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Play-based intervention to enhance executive function in young children with disabilities: A systematic literature review

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Abstract

Executive function such as working memory, inhibitory control, and cognitive flexibility is crucial for early learning, yet children with disabilities often face delays. Play-based interventions are increasingly recognized as effective strategies for supporting executive function in inclusive early childhood settings. Guided by PRISMA 2020, the researchers systematically reviewed studies published between 2016 and 2025. Of 50 initially identified studies, 30 met final inclusion criteria after screening and appraisal (JBI, CASP; inter-rater reliability confirmed with Cohen's Kappa). Studies were coded into three categories: analog, digital, and hybrid play models. Twenty seven of 30 studies (90%) reported significant executive function gains. Analog models (n=14) enhanced inhibitory control, cognitive flexibility, and self-regulation through social structures and play rules. Digital models (n=13), such as serious games, computer-based cognitive games, and digital storytelling. Hybrid models (n=3) integrated scaffolding and digital mediation strengthened working memory, inhibitory control, and emotion regulation; AR-enhanced storybooks in Indonesia showed notable effects. Analog play ensures ecological validity, digital tools deliver structured cognitive demands, and hybrid approaches demonstrably integrate both strengths, yielding broader and more transferable executive function benefits. This review contributes a taxonomy of executive function focused play interventions and highlights their alignment with inclusive ECE reforms in Indonesia. Future research should pursue rigorous RCTs, longitudinal designs, and curriculum integration to evaluate sustainability and scalability.

Keywords: executive function; play-based intervention; analog; digital; hybrid

INTRODUCTION

Executive function plays a pivotal role in early childhood development, shaping self-regulation, working memory, and cognitive flexibility that strongly influence later academic achievement, social competence, and emotional adjustment (Zelazo, 2020). In early educational settings, supporting executive function has become increasingly urgent, particularly for children with disabilities who often experience developmental delays that put them at greater risk of long-term learning and behavioral difficulties (Blair & Raver, 2015).

A growing body of research highlights play-based approaches, including imaginative, structured, and gamified play, as effective contexts for children to practice planning, shifting attention, and inhibiting (Bodrova & Leong, 2018; Veraksa et al., 2022). For children with disabilities, executive function is especially critical because deficits in attention, memory, and problem-solving can undermine daily functioning and limit participation in both academic and social contexts (Zardo & Schroeder, 2023).

In the Indonesian context, inclusive early childhood education is formally promoted through national regulations such as The Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 137 of 2014 on National Standards for Early Childhood Education and The Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 146 of 2014 on the Early Childhood Curriculum. More recently, the *Merdeka Belajar* policy has also emphasized the importance of inclusion. However, the implementation remains uneven, particularly in providing pedagogical models that address the executive function needs of children with disabilities. This underscores the urgency of evidence-based frameworks that can guide teachers in inclusive early childhood education.

Recent studies suggest that both traditional and digital play modalities can enhance executive function outcomes. For example, play-based interventions have been shown to reduce ADHD symptoms in preschoolers (Panesi & Ferlino, 2023), while science-based play fosters cognitive flexibility and inhibitory control (Carulla et al., 2021). Nevertheless, the mechanisms through which play contributes to executive function growth remain contested. Some scholars emphasize the role of social interaction and scaffolding (Veraksa et al., 2022), whereas others stress the need for structured interventions that combine cognitive challenge and movement (Muir et al., 2023).

The emerging trend of integrating gamification with traditional play indicates the potential of hybrid approaches that address both cognitive and behavioral aspects of executive function development. Such approaches align with early intervention perspectives that highlight the importance of timely cognitive stimulation to prevent later psychopathology (Matthys, 2023). However, despite the increasing evidence base, gaps remain regarding: (1) how different play models analog, digital, and hybrid map onto specific executive function domains; (2) the extent to which intervention features such as dosage, facilitator roles, and ecological validity influence effectiveness; and (3) the lack of standardized reporting that limits cross-study comparability. Accordingly, this review is guided by the following research question: How have play-based models across analog, digital, and hybrid modalities been designed and implemented to enhance executive function in young children with disabilities between 2016 and 2025?.

This systematic literature review, therefore, aimed to consolidate and refine existing evidence by focusing on play-based interventions for young children with disabilities. Specifically, the review sought to (1) map and classify play-based models linked to executive function domains, (2) analyze their design components and contextual applicability, and (3) provide practical insights for educators and therapists in inclusive early childhood education. By addressing these objectives, this article contributes both conceptual clarity and practical guidance for advancing executive function development in young children with disabilities through adaptive and evidence-based play models.

RESEARCH METHOD

This study employed a systematic literature review (SLR) to investigate play-based models for enhancing executive function in young children with disabilities. The review process followed the PRISMA 2020 guidelines to ensure methodological rigor, transparency, and replicability. Articles were retrieved from Scopus, Web of Science, and ERIC databases known for their comprehensive coverage of peer-reviewed education and psychology research. The search was conducted for publications between 2016 and 2025 using combinations of keywords: *"executive function," "play-based intervention," "imaginative play," "digital play," "hybrid play,"* and *"children with disabilities."* Boolean operators (AND, OR) and truncations were applied to optimize search results. Studies were included if they: (1) focused on children aged 3–8 years (early childhood), (2) examined executive function outcomes (working memory, inhibitory control, or cognitive flexibility), (3) reported on play-based interventions (analog, digital, or hybrid), (4) targeted populations including children with developmental, sensory, or motor disabilities, and (5) were peer-reviewed journal articles in English. Exclusion criteria eliminated: (1) non-empirical studies (reviews, theoretical papers, opinion pieces); (2) dissertations, conference abstracts, and unpublished manuscripts; and (3) studies outside the age range or without clear executive function measurement.

The search initially identified 312 records. After removing duplicates, 274 records remained. Title and abstract screening excluded 186 studies, leaving 88 full-texts for eligibility assessment. Following critical appraisal and stricter application of inclusion criteria, 58 full-text articles were excluded for the following reasons: (1) population outside the age range (n = 18), (2) no clear executive function outcomes (n = 15), (3) non-empirical or descriptive only (n = 12), and (4) methodological limitations such as lack of a comparison group or weak design quality (n = 13).

Ultimately, 30 studies met all inclusion criteria and were included in the synthesis. The step-by-step selection process is illustrated in Figure 1, which presents the PRISMA 2020 flow diagram of study selection. To ensure reliability, two reviewers independently conducted the screening. A random 20% subset of studies was cross-coded, and inter-rater agreement was calculated using Cohen's Kappa ($\kappa = 0.82$), indicating substantial agreement. Any discrepancies were resolved through discussion until a consensus was reached.

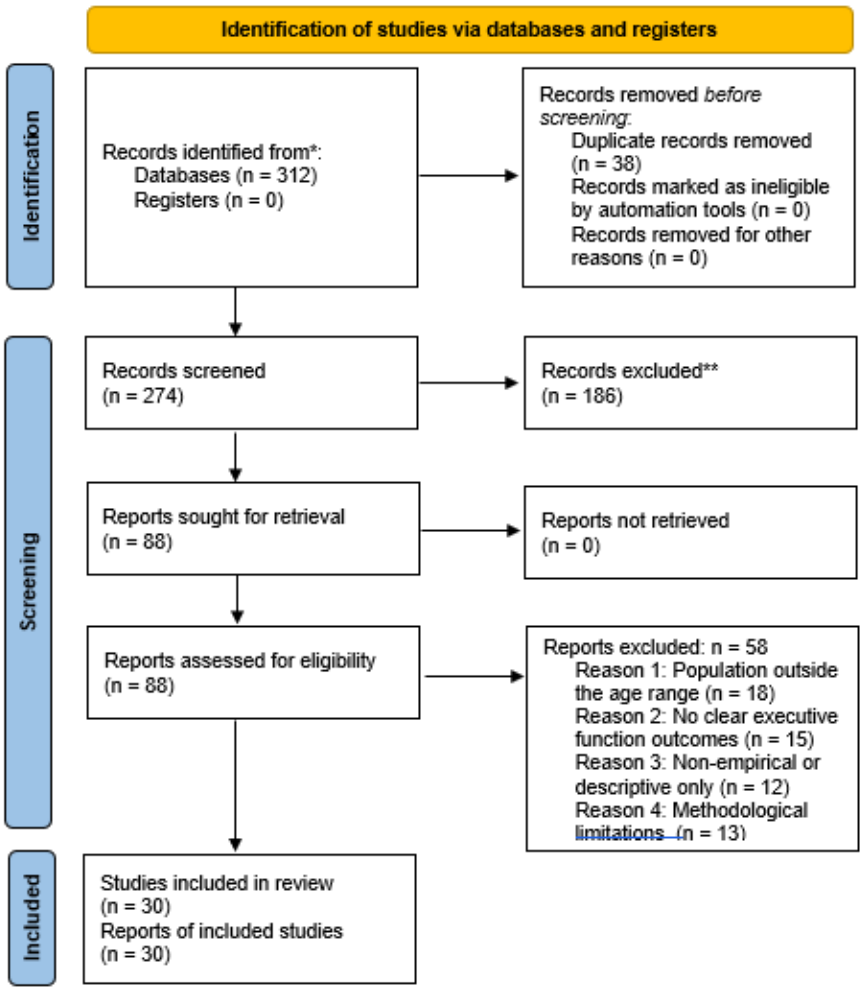

Figure 1. PRISMA 2020 Flow Diagram of Study Selection Process (Adapted from Haddaway et al., 2022)

All included studies underwent critical appraisal. The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Quasi-Experimental Studies was applied to quasi-experimental designs, while the Critical Appraisal Skills Programme (CASP) checklist was used for randomized controlled trials. Appraisal criteria included clarity of research aims, appropriateness of methodology, validity of executive function measures, control of confounders, and adequacy of data analysis. Studies were not excluded based on appraisal scores; rather, appraisal outcomes informed the interpretation and weighting of the findings. Each study was systematically coded for publication details (author, year, country), population characteristics (sample size, age, type of disability), type of play-based model (analog, digital, hybrid), executive function outcomes measured (working memory, inhibitory control, cognitive

flexibility), intervention features (dosage, facilitator role, ecological validity), and reported effectiveness and limitations.

Coding was conducted independently by two reviewers, with discrepancies resolved through consensus. Data were analyzed using thematic synthesis to identify recurring patterns and conceptual categories across interventions. Comparative analysis was conducted to examine differences in effectiveness between digital, analog, and hybrid models, as well as moderating factors such as intrinsic versus extrinsic motivation. This combined mapping and synthesis approach provided both breadth of evidence coverage and depth of conceptual insight, ensuring a comprehensive review of the literature.

FINDINGS & DISCUSSION

Findings

Overview of Included Studies

Of 50 screened studies, 30 met final criteria; 27 (90%) reported significant EF gains. Analog interventions (14/30) most often enhanced cognitive flexibility and socially embedded inhibition, with 12/14 showing significant effects. Digital programs (13/30) targeted mostly at working memory then inhibitory control and cognitive flexibility, with 12/13 reporting significant improvements in at least one EF domain. Hybrid/AR models (3/30), particularly those sequencing analog–digital–analog routines, yielded the broadest and most transferable executive function benefits. All three Hybrid/AR models demonstrated gains across at least two executive function domains, offering the broadest and most transferable benefits despite limited empirical representation. Thirty studies met the final inclusion criteria. All involved a clearly defined play-based intervention (analog, digital, or hybrid), measured executive function outcomes such as working memory, inhibitory control, and cognitive flexibility, targeted children aged three to eight with developmental disabilities, and employed empirical designs (randomized controlled trials, quasi-experiments, or controlled studies). This selection directly addresses the research question: *How have analog, digital, and hybrid play models been designed and implemented to enhance executive function in young children with disabilities between 2016 and 2025?.*

Across the included studies, executive function was primarily assessed using standardized task-based measures, including the Dimensional Change Card Sort, Go/No-Go and Stroop-like inhibition tasks, and working-memory span measures (digit and visuospatial), with several studies also reporting composite executive function indices. Sample sizes were predominantly small to medium (approximately 25–120 participants), and ADHD and autism spectrum disorder (ASD) were the most frequently represented profiles, followed by developmental language disorder, developmental coordination disorder, and cerebral palsy (Wilkes-Gillan et al., 2016; Panesi & Ferlino, 2023) . Interventions were typically scaffolded by teachers, therapists, or parents, particularly in analog and hybrid models. Quality appraisal using JBI and CASP tools indicated overall moderate to high methodological quality, with recurrent limitations including restricted sample sizes, variable reporting of intervention

fidelity, and limited follow-up periods (Carulla et al., 2021). Key weaknesses included small to medium sample sizes, inconsistent reporting of intervention fidelity, and limited follow-up periods across studies.

The studies meeting the final inclusion criteria spanned multiple geographic regions, including Europe, North America, and Asia, and involved diverse populations of young children with developmental disabilities, most frequently ADHD and autism spectrum disorder (ASD), followed by developmental language disorder, developmental coordination disorder, specific learning disorders, and cerebral palsy. The evidence base encompassed three play modalities such as analog, digital, and hybrid/AR models. Overall, 27 of the 30 studies (90%) reported statistically significant improvements in at least one executive function domain, most commonly inhibitory control and working memory. To ensure methodological breadth, three hybrid/AR studies were retained, including augmented reality game-based cognitive–motor training for children with ASD (Nekar et al., 2022), which illustrates the clinical application of augmented reality within structured, scaffolded play routines and complements classroom- and therapy-based analog and digital interventions.

Table 1. Characteristics of the 30 Studies on Play-Based Interventions and Executive Function Outcomes

Author(s)	Year	Country	Sample	Play Model	Executive function Outcomes	DOI
Panesi & Ferlino	2023	Italy	Preschoolers with ADHD	Hybrid Play Model	Working memory, inhibitory control, cognitive flexibility.	https://doi.org/10.18178/ijiet.2023.13.4.1844
Zwitserlood et al.	2022	Netherlands	Children with DLD	Digital Play Model	Inhibitory control, flexibility	10.3390/app12031643
Korpa et al.	2020	Europe	Children with ADHD	Digital Executive function Train Program	Working memory, inhibition	https://doi.org/10.1177/1087054720956723
Carulla et al.	2021	Spain	Children with disabilities	Science-based Analog Play	Inhibitory control, flexibility	10.3390/ijerph18020588
Sukhikh et al.	2022	Russia	Children with LD	Analog Play Model	Inhibition, flexibility	10.3389/fpsyg.2022.1057209
Muir et al.	2023	Not mention	Children with ADD	Analog Play Model	Cognitive flexibility, Inhibitory control	https://doi.org/10.1007/s10648-023-09740-6
Winarsunu et al.	2022	Indonesia	Preschoolers with ADHD	Analog Play Model	Self-regulation	https://doi.org/10.12928/jehcp.v11i4.23477
Kholilah & Solichatun	2018	Indonesia	Preschoolers with ADHD	Analog Play Models	Working Memory	https://doi.org/10.18860/PSI.V15I1.6662
Capodieci et al.	2022	Italy	Children with SLD	Digital play model	Working memory, inhibitory control	https://doi.org/10.3390/children9060822
Rice et al.	2023	United States	Children with ASD	Analog Play Model	Working memory and cognitive flexibility	https://doi.org/10.1007/s12671-022-02063-7
Macoun et al.	2020	Canada	Children with ASD	Hybrid Play Model	Working memory, emotion-regulation	https://doi.org/10.1007/S10803-020-04723-W
Wilkes-Gillan et al.	2016	Australia	Children with ADHD	Analog Play Model	Social Executive function, inhibition	10.1371/journal.pone.0160558

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Author(s)	Year	Country	Sample	Play Model	Executive function Outcomes	DOI
Rico-Olarte et al.	2022	Colombia	Children diagnosed with Specific Learning Disorders (SLD)	Digital Play Model	Working Memory	https://doi.org/10.3390/app12168281
Nekar et al.	2022	Korea	Children with ASD	Hybrid / AR-based Play Model (AR game-based cognitive–motor training)	Working memory, inhibitory control, attention regulation, behavioral self-regulation	https://doi.org/10.3390/healthcare10101981
Rautenbach et al.	2025	South Africa	Children with disabilities	Play-based OT	Inhibition, cognitive flexibility	10.1080/19411243.2024.2360414
Wiest et al.	2022	USA	Children diagnosed with ADHD and SLD	Digital play model	Working memory, inhibitory control	https://doi.org/10.3390/brainsci12020141
Sun et al.	2022	Not mention	Children with ADHD	Analog Play Model	Working memory, inhibitory control, cognitive flexibility	https://doi.org/10.1371/journal.pone.0272121
Cao et al.	2020	United States	Children age with ADHD and ASD	Digital Play Models	Working memory	https://doi.org/10.3389/FPSYG.2020.580329
Barnes et al.	2021	United States	Children with learning and physical disabilities	Analog Play Model	Cognitive flexibility	https://doi.org/10.3389/FPSYG.2021.655246
Hassan	2024	Egypt	Preschoolers with dyspraxia	Analog Play Model	Working memory, inhibitory control, and cognitive flexibility	https://doi.org/10.21608/mfes.2024.289255.1831
Faja, S., et al.	2021	United States	Children with ASD	Digital play model	Inhibitory control, cognitive flexibility, working memory	https://doi.org/10.1177/13623613211014990
López-Nieto et al.	2022	Australia	Children with ASD	Digital play model, symbolic play	Working memory	https://doi.org/10.3390/children9091355

Author(s)	Year	Country	Sample	Play Model	Executive function Outcomes	DOI
Gkora & Drigas	2024	Greece	Children with ADHD, ASD	Digital play models	Working memory, cognitive flexibility, inhibitory control	https://doi.org/10.36560/17520241974
Milajerdi et al.	2021	Iran	Children with ASD	Analog Play Model	Cognitive flexibility	https://doi.org/10.1089/G4H.2019.0180
Veldman et al.	2020	Australia	Children with celebral palsy	Analog Play Model	Cognitive flexibility	https://doi.org/10.1123/JPAH.2019-0381
Ji et al.	2022	China	Children with ASD	Digital play model	Working memory, inhibitory control, cognitive flexibility	https://doi.org/10.3390/children9040507
Mulyati	2023	Indonesia	Children with ADHD	Digital play model	Working memory	https://doi.org/10.23917/khif.v9i1.18393
Lussier-Desrochers et al.	2023	Canada	Children with ADHD and ASD	Digital Play Model	Emotional self-regulation, inhibition, cognitive flexibility, working memory	https://doi.org/10.1007/s41252-023-00319-4
Chevaux & Moehn	2023	USA, UK, and Brazil	Children with ASD	Digital play model	Working memory	https://doi.org/10.1186/s12888-022-04501-1
Lindley-Baker & Mills	2022	East England	Children with Neurodiverse Developmental Disorders (NDDs)	Analog Play Model	Working memory	https://doi.org/10.1111/1467-8578.12411

Table 1 provides a summary of selected study characteristics. They include country, sample, play model, measured executive function domains, and DOI references.

Analog Play Models

Analog play interventions across the reviewed studies encompassed pretend and sociodramatic play, rule-based games, structured play therapy, and curriculum-embedded classroom activities, implemented primarily in naturalistic educational or therapeutic settings. Session durations typically ranged from 20 to 45 minutes, delivered two to four times per week, and consistently emphasized adult scaffolding, explicit rule structures, role enactment, and multi-step goal-oriented activities (Carulla et al., 2021; Muir et al., 2023; Rautenbach et al., 2025). Rather than relying on technological mediation, these interventions positioned play as a socially organized activity in which executive demands emerged from shared rules, negotiated roles, and emotionally meaningful interactions.

Across the fourteen analog studies, inhibitory control emerged as the most consistently improved executive function domain, particularly in interventions using rule-governed cooperative play and turn-taking routines. Empirical evidence showed that structured play contexts requiring children to suppress impulsive actions in order to follow game rules or peer agreements led to significant gains in behavioral inhibition (Wilkes-Gillan et al., 2016; Sun et al., 2022; Barnes et al., 2021). These findings indicate that inhibition in analog play is strengthened not through task repetition alone, but through social accountability to shared rules that must be upheld for play to continue.

Working memory improvements were most evident in studies that required children to maintain goals, remember roles, and sequence actions across extended play episodes. For example, preschool interventions involving sustained pretend scenarios and planned role enactments demonstrated gains in working memory through repeated engagement in goal maintenance and rule recall (Kholilah & Solichatun, 2018; Rice et al., 2023; Lindley-Baker & Mills, 2022). These findings suggest that analog play supports working memory when cognitive demands are embedded within meaningful narratives and predictable routines, rather than isolated memory tasks.

Cognitive flexibility was primarily enhanced through guided role-switching, changing play rules, and adaptive responses to peers' actions. Studies involving imaginative role play and cooperative construction tasks showed that children became more adept at shifting perspectives and strategies when adults intentionally structured moments of transition within play scenarios (Sukhikh et al., 2022; Muir et al., 2023; Veldman et al., 2020). Flexibility gains were strongest when role changes were socially motivated and emotionally grounded, rather than imposed abruptly.

Several studies highlighted key moderators influencing analog play effectiveness, including the quality of adult scaffolding, clarity and consistency of rules, and the emotional engagement of the play narrative. Interventions with well-calibrated adult support where rules were modeled,

reinforced, and gradually transferred to children produced more stable executive function gains than less structured implementations (Carulla et al., 2021; Rautenbach et al., 2025). Importantly, emotionally engaging scenarios, such as cooperative pretend roles or socially meaningful storylines, increased children's motivation to regulate behavior in order to sustain shared play (Milajerdi et al., 2021;; Hassan, 2024)

From a therapeutic perspective, play-based occupational therapy and group play therapy demonstrated that rule-governed, cooperative tasks effectively fostered both inhibitory control and cognitive flexibility when therapists carefully adjusted rule complexity and feedback timing (Rautenbach et al., 2025). In educational settings, classroom-based analog play interventions similarly showed that frequent, scaffolded play routines, even when brief, could yield meaningful improvements in executive functioning by embedding regulation demands within everyday activities (Winarsunu et al., 2022; Barnes et al., 2021).

Taken together, the reviewed evidence indicates that analog play models support executive function development most robustly when play is structured, socially mediated, and emotionally meaningful. Tangible roles, explicit rules, and iterative adult scaffolding transform analog play into a context for rehearsing inhibition, working memory, and cognitive flexibility, underscoring its enduring value as a developmentally grounded approach to executive function support in early childhood.

Digital Play Models

Digital play interventions across the reviewed studies demonstrated consistent and robust effects on executive function, particularly working memory and attentional control, with additional gains in inhibitory control and cognitive flexibility in several designs. The digital evidence base comprises computer-based executive function training programs, app-based cognitive games, virtual sport activities, tablet-mediated symbolic play, and digital task environments, as reported by Korpa et al. (2020), Cao et al. (2020), Capodieci et al. (2022), Zwitserlood et al. (2022), Rico-Olarte et al. (2022), Wiest et al. (2022), Lussier-Desrochers et al. (2023), Ji et al. (2022), Mulyati (2023), Chevaux and Moehn (2023), and Faja et al. (2021). Despite variation in format and target populations, these interventions shared a common design principle: structuring play into time-bounded, rule-governed challenges that require goal maintenance, response selection, and rapid updating.

Compared with analog play, digital models uniquely contributed precision and controllability to executive function practice. Several studies implemented adaptive difficulty calibration, performance contingent pacing, and immediate multimodal feedback, which intensified working-memory updating and attentional engagement while maintaining motivation (Korpa et al., 2020; Cao et al., 2020; Capodieci et al., 2022). In children with ADHD, ASD, and learning-related difficulties, such features supported repeated executive rehearsal without excessive cognitive load, contributing to reliable short-term gains in core executive processes (Faja et al., 2021; Wiest et al., 2022).

A subset of studies embedded executive function demands within digital storytelling and symbolic play environments, rather than isolated drill -based tasks. Zwitserlood et al. (2022) and Lussier-Desrochers et al. (2023) demonstrated that tablet-based narratives, visual schedules, and symbolic cues externalized goals and rules, enabling children to maintain task demands while reducing extraneous load (Zwitserlood et al., 2022; Lussier-Desrochers et al., 2023). Similarly, Rico-Olarte et al. (2022) and Mulyati (2023) showed that game-like digital activities with narrative framing supported inhibitory control and flexibility by making rule changes explicit and visually traceable (Rico-Olarte et al., 2022 ; Mulyati, 2023). In these designs, digital media functioned to stabilize goals and rule structures, rather than replace imaginative engagement.

Several studies explicitly addressed transfer and generalization, highlighting the limits of digital-only delivery. Ji et al. (2022) reported improvements across working memory, inhibitory control, and cognitive flexibility following virtual sport-based training, but emphasized the need for complementary physical or socially mediated activities to sustain gains (Ji et al., 2022). Likewise, Chevaux and Moehn (2023) and Capodieci et al. (2022) noted that executive function improvements were strongest when digital tasks were embedded within adult-guided routines or followed by off-screen application (Chevaux & Moehn, 2023; Capodieci et al., 2022)

Across studies, implementation parameters were relatively consistent, typically involving 20–40-minute sessions delivered two to four times per week, with explicit goals and repeated rule rehearsal. What distinguishes digital delivery is the addition of adaptive challenge titration, immediate performance feedback, and data-driven monitoring of engagement and fidelity. Moderators of effectiveness overlapped with those identified in analog play such as adult scaffolding, rule complexity, and emotional engagement while also including interface usability and calibration of digital cognitive load. Collectively, evidence from these thirteen studies indicates that digital play enhances executive function by tightening the rule feedback loop and enabling high-frequency, adaptive practice, operating most effectively as a precision layer that complements, rather than substitutes for, socially mediated analog play.

Hybrid Play Models

Hybrid play models, represented by three studies in the reviewed corpus, deliberately integrated analog play with digital or augmented reality (AR) mediation to capitalize on the complementary affordances of both modalities (Macoun et al., 2020; Panesi & Ferlino, 2023; Nekar et al., 2022). Across these designs, digital elements functioned primarily as scaffolding tools clarifying rules, structuring timing, and externalizing task demands while executive function practice remained embedded in embodied, socially organized play routines. Empirically, all three studies reported gains across at least two executive function domains, most consistently working memory and inhibitory control, with AR-supported interventions additionally demonstrating improvements related to emotion regulation and behavioral organization, particularly in children with autism spectrum disorder (Nekar et al., 2022).

A shared design feature across the hybrid studies was the use of sequenced analog–digital–analog routines, which supported the transfer of executive function gains beyond the digital interface. Digital mediation enhanced precision and feedback, whereas analog enactment preserved social coordination, emotional engagement, and contextual meaning, addressing limitations observed in digital-only interventions (Macoun et al., 2020; Panesi & Ferlino, 2023a). Adult scaffolding was central to aligning digital prompts with children's actions and gradually fading support as self-regulation stabilized. Collectively, although the number of studies remains limited, hybrid and AR-supported play models consistently produced gains across multiple executive function domains. By integrating digital scaffolding with embodied, socially meaningful play, these approaches support more transferable regulation skills than analog or digital models alone. As such, hybrid and AR play represents a promising direction for future research and intervention design in early childhood contexts.

Cross-Modality Insights

Across analog, digital, and hybrid/AR play modalities (2016–2025)**,** studies consistently converge on three design principles for strengthening executive function in young children with disabilities such as explicit rules, intentional adult scaffolding, and progressive cognitive challenge**.** Analog play supports inhibitory control and cognitive flexibility through socially negotiated, emotionally meaningful role enactment, while digital play enhances working memory and attentional control via adaptive pacing and immediate feedback, with transfer contingent on adult mediation and off-screen enactment (Wilkes-Gillan et al., 2016; Barnes et al., 2021; un et al., 2022); Rautenbach et al., 2025; Korpa et al., 2020; Cao et al., 2020; Capodieci et al., 2022; Wiest et al., 2022; Chevaux & Moehn, 2023; Ji et al., 2022). Hybrid and AR-supported models integrate these strengths by embedding digital cues within embodied, socially meaningful play, producing the broadest and most transferable multi-domain executive function gains and framing play modalities as an interdependent ecosystem rather than a hierarchy (Macoun et al., 2020; Panesi & Ferlino, 2023; (Nekar et al., 2022).

Implementation patterns were largely consistent across modalities, typically involving 20–40-minute sessions conducted two to four times per week, with clear goals, gradual scaffold fading, and reflective dialogue. Effectiveness was moderated by adult scaffolding quality, rule complexity, and emotional engagement, with hybrid designs additionally requiring alignment between digital cues, embodied action, and sensory load. Overall, evidence across modalities indicates that executive function development is strongest when digital precision and analog meaning operate together, positioning play not as a hierarchy but as an interdependent ecosystem supporting inhibition, working-memory updating, and cognitive flexibility across diverse developmental contexts.

Discussion

In the Indonesian context, inclusive early childhood education is formally mandated through The Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 137 of 2014 on National Standards for Early Childhood Education and The Regulation of

the Minister of Education and Culture of the Republic of Indonesia No. 146 of 2014 on the Early Childhood Curriculum, both of which emphasize holistic child development, play-based learning, and responsiveness to children's diverse developmental needs. More recently, the Merdeka Belajar policy has further reinforced principles of inclusion, flexibility, and teacher autonomy in designing learning experiences. Despite this strong regulatory framework, implementation in inclusive PAUD settings remains uneven, particularly in the availability of pedagogical models that explicitly address executive function development for children with disabilities. This gap highlights the need for evidence-based and theoretically grounded approaches that can translate national policy aspirations into concrete classroom practices.

This review demonstrates that play-based interventions across analog, digital, and hybrid/AR modalities are theoretically coherent when examined through the lens of Cultural-Historical Theory and contemporary executive function frameworks. Consistent with Cultural-Historical Theory, executive function development across the 30 studies reviewed (2016–2025) was not determined by the medium of play, but by how rules, goals, mediation, and social interaction were structured within meaningful activity systems (Vygotsky, 1978). This finding aligns with neuroconstructivist perspectives that conceptualize executive function as emerging through contextually embedded, goal directed practice rather than isolated cognitive training (Diamond, 2013).

Within analog play models, executive function gains were consistently driven by socially negotiated rules, shared goals, and emotionally meaningful role enactment, leading to robust improvements in inhibitory control and cognitive flexibility (Wilkes-Gillan et al., 2016; Barnes et al., 2021; Sun et al., 2022; Rautenbach et al., 2025). From a cultural-historical perspective, children regulated their behavior not to comply with external demands, but to preserve the meaning of collective play, rendering regulation intrinsically motivated. Adult scaffolding through role clarification, rule maintenance, and gradual fading of support functioned as a mediational process within the Zone of Proximal Development, enabling children to move from other-regulation to self-regulation, as theorized by Vygotsky.

In contrast, digital play models strengthened executive function through precision, adaptivity, and feedback density, yielding reliable short-term gains in working memory and attentional control, particularly among children with ADHD, ASD, and learning-related difficulties (Korpa et al., 2020;Cao et al., 2020; Capodieci et al., 2022; Wiest et al., 2022). However, consistent with CHT, several studies indicated that transfer beyond the digital task context depended on social mediation, such as teacher guidance and opportunities for off-screen (Chevaux & Moehn, 2023; Ji et al., 2022). Without such mediation, executive function gains tended to remain task-specific, underscoring that digital tools function as psychological tools only when embedded in socially organized activity rather than as standalone training devices (Vygotsky, 1978; Diamond, 2013).

Hybrid and AR-supported play models emerged as a theoretically and empirically coherent response to these limitations by integrating digital scaffolding with embodied, socially meaningful play. Across the three hybrid/AR studies, interventions typically followed analog–

digital–analog sequences, in which digital cues externalized rules, structured timing, and reduced cognitive load, while analog enactment preserved social coordination and emotional engagement (Macoun et al., 2020; Panesi & Ferlino, 2023; Nekar et al., 2022). Empirically, all hybrid/AR models demonstrated multi-domain executive function gains, most consistently in working memory and inhibitory control, with additional benefits for emotion regulation. From a cultural-historical standpoint, these models most clearly operationalize mediation and internalization, as regulation is supported by external tools and gradually internalized through shared play activity (Vygotsky, 1978; Zelazo & Carlson, 2020).

Overall, executive function enhancement across the reviewed studies emerges as a multi layered design achievement rather than a single-medium effect. Children progressed from externally supported regulation (explicit rules, adult prompts, digital cues) toward self-initiated regulation (internalized rules, strategic self-monitoring, emotional control), reflecting both cultural-historical developmental trajectories and contemporary executive function models (Vygotsky, 1978; Zelazo & Carlson, 2020). Across modalities, inhibitory control was most consistently supported through rule-based contingencies, working memory through multi-step goal tracking, and cognitive flexibility through emotionally charged, dynamic play scenarios. Taken together, this synthesis answers the review question by clarifying how analog, digital, and hybrid play-based models have been designed and implemented to enhance specific executive function domains in young children with disabilities between 2016 and 2025, while articulating cross-modality design principles grounded in Cultural-Historical Theory.

CONCLUSION

This review synthesizes evidence from 30 studies published between 2016 and 2025 to examine how analog, digital, and hybrid/AR play-based models have been designed and implemented to enhance executive function in young children with disabilities. Across modalities, findings demonstrate that executive function development is driven not by the medium itself, but by the organization of play through explicit rules, intentional scaffolding, and progressive cognitive challenge, consistent with Cultural-Historical Theory. Analog play most strongly supports inhibitory control and cognitive flexibility through socially negotiated, emotionally meaningful activity; digital play yields precise, short-term gains in working memory and attentional control through adaptive feedback and structured repetition; and hybrid or AR-supported play integrates these strengths, producing the broadest and most transferable multi-domain executive function outcomes. Effective interventions shared common implementation features, including regular dosage, active facilitator mediation, and high ecological validity, underscoring the importance of play as a socially situated activity system. Overall, this synthesis clarifies how different play modalities map onto specific executive function domains, identifies key design and implementation features influencing effectiveness, and provides a coherent theoretical and practical foundation for advancing inclusive early childhood education, particularly within contexts such as Indonesian PAUD that emphasize play-based, developmentally grounded learning.

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