structured EF training program designed to support those with SEN. The EF training program will include weekly group training sessions lasting 1 hour each, which will be organized in small groups of 6 students to foster interaction and peer support. The package is structured into 7 chapters, each addressing a core EF domain through 2 separate lessons: one targeting cool EF and one targeting hot EF. Although the lessons are distinct, they are designed to complement each other, reinforcing connections between cognitive control and emotional regulation. The dual EF training package is organized into 7 thematic units, each designed to pair a core cool EF skill with its hot EF counterpart (Table 1). This paired structure ensures that cognitive and socioemotional regulation are developed in tandem rather than in isolation.

Unit 1, central attention, addresses the capacity to sustain focus on goal-relevant tasks (cool EF) while managing attention in the presence of emotionally salient or sensory distractions (hot EF). This foundational skill supports both academic concentration and socioemotional engagement.

Unit 2, goal setting, targets the formulation and maintenance of specific, measurable, achievable, relevant, and time-bound goals and the sequencing of actions (cool EF), alongside cultivating persistence and a growth mindset when confronted with frustration or setbacks (hot EF). In combination, these skills enable students not only to set goals but also to sustain the motivational drive required to achieve them.

Unit 3, monitoring, emphasizes tracking task progress, detecting errors, and adjusting strategies (cool EF), coupled with regulating the emotions that emerge during task performance (hot EF). This integration highlights how cognitive self-evaluation and emotional control jointly influence successful task completion.

Unit 4, organization, focuses on structuring and sequencing information and materials (cool EF) while also supporting the organization of internal thoughts and perspectives (hot EF). This dual focus helps students to manage both external academic demands and internal socioemotional processes.

Unit 5, inhibition, trains the suppression of prepotent or irrelevant responses (cool EF) and the ability to delay gratification and control impulsive behavior in emotionally charged contexts (hot EF). By pairing these aspects, the program addresses inhibitory control across both cognitive and motivational domains.

Unit 6, mental flexibility, develops the ability to shift between rules, strategies, or perspectives in problem-solving (cool EF), together with challenging rigid emotional or social responses and adapting to new perspectives (hot EF). This reflects the need for flexibility not only in thinking but also in navigating social and affective demands.

Finally, unit 7, working memory, strengthens the capacity to hold and manipulate information for reasoning and learning (cool EF), while exploring how emotions influence memory encoding and recall (hot EF). This integration acknowledges the interaction between cognitive load and emotional salience in shaping learning outcomes.

Taken together, these units represent the first structured attempt to systematically integrate hot and cool EF training across a complete curriculum, providing a comprehensive and ecologically valid framework for supporting children with SEN.

More importantly, the dual EF training package is structured around a flow that provides a systematic framework for teaching, practicing, and consolidating EF skills in both cognitive and affective domains. There are 4 parts, namely knowledge, experience, application, and nourishment. Knowledge represents the explicit teaching of EF concepts, including in-depth explanations of targeted skills and their relevance to learning and daily functioning. This stage ensures that students acquire a conceptual understanding of EF processes. Experience involves guided practice through mini-games, cognitive tasks, and structured activities that allow students to actively experience the operation of a particular EF skill. In this way, abstract concepts are reinforced through direct engagement. Application extends learning to authentic contexts, encouraging students to apply EF strategies to daily life through role-play, classroom routines, and real-world problem-solving examples. Finally, nourishment provides ongoing scaffolding to strengthen and sustain EF use over time. This may include providing worksheets, visual reminders, self-monitoring checklists, or digital tools that help students transfer EF strategies beyond structured lessons into naturalistic settings. By sequencing knowledge, experience, application, and nourishment (KEAN), the KEAN framework supports not only the acquisition of EF skills but also their generalization to functional outcomes, aligning with best practices in cognitive training and inclusive education.

The EF training package was reviewed and refined by educational psychologists to ensure activities, instructions, and materials were age-appropriate and deliverable in schools. No pilot study was conducted prior to the present study. This study represents the first formal evaluation of the intervention's effectiveness.

Table 1. Structure of the dual executive function training package.

Unit	Cool EF[a]	Hot EF	Rationale
Central attention	Sustaining focus on goal-directed tasks and resisting irrelevant stimuli	Managing attention in the presence of emotionally or sensory charged distractions	Executive attention is a foundational EF capacity that enables the allocation of cognitive resources. Linking it with affective distractors highlights how attention regulation underpins both academic focus and socioemotional functioning.
Goal setting	Formulating and maintaining SMART[b] goals and sequencing actions	Cultivating persistence and a growth mindset in the face of frustration or setbacks	Goal setting bridges planning (cool EF) with motivational drive (hot EF), ensuring that students not only set goals but also sustain effort under emotional pressure.
Monitoring	Tracking progress, detecting errors, and adjusting strategies	Regulating emotions that arise during task performance, such as frustration or anxiety	Self-monitoring involves both evaluating cognitive performance and managing the affective responses triggered by success or failure.
Organization	Structuring information, materials, and tasks	Organizing internal thoughts and perspectives and managing competing viewpoints	Organization is cognitive in terms of sequencing information but also emotional/social when students must reconcile perspectives or regulate their self-concept.
Inhibition	Suppressing prepotent or irrelevant responses	Delaying gratification and inhibiting impulsive responses in emotionally salient contexts	Inhibition is central to EF theory. Integrating delay of gratification ties behavioral suppression to motivational regulation.
Mental flexibility	Shifting between rules, strategies, or perspectives in problem-solving	Challenging rigid emotional or social responses and adapting to new perspectives	Flexibility is both cognitive and socioemotional. Pairing them reflects how adaptive thinking and adaptive social behavior rely on similar control processes.
Working memory	Holding and manipulating information to support reasoning and learning	Understanding how emotions influence memory encoding and recall	Memory is not purely cognitive; emotional salience shapes what is remembered. Integrating both domains captures this duality.

[a]EF: executive function.
[b]SMART: specific, measurable, achievable, relevant, and time-bound goals.

Instruments

Primary Outcomes

Verbal Working Memory (by Students)

Verbal working memory will be assessed using the Backward Digit Span subtest from the Wechsler Intelligence Scale for Children–Third Edition (WISC-III) [33]. In this task, participants will be presented orally with a sequence of 2 to 9 digits and will be asked to recall them in reverse order. They will need to retain auditory information while filtering out irrelevant details and concentrating on the important ones. The Backward Digit Span subtest will include 18 trials, and participants will earn 1 point for each correctly repeated

backward digit sequence. A higher score indicates greater verbal working memory capacity [33].

Inhibition (by Students)

The Stroop Color and Word Test is a widely used assessment for measuring inhibition [34,35]. In this test, participants will be presented with color words printed in mismatched ink colors (eg, the word "red" written in blue ink). They will be instructed to quickly name the ink color of each word while ignoring the word's meaning. This effort to suppress the meaning of the word to identify the ink color consistently leads to longer response times compared to naming the color of congruent stimuli (such as "red" printed in red ink). This phenomenon is referred to as the Stroop effect [36]. The primary measures in the Stroop test are response latency, which is the time in milliseconds from stimulus onset to the participant's response, and an interference score, typically calculated as the difference in response latencies between incongruent and congruent stimuli or between incongruent and colored nonlexical stimuli. In the current study, only the interference score will be used to assess participants' inhibitory capacity.

Attentional Control and Cognitive Flexibility (by Students)

The Contingency Naming Test (CNT) [37] will assess attentional control and cognitive flexibility through 4 rules of increasing difficulty, using a stimulus set that includes 9 practice items and 27 test items. Each stimulus will consist of an outer shape (circle, triangle, or square) in various colors (blue, yellow, or red), along with a smaller, independent shape (circle, triangle, or square) inside the outer shape. Some stimuli will feature a backward arrow positioned directly above the outer shape. Participants will be instructed to name the stimuli based on the rule level within a set time limit. In level A (attentional control; CNT subtests 1 and 2), participants will be required to identify either the color (rule A1) or the shape (rule A2) of each stimulus. In level B (cognitive flexibility; CNT subtests 3 and 4), participants will alternate between naming the stimuli by color or by shape, depending on 1 attribute (rule B1) or 2 attributes (rule B2) [6]. In contrast to other EF measures, the CNT will not require participants to inhibit automatic responses. Instead, they will choose the correct response from 2 equally prominent options [38]. Although interpretations of CNT scores can differ, there is broad agreement that level A assesses attentional skills, whereas level B evaluates cognitive flexibility, emphasizing the capacity to intentionally switch between responses based on varying attributes [37,39].

Secondary Outcomes

School Satisfaction (by Students)

School satisfaction will be assessed using 6 items derived from the Longitudinal Study of Australian Children [40]. Respondents will rate each item on a 4-point Likert scale ranging from strongly agree to strongly disagree. The 6 items demonstrated strong internal consistency, with an α value of 0.91.

Executive Functioning (by Parents and Teachers)

A short form of the BRIEF [41] includes questionnaires for both parents and teachers aimed at evaluating EF in home and school settings. The BRIEF contains 24 items, which produce 8 scales: initiate, working memory, plan/organize, organization of materials, monitor, inhibit, shift, and emotional control. Parents and teachers will rate their child's or student's behavior on a 3-point Likert scale ranging from 1 (never) to 3 (often). The internal consistency of the BRIEF short form in the normative sample was acceptable, with α values ranging from 0.68 to 0.81 across all subscales.

Social Participation (by Teachers)

The Social Participation Questionnaire (SPQ) [42] consists of 24 statements distributed across 4 subscales: friendships/relationships (5 items), contacts/interactions (9 items), students' social self-perception (5 items), and acceptance by classmates (5 items). Class teachers will complete the SPQ for the students by responding to the statements on a 5-point Likert-type scale, with options ranging from 1 (this does not apply at all) to 5 (this strongly applies). The reliability of the SPQ is deemed adequate, with a coefficient α of 0.78 [42].

Severity of Disability (by Parents)

The severity of disability will be measured based on the 7 domains of life: material well-being, health, safety, productive activity, place in community, intimacy, and emotional well-being [43]. The 7 items will be rated on a 5-point Likert scale, ranging from 1 (not at all affected) to 5 (extremely affected).

Data Analysis

Interim analysis will not take place, and data analysis will commence only after the posttest phase. The principal investigator and trained research assistants will have access to the final dataset. Data analysis will be carried out using SPSS (version 30.0; IBM Corp). A missing value analysis procedure will be performed to identify any missing values in the dataset. To ensure the accuracy of the data file, the data will be screened for univariate ($z \geq 3.29$) and multivariate outliers using the Mahalanobis distance test [44]. The demographic characteristics of the participants will be examined using the chi-square test for independence (for nominal variables) and 1-way ANOVA (for continuous variables). To examine changes in outcome measures among the 6 study groups (experimental and waitlist control groups for each diagnosis: ASD, ADHD, and SpLD), a mixed-design analysis of covariance will be used. In this analysis, group (experimental vs waitlist control) will serve as the between-participant factor, and time (pretest vs posttest) will serve as the within-participant factor. Pretest performance and the number of training sessions will be considered as covariates to control for baseline differences and intervention intensity. Subgroup analyses will be performed separately for each diagnostic category (ASD, ADHD, and SpLD) to assess the effects of the intervention within each diagnosis. If significant main effects or interactions are found, post hoc pairwise

comparisons with appropriate corrections will be conducted to further explore differences between specific groups. All statistical analyses will use a 2-tailed significance level of α=.05.

Results

This study is funded by Advance Children Medical and Education Foundation Limited from September 2025 to December 2026. Recruitment of participants commenced early in 2026. By June 2026, 30 participants with ADHD, 30 with ASD, and 45 with SpLD had been enrolled. Baseline assessments were completed for all participants. The findings are expected to be submitted for publication in 2027. Knowledge exchange seminars and workshops will take place at both the participating schools and the author's institution. Research results will be shared at local and international conferences to ensure broad public dissemination. The study's outcomes will be published in prominent journals. Following the study's completion, the full protocol, participant-level dataset, and statistical code will be made publicly accessible.

Discussion

This protocol describes a randomized controlled trial to evaluate the effectiveness of the dual EF training package, a structured classroom-based intervention that integrates cool and hot EF training for children with SEN. The program addresses a gap in the literature, as many EF interventions have focused primarily on cognitive skills or have addressed socioemotional functioning only incidentally [45]. This study will provide evidence on the effectiveness of an integrated dual EF approach delivered within a school context.

The trial may contribute to the field in several ways. Conceptually, it will extend EF theory by testing a model that treats hot and cool EF as complementary domains, reinforcing each other through parallel training. Empirically, it will provide evidence on the effects of delivering dual EF training to students with ADHD, ASD, and SpLD in mainstream classrooms. Practically, the findings may provide preliminary evidence on the feasibility and potential usefulness of structured, curriculum-linked EF activities in school settings. This aligns with recent calls for interventions that are both inclusive and ecologically valid, ensuring that skills learned in structured tasks generalize to authentic school and life contexts [46].

Several limitations should be acknowledged. The 2-arm design does not include separate intervention arms targeting individual EF components [47]. Any observed effects cannot be attributed to a specific EF component, and the study cannot determine whether the combined program offers greater benefits than either component alone. Findings will consequently be interpreted as evidence of the effectiveness of the integrated dual EF program relative to the waitlist control condition. Future multiarm trials comparing individual and combined EF interventions would be needed to determine the contribution of specific components and whether combining them provides additional benefit.

Another limitation is that parent and teacher reports, although ecologically relevant, may be subject to reporting bias. The relatively short intervention period of 7 weeks may also limit conclusions regarding the maintenance of effects over time. Although fidelity procedures are in place, variation in teacher implementation may influence outcomes. Additionally, SEN populations are heterogeneous, and the sample may not provide sufficient power to determine whether effects differ across diagnostic groups.

Overall, this trial will provide evidence on the effects of a structured dual EF program for students with SEN and will help clarify whether an integrated approach targeting hot and cool EF warrants further investigation. If beneficial effects are observed, future research should examine their longer-term maintenance, the contribution of individual program components, and the applicability of the intervention across diverse educational and cultural contexts. The findings may also help inform future research on inclusive school-based approaches to supporting EF in students with SEN.

Generative AI Use

Generative AI tools were not used at any stage in the preparation of this manuscript.

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This study is funded by the Advance Children Medical and Education Foundation Limited. The funding body played no role in the study design or writing of the protocol manuscript and will play no role in data collection and analysis, data interpretation, and writing. Planning, study design, and writing were carried out by the authors of this manuscript.

Data Availability

The datasets used and/or analyzed during the current study will be available from the corresponding author upon reasonable request.

Authors' Contributions

KP was responsible for the conception of the research questions, study design, and writing. MSH was responsible for data analysis and writing. WKWL, YNY, and MSHH were responsible for providing input on the paper. All authors have reviewed and agreed on the final version of the manuscript.

Conflicts of Interest

None declared.

Checklist 1

SPIRIT checklist.
[DOCX File (Microsoft Word File), 35 KB-Checklist 1]

Peer Review Report 1

Funder peer review report.
[PDF File (Adobe File), 486 KB-Peer Review Report 1]

References

1. Miyake A, Friedman NP. The nature and organization of individual differences in executive functions: four general conclusions. Curr Dir Psychol Sci. Feb 2012;21(1):8-14. [doi: 10.1177/0963721411429458] [Medline: 22773897]
2. Chan RCK, Shum D, Toulopoulou T, Chen EYH. Assessment of executive functions: review of instruments and identification of critical issues. Arch Clin Neuropsychol. Mar 2008;23(2):201-216. [doi: 10.1016/j.acn.2007.08.010] [Medline: 18096360]
3. Zelazo PD, Carlson SM. Hot and cool executive function in childhood and adolescence: development and plasticity. Child Dev Perspect. Dec 1, 2012;6(4):354-360. [doi: 10.1111/j.1750-8606.2012.00246.x]
4. Best JR, Miller PH. A developmental perspective on executive function. Child Dev. 2010;81(6):1641-1660. [doi: 10.1111/j.1467-8624.2010.01499.x] [Medline: 21077853]
5. Salehinejad MA, Ghanavati E, Rashid MHA, Nitsche MA. Hot and cold executive functions in the brain: a prefrontal-cingular network. Brain Neurosci Adv. 2021;5:23982128211007769. [doi: 10.1177/23982128211007769] [Medline: 33997292]
6. Kofler MJ, Irwin LN, Soto EF, Groves NB, Harmon SL, Sarver DE. Executive functioning heterogeneity in pediatric ADHD. J Abnorm Child Psychol. Feb 2019;47(2):273-286. [doi: 10.1007/s10802-018-0438-2] [Medline: 29705926]
7. DuPaul GJ, Gormley MJ, Laracy SD. Comorbidity of LD and ADHD: implications of DSM-5 for assessment and treatment. J Learn Disabil. 2013;46(1):43-51. [doi: 10.1177/0022219412464351] [Medline: 23144063]
8. Meltzer L, editor. Executive Function in Education: From Theory to Practice. 2nd ed. Guilford Publications; 2018. ISBN: 9781462534531
9. Willcutt EG, Doyle AE, Nigg JT, Faraone SV, Pennington BF. Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. Biol Psychiatry. Jun 1, 2005;57(11):1336-1346. [doi: 10.1016/j.biopsych.2005.02.006] [Medline: 15950006]
10. Barkley RA. Emotional dysregulation is a core component of ADHD. In: Barkley RA, editor. Attention-Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment. Guilford Press; 2015:81-115. URL: https://www.jstor.org/stable/10.1521/jj.41115873 [Accessed 2026-11-06]
11. Geurts HM, van den Bergh S, Ruzzano L. Prepotent response inhibition and interference control in autism spectrum disorders: two meta-analyses. Autism Res. Aug 2014;7(4):407-420. [doi: 10.1002/aur.1369] [Medline: 24596300]
12. Hill EL. Executive dysfunction in autism. Trends Cogn Sci. Jan 2004;8(1):26-32. [doi: 10.1016/j.tics.2003.11.003] [Medline: 14697400]
13. Demetriou EA, DeMayo MM, Guastella AJ. Executive function in autism spectrum disorder: history, theoretical models, empirical findings, and potential as an endophenotype. Front Psychiatry. 2019;10:753. [doi: 10.3389/fpsyt.2019.00753] [Medline: 31780959]
14. Mazefsky CA, Herrington J, Siegel M, et al. The role of emotion regulation in autism spectrum disorder. J Am Acad Child Adolesc Psychiatry. Jul 2013;52(7):679-688. [doi: 10.1016/j.jaac.2013.05.006] [Medline: 23800481]
15. Peng P, Fuchs D. A meta-analysis of working memory deficits in children with learning difficulties: is there a difference between verbal domain and numerical domain? J Learn Disabil. 2016;49(1):3-20. [doi: 10.1177/0022219414521667] [Medline: 24548914]
16. Re AM, Capodieci A, Cornoldi C. Effect of training focused on executive functions (attention, inhibition, and working memory) in preschoolers exhibiting ADHD symptoms. Front Psychol. 2015;6:1161. [doi: 10.3389/fpsyg.2015.01161] [Medline: 26300836]
17. Kim MJ, Park HY, Yoo EY, Kim JR. Effects of a cognitive-functional intervention method on improving executive function and self-directed learning in school-aged children with attention deficit hyperactivity disorder: a single-subject design study. Occup Ther Int. 2020;2020:1250801. [doi: 10.1155/2020/1250801] [Medline: 32728351]
18. Shuai L, Daley D, Wang YF, et al. Executive function training for children with attention deficit hyperactivity disorder. Chin Med J (Engl). Mar 5, 2017;130(5):549-558. [doi: 10.4103/0366-6999.200541] [Medline: 28229986]

19. Jasni SH, Graham F, Bell E, Tan VTY. Systematic review of group-based emotion regulation interventions for autistic children's socio-emotional competence. OTJR (Thorofare N J). Jul 2026;46(3):402-421. [doi: 10.1177/15394492251330507] [Medline: 40231407]
20. Kenworthy L, Anthony LG, Naiman DQ, et al. Randomized controlled effectiveness trial of executive function intervention for children on the autism spectrum. J Child Psychol Psychiatry. Apr 2014;55(4):374-383. [doi: 10.1111/jcpp.12161] [Medline: 24256459]
21. Beaumont R, Sofronoff K. A multi-component social skills intervention for children with Asperger syndrome: the Junior Detective Training Program. J Child Psychol Psychiatry. Jul 2008;49(7):743-753. [doi: 10.1111/j.1469-7610.2008.01920.x] [Medline: 18503531]
22. Wong C, Odom SL, Hume KA, et al. Evidence-based practices for children, youth, and young adults with autism spectrum disorder: a comprehensive review. J Autism Dev Disord. Jul 2015;45(7):1951-1966. [doi: 10.1007/s10803-014-2351-z] [Medline: 25578338]
23. Holmes CJ, Kim-Spoon J, Deater-Deckard K. Linking executive function and peer problems from early childhood through middle adolescence. J Abnorm Child Psychol. Jan 2016;44(1):31-42. [doi: 10.1007/s10802-015-0044-5] [Medline: 26096194]
24. Gathercole SE, Dunning DL, Holmes J, Norris D. Working memory training involves learning new skills. J Mem Lang. Sep 12, 2016;105:19-42. [doi: 10.1016/j.jml.2018.10.003] [Medline: 31235992]
25. Shenhav A, Botvinick MM, Cohen JD. The expected value of control: an integrative theory of anterior cingulate cortex function. Neuron. Jul 24, 2013;79(2):217-240. [doi: 10.1016/j.neuron.2013.07.007] [Medline: 23889930]
26. Zimmerman BJ. Attaining self-regulation: a social cognitive perspective. In: Boekaerts M, Pintrich PR, Zeidner M, editors. Handbook of Self-Regulation. Academic Press; 2000:13-39. [doi: 10.1016/B978-012109890-2/50031-7]
27. Blair C, Raver CC. School readiness and self-regulation: a developmental psychobiological approach. Annu Rev Psychol. Jan 3, 2015;66(1):711-731. [doi: 10.1146/annurev-psych-010814-015221] [Medline: 25148852]
28. Bodrova E, Leong D. Tools of the Mind: The Vygotskian Approach to Early Childhood Education. 3rd ed. Routledge; 2024. ISBN: 9780367759667
29. Singh LJ, Gaye F, Cole AM, Chan ESM, Kofler MJ. Central executive training for ADHD: effects on academic achievement, productivity, and success in the classroom. Neuropsychology. May 2022;36(4):330-345. [doi: 10.1037/neu0000798] [Medline: 35343732]
30. Dyresen A, Stubberud J, Fjermestad KW, Haugen I, Øie MG. Executive control training for adolescents with ADHD: study protocol for a randomised controlled trial. Contemp Clin Trials. Jan 2024;136:107404. [doi: 10.1016/j.cct.2023.107404] [Medline: 38070766]
31. Dovis S, Van der Oord S, Wiers RW, Prins PJM. Improving executive functioning in children with ADHD: training multiple executive functions within the context of a computer game. a randomized double-blind placebo controlled trial. PLoS One. 2015;10(4):e0121651. [doi: 10.1371/journal.pone.0121651] [Medline: 25844638]
32. Chan AW, Boutron I, Hopewell S, et al. SPIRIT 2025 statement: updated guideline for protocols of randomised trials. BMJ. ;389:e081477. [doi: 10.1136/bmj-2024-081477]
33. Wechsler D. Wechsler Intelligence Scale for Children–Third Edition. Psychological Corporation; 1991.
34. Dimoska-Di Marco A, McDonald S, Kelly M, Tate R, Johnstone S. A meta-analysis of response inhibition and Stroop interference control deficits in adults with traumatic brain injury (TBI). J Clin Exp Neuropsychol. Apr 2011;33(4):471-485. [doi: 10.1080/13803395.2010.533158] [Medline: 21229434]
35. Ellis ML, Weiss B, Lochman JE. Executive functions in children: associations with aggressive behavior and appraisal processing. J Abnorm Child Psychol. Oct 2009;37(7):945-956. [doi: 10.1007/s10802-009-9321-5] [Medline: 19408113]
36. MacLeod CM. Half a century of research on the Stroop effect: an integrative review. Psychol Bull. Mar 1991;109(2):163-203. [doi: 10.1037/0033-2909.109.2.163] [Medline: 2034749]
37. Anderson PJ, Anderson V, Northam E, Taylor HG. Standardization of the Contingency Naming Test (CNT) for school-aged children: a measure of reactive flexibility. Clin Neuropsychol Assess. 2000;1:247-273. URL: https://research.monash.edu/en/publications/standardization-of-the-contingency-naming-test-cnt-for-school-age/? [Accessed 2026-10-31]
38. Kirk JW, Mazzocco MMM, Kover ST. Assessing executive dysfunction in girls with fragile X or Turner syndrome using the Contingency Naming Test (CNT). Dev Neuropsychol. 2005;28(3):755-777. [doi: 10.1207/s15326942dn2803_2] [Medline: 16266248]
39. Dempster FN, Corkill AJ. Individual differences in susceptibility to interference and general cognitive ability. Acta Psychol (Amst). Apr 1999;101(2-3):395-416. [doi: 10.1016/S0001-6918(99)00013-X]
40. Arciuli J, Emerson E. Type of disability, gender, and age affect school satisfaction: findings from the UK Millennium Cohort Study. Br J Educ Psychol. Sep 2020;90(3):870-885. [doi: 10.1111/bjep.12344] [Medline: 32150645]

41. LeJeune B, Beebe D, Noll J, Kenealy L, Isquith P, Gioia G. Psychometric support for an abbreviated version of the Behavior Rating Inventory of Executive Function (BRIEF) Parent Form. Child Neuropsychol. 2010;16(2):182-201. [doi: 10.1080/09297040903352556] [Medline: 20029694]
42. Koster M, Minnaert A, Nakken H, Jan Pijl S, van Houten EJ. Assessing social participation of students with special needs in inclusive education: validation of the social participation questionnaire. J Psychoeduc Assess. Jun 2011;29(3):199-213. [doi: 10.1177/0734282910384065]
43. Land KC, Lamb VL, Mustillo SK. Child and youth well-being in the United States, 1975–1998: some findings from a new index. Soc Indic Res. Dec 2001;56(3):241-318. [doi: 10.1023/A:1012485315266]
44. Tabachnick BG, Fidell LS. Using Multivariate Statistics. 7th ed. Pearson; 2018. ISBN: 9780134790541
45. Diamond A. Executive functions. Annu Rev Psychol. 2013;64:135-168. [doi: 10.1146/annurev-psych-113011-143750] [Medline: 23020641]
46. Muir RA, Howard SJ, Kervin L. Supporting early childhood educators to foster children's self-regulation and executive functioning through professional learning. Early Child Res Q. 2024;67:170-181. [doi: 10.1016/j.ecresq.2023.12.001]
47. Grayling MJ, Mander AP. Two-stage single-arm trials are rarely analyzed effectively or reported adequately. JCO Precis Oncol. 2021;5:00276. [doi: 10.1200/PO.21.00276] [Medline: 34950839]

Abbreviations

ADHD: attention-deficit/hyperactivity disorder
ASD: autism spectrum disorder
BRIEF: Behavior Rating Inventory of Executive Function
CNT: Contingency Naming Test
Cog-Fun: cognitive-functional
EF: executive function
KEAN: knowledge, experience, application, and nourishment
SEN: special educational needs
SPIRIT: Standard Protocol Items: Recommendations for Interventional Trials
SpLD: specific learning difficulties
SPQ: Social Participation Questionnaire
WISC-III: Wechsler Intelligence Scale for Children–Third Edition

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