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REVIEW ARTICLE

Working Memory in Preschool Children: A Cattell-Horn-Carroll Informed Assessment-to-Intervention Framework

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ABSTRACT

Working memory (WM) plays a critical role in preschool children's ability to follow instructions, regulate their behavior, retain information, and engage in early literacy and numeracy activities. Difficulties in WM may affect classroom participation and be misinterpreted as inattentiveness, noncompliance, or low motivation. This article examines preschoolers working memory through the lens of the Cattell-Horn-Carroll (CHC) theory of cognitive abilities, with particular attention to the working memory (represented as Gwm in the CHC model) and its narrow abilities or sub-processes. Drawing on developmental and contemporary research, the article reviews evidence regarding the structure and developmental progression of working memory in early childhood and discusses its implications for assessment and intervention. A CHC-informed assessment-to-intervention pathway is proposed to assist educational therapists and preschool practitioners in translating cognitive assessment findings into meaningful, participation-oriented supports. Emphasis is placed on functional interpretation, structured observation, hypothesis-driven planning, environmental accommodations, strategy instruction, and low-burden progress monitoring embedded within everyday preschool routines. Practical intervention activities aligned with auditory-verbal, visuospatial, and cross-domain working-memory demands are also outlined. Rather than conceptualizing intervention as isolated cognitive training, the article advocates for developmentally appropriate, play-based scaffolding that reduces unnecessary memory demands while promoting engagement, competence, and successful participation in authentic learning contexts. The article concludes by highlighting the value of CHC-informed practice in supporting preschool children's working-memory needs and identifies directions for future research on ecologically valid and sustainable intervention approaches.

***Keywords**: Cattell-Horn-Carroll, educational therapy, intervention, working memory, cognitive profiling*

1. INTRODUCTION

Working memory (WM) refers to the capacity to temporarily hold and manipulate information while completing a task. In preschool children, WM supports everyday activities, e.g., following multi-step instructions, remembering rules of a game, executing short or simple action sequences, and retaining the letter sounds of newly acquired words long enough to repeat and use them. When WM demands exceed a young child's capacity, even a motivated child may appear inattentive, uncooperative, or careless in classroom and therapeutic settings. Traditional multi-component models conceptualize WM as comprising a domain-general control system (the central executive) and domain-specific storage systems for verbal and visuospatial information [1].

Developmental research indicates that key components of WM can be assessed in early childhood and show substantial growth throughout the school years [2,3]. Longitudinal research indicates that executive functioning (EF) processes, including WM, continue to develop throughout the early school years and are associated with later academic outcomes. Studies showed that EF and academic achievement influence one another over time [4,5]. Their findings support the view that EF skills continue to develop beyond preschool and remain important throughout the school years. In an earlier study done by Bull and his team [5] that followed children from preschool into primary school, its findings indicated that WM and EF skills measured at age 4-5 years predicted later academic achievement at age 7. That finding showed the continuing developmental significance of these processes across the early school period. It may also be shaped by contextual influences, including socioeconomic conditions and the quality of cognitive stimulation available in children's environments as confirmed by another longitudinal study done by Rosen and team [6]. This latter study examined children aged approximately 5 to 6 years over an 18-month period. The results of the study found that socioeconomic status (SES) influenced EF development through differences in cognitive stimulation in the home environment. It also provided direct evidence that contextual factors shape developmental trajectories in executive functions.

For practitioners such as early childhood educators and educational therapists, the key challenge is not whether WM matters, but how assessment findings can be translated into meaningful intervention support for preschool children. Although the Cattell-Horn-Carroll (CHC) theory is widely used to interpret psychoeducational profiles [7,8], its application to WM intervention in preschool settings is often described in broad terms rather than through a clearly articulated practice pathway [9].

This article examines preschool WM within the CHC framework and proposes a practical assessment-to-intervention pathway for educational therapists and early childhood practitioners. By integrating CHC conceptualizations of WM with developmental evidence, it aims to provide a developmentally sensitive framework to support assessment, intervention planning, and communication with families and staff. The article first situates WM within the CHC framework, then reviews relevant developmental evidence, and finally outlines an applied assessment-to-intervention pathway with examples from preschool practice.

2. RESEARCH METHODOLOGY

The author of this article has adopted a conceptual and practitioner-oriented methodology grounded in narrative literature review and theoretical synthesis. Rather than reporting findings from an empirical investigation, the current article integrates contemporary literature on WM, early childhood development, and the CHC theory of cognitive abilities to construct a developmentally sensitive framework for preschool assessment and intervention. The methodological approach is interpretive and integrative in nature, drawing together theoretical, developmental, and practice-based evidence to address how working-memory difficulties in preschool children may be understood and supported within educational and therapeutic contexts.

The literature reviewed for this article includes seminal and contemporary scholarship on WM, EF, and CHC theory, with particular attention to studies relevant to preschool and early childhood populations. Priority was given to peer-reviewed journal articles, theoretical works, meta-analyses, systematic reviews, and foundational texts examining the structure, development, and functional implications of WM, as well as intervention approaches applicable to young children. Particular emphasis was placed on research addressing WM processes (Gwm), including short-term memory (Gsm) functions, developmental trajectories, and ecologically valid intervention strategies that support participation in naturalistic preschool settings [2,10–12].

A narrative synthesis approach was employed to interpret and organise the literature into three interconnected domains: (i) conceptualization of WM within the CHC framework, (ii) developmental evidence regarding preschool WM and functional manifestations of difficulty, and (iii) translation of assessment findings into practical intervention planning for educational therapists and early childhood practitioners. This synthesis informed the development of a CHC-informed assessment-to-intervention pathway designed to bridge cognitive assessment findings with functional supports embedded in everyday preschool activities.

Given the applied focus of the article, methodological emphasis was placed not only on theoretical coherence but also on ecological and practical relevance. The proposed intervention pathway and activity examples were therefore informed by principles of developmentally appropriate practice, participation-based intervention, and mediated adult support within authentic preschool routines. In this way, the methodology prioritises translational relevance by linking cognitive theory to practical decision-making in assessment, intervention planning, and classroom implementation. Table 1 provides CHC-related and Gwm relevant studies cited in this article and their specific relevance to Gwm within the CHC framework and how each study informs the proposed assessment-to-intervention pathway in this article.

Table 1. CHC-Based and Gwm Related Research Studies

Year	Study Focus	Population	CHC/Gwm Relevance	Key Findings	Relevance to Present Article
2004 [3]	Developmental structure of WM	Children aged 4-15 years	Relevant to developmental growth of Gwm	WM becomes increasingly differentiated & efficient across childhood	Provides developmental basis for early assessment & intervention in preschool populations
2005 [29]	Capacity of attention in WM	General population	Related to executive attention underlying Gwm	WM capacity depends partly on attentional control	Explains Gwm difficulties may reflect attention regulation rather than storage alone
2005 [14]	CHC theory overview	Theoretical	Direct CHC theoretical relevance	Supports conceptual placement of Gwm within CHC framework	Clarifies broad & narrow cognitive abilities in CHC taxonomy
2006 [2]	Structure of verbal & visuo-spatial short-term & WM	Children aged 4-11 years	Strong relevance to Gwm distinction within CHC	Verbal & visuo-spatial WM were separable constructs with shared processing demands	Supports discussion of differentiated WM profiles in preschool children & the distinction between storage & active processing
2007 [30]	Executive attention & WM variation	General population	Narrow CHC processes related to Gwm	Variations in WM capacity reflect executive attention & cognitive control	Supports interpretation of Gwm as involving attentional regulation & mental manipulation

2012 [10]	Theoretical models of WM	General / theoretical	Conceptual relevance to Gwm	WM involves temporary storage & manipulation of information through executive processes	Supports conceptual explanation of Gwm beyond simple short-term memory (STM)
2014 [11]	WM & cognitive development	Educational / developmental context	Relevant to attentional control component of Gwm	WM under-pins learning, cognitive development, & learning performance	Supports functional interpretation of preschool WM difficulties
2016 [32]	Meta-analysis of WM training	Children & adolescents	Gwm intervention relevance	Limited evidence for far-transfer effects on intelligence / broader cognition	Supports emphasis on participation-focused intervention rather than "brain training"
2017 [34]	WM training & improvement in fluid intelligence	Preschool children	Gwm & its relationship with Gf (fluid reasoning)	WM training improved WM performance & gains in Gf	Suggests that improving Gwm may enhance Gf
2018 [12]	CHC theory & cognitive abilities	Theoretical / assessment context	Direct CHC relevance to Gwm	Gwm as a narrower process within Gsm	Provides theoretical foundation for locating WM within CHC
2022 [35]	Adaptive WM training	Children	Gwm intervention relevance	Limited transfer effects observed	Reinforces ecological & contextual intervention focus
2023 [16]	Contemporary appraisal of CHC theory	Theoretical	Expands CHC understanding of Gwm	Highlights evolving interpretation of CHC constructs & inter-relationships	Supports updated interpretation of WM in CHC-informed practice
2023 [18]	Psychometric network analysis of CHC abilities	Theoretical / psychometric	Relevant to centrality of WM	Suggests WM & attentional control occupy central roles within cognitive systems	Supports functional significance of Gwm for preschool learning
2024 [36]	Professional learning for executive function support	Early childhood educators	Indirect relevance to Gwm support	Educator-mediated support improves children's self-regulation & EF skills	Supports teacher-guided scaffolding strategies
2024 [37]	Systematic review of WM applications	Children with learning difficulties (LD)	Gwm intervention relevance	Intervention effects depend on design principles & contextual supports	Supports structured, age-appropriate intervention planning
2024 [38]	Effects of WM training in preschoolers	Preschool children	Intervention relevance to Gwm	Training improved WM, self-regulation, & reasoning under mediated support	Supports play-based & mediated intervention approaches in preschool settings
2025 [39]	Adaptive WM training	Children	Intervention relevance	Training effects stronger for near-transfer than broad transfer outcomes	Supports caution regarding standalone cognitive training
2025 [40]	Parent-led EF intervention	Toddlers	Related to executive functioning and Gwm	Parent-mediated approaches may improve EF skills	Supports adult scaffolding & mediated learning in preschool practice
2025 [41]	School-based WM training	School-aged children	Gwm intervention relevance	Effectiveness depends on mechanisms & implement-ation context	Supports embedded intervention within authentic activities
2025 [42]	Play & executive function	Preschool children	Indirect relevance to Gwm	Child-appropriate play supports EF	Supports play-based intervention model

				skills	proposed in the article

Note: *Studies were tabulated based on their conceptual, developmental, psychometric, or intervention relevance to working memory as discussed in the present article.*

Gwm = working memory processes; CHC = Cattell-Horne-Carroll; WM = working memory; EF = executive functioning

3. CHC FRAMEWORK: LOCATING WORKING MEMORY WITHIN GSM AND GWM

Figure 1 presents the CHC theory of cognitive abilities as a three-stratum hierarchy comprising general intelligence (*g*) at Stratum III, broad abilities at Stratum II, and narrower abilities at Stratum I [13,14]. The figure is intended not as a comprehensive review of CHC theory but as a practical framework for locating WM within the broad ability of Gwm and linking cognitive constructs to observable behaviors in preschool children.

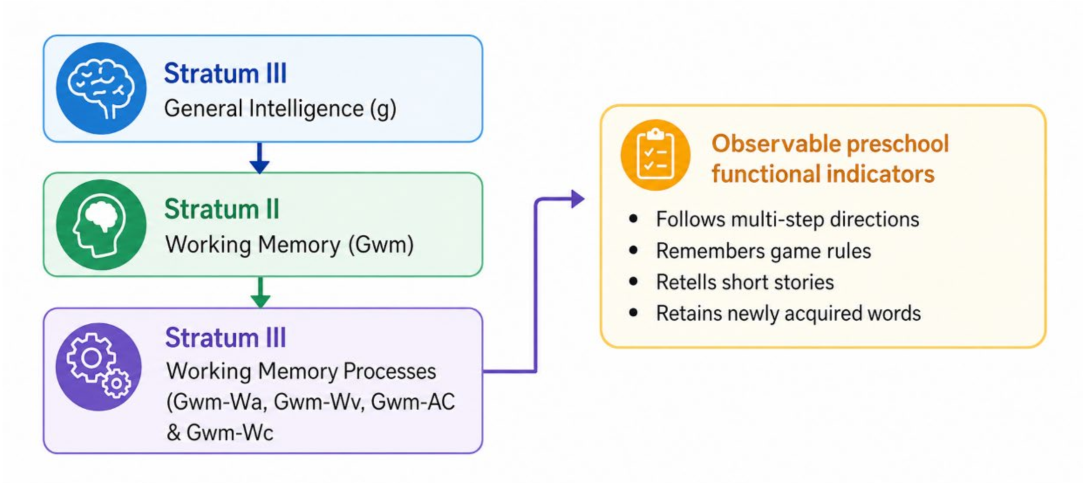

Figure 1: A simplified CHC framework for locating WM within the broader domain of Gwm and linking this construct to observable functional indicators in preschool children.

Gwm-Wa = auditory short-term storage; Gwm-Wv = visual-spatial short-term storage; Gwm-AC = attentional control; Gwm-Wc = working memory capacity; CHC = Cattell-Horne-Carroll; WM = working memory

Within CHC theory, Gwm represents a domain-independent capacity for temporarily storing and manipulating information while completing a task [15]. Contemporary CHC interpretations commonly describe Gwm through several narrower abilities, including: (a) Gwm-Wa (auditory short-term storage), the ability to encode and maintain verbal or auditory information; (b) Gwm-Wv (visual-spatial short-term storage), the ability to encode and maintain visual or spatial information; (c) Gwm-Wc (working memory capacity), the ability to hold and mentally manipulate information in immediate awareness; and (d) Gwm-AC (attentional control), the ability to direct and sustain attention toward relevant information while inhibiting distractions [12,16]. Although terminology varies across assessment instruments and interpretive crosswalks, defining these constructs explicitly helps practitioners translate test results into meaningful educational and therapeutic recommendations [17].

From a practical perspective, the CHC framework provides clinicians, psychologists, educational therapists, and teachers with a shared language for describing cognitive strengths and needs [12,17]. Broad abilities, e.g., comprehension-knowledge (Gc), fluid reasoning (Gf), long-term storage and retrieval (Glr), processing speed (Gs), and Gwm are frequently used to interpret learning profiles and identify factors that may support or constrain classroom performance. More recent CHC developments have further highlighted the central role of WM and attentional control within broader cognitive ability networks [16,18].

The value of Gwm interpretation lies not in the cognitive labels themselves but in their translation into observable functional behaviours. For example, weaknesses in Gwm-Wa may be reflected in a child who forgets part of a two- or three-step instruction, has difficulty recalling the sounds in a newly learned word, or struggles to remember classroom rules delivered verbally. Such behaviours are consistent with research showing that limitations in verbal short-term memory affect children's ability to follow instructions and retain classroom information [19,20]. Assessment findings suggesting reduced auditory short-term storage may lead practitioners to provide shorter verbal directions, visual supports, repetition, and opportunities for rehearsal during learning activities [21].

Similarly, difficulties in Gwm-Wv may appear when a child loses track of visual information, forgets the location of materials, struggles to copy simple patterns, or cannot remember the sequence of actions demonstrated by a teacher. Visual-spatial working-memory weaknesses have been associated with challenges in remembering locations, patterns, and visually presented information during learning tasks [22,23]. Intervention may therefore involve visual schedules, picture cues, colour-coded materials, and step-by-step modelling to reduce visual-spatial memory demands [21].

Gwm-Wc, which reflects the active manipulation of information, is often challenged when children must hold information in mind while simultaneously carrying out another task. For example, a preschool child may remember only the first part of a direction such as "*Get your workbook, put it on the table, and then sit on the carpet*," or may lose track of a story while answering comprehension questions. Research suggests that working-memory capacity is closely related to children's ability to manage complex learning tasks that require simultaneous storage and processing of information [24,25]. Assessment findings indicating limitations in working-memory capacity may guide practitioners to simplify task demands, break activities into smaller steps, provide external memory aids, and gradually increase cognitive load as competence develops [19].

Difficulties in Gwm-AC are often observed when children are unable to maintain focus on relevant information or are easily distracted by competing stimuli. A child may forget a task midway because attention shifts to another activity, or may lose track of game rules when environmental distractions are present. Contemporary models increasingly emphasise attentional control as a core component of WM and EF because it supports the maintenance of task goals and the inhibition of irrelevant information [18,26,27]. In these cases, intervention may focus on reducing distractions, establishing predictable routines, using visual reminders, teaching self-monitoring strategies, and embedding brief opportunities for attentional practice within everyday classroom activities [28].

This behavioral translation is particularly important in preschool assessment and intervention planning. Cognitive scores alone provide limited guidance unless they are connected to the child's day-to-day functioning. By linking Gwm abilities to specific classroom behaviours and learning demands, the CHC framework enables practitioners to move beyond test interpretation toward practical decisions about task design, instructional scaffolding, environmental supports, and targeted intervention [12,17]. In this way, assessment becomes a pathway for understanding not only how a child performs on a test, but also how best to support learning and participation in everyday educational contexts.

3. WHAT IS WORKING MEMORY CAPACITY?

WM plays a central role in activities, e.g., following instructions, listening to stories, learning new vocabulary, solving problems, and participating in classroom routines. Within the CHC framework, WM is typically located within the broad ability of Gwm and is associated with several narrower processes that support the temporary storage and active use of information. WM capacity therefore involves more than simply remembering information for a few seconds; it also requires the efficient allocation of attention so that information can be maintained, manipulated, and used to guide behaviour. Children with stronger WM capacity are generally better able to keep track of task demands, coordinate multiple pieces of information, and complete cognitively demanding activities, whereas limitations in WM may constrain learning, independence, and participation in classroom activities [10-12].

In preschool settings, WM capacity can be observed through everyday behaviors. For example, a child with adequate WM may successfully follow a three-step instruction such as, "*Put your drawing in your folder, wash your hands, and then sit on the carpet*" In contrast, a child with limited WM may remember only the first step or become distracted before completing the sequence. Similarly, during storybook reading, children rely on WM capacity to remember characters, events, and key details while integrating new information as the story unfolds. Difficulties in WM may therefore appear as losing track of the storyline, forgetting previously introduced characters, or struggling to answer simple comprehension questions.

From a CHC perspective, WM capacity can be understood as the coordinated interaction of several related processes, particularly immediate storage, attentional control, and the active management of information during task performance. Immediate storage supports the temporary retention of information such as sounds, words, locations, or short sequences. For example, a preschool child learning a new word must retain its sound pattern long enough to repeat it accurately, while a child completing a puzzle may need to remember the location of a missing piece. These functions correspond closely to the CHC narrow abilities of Gwm-Wa and Gwm-Wv.

Gwm-AC enables children to focus on relevant information while resisting distractions. During circle time, for example, a child may need to remember a teacher's question while ignoring surrounding noises or the movements of classmates. When attentional control is weak, the child may lose track of instructions, abandon a task midway, or appear inattentive even when motivated to participate. Such difficulties are often observed in preschool classrooms where multiple sources of stimulation compete for children's attention.

Gwm-Wc also requires the active manipulation and updating of information. Updating occurs when children replace information that is no longer relevant with new information that better fits current task demands. For instance, during a sorting activity, a teacher may initially ask children to sort objects by colour and later switch the rule to sorting by shape. Successful performance requires children to inhibit the previous rule, remember the new rule, and apply it consistently. Likewise, when building with blocks, children may need to revise their plan after discovering that a structure is unstable, holding the original goal in mind while adapting their actions. These examples illustrate that WM involves not only storing information but also flexibly managing it in response to changing demands.

Understanding these component processes is important because preschool children may experience WM difficulties for different reasons. One child may struggle primarily with retaining verbal information (Gwm-Wa), another may have difficulty maintaining visual-spatial information (Gwm-Wv), while a third may have adequate storage but weak attentional control (Gwm-AC) or difficulty manipulating information (Gwm-Wc). Distinguishing among these processes helps practitioners move beyond a general description of "poor WM" and identify more targeted supports. For example, children with storage difficulties may benefit from shorter instructions and visual reminders, whereas children with attentional-control difficulties may require reduced distractions, structured routines, and additional cues to maintain task focus. Such distinctions are essential if assessment findings are to guide effective intervention in preschool classrooms and therapeutic settings [12,29,30].

4. WHAT DEVELOPMENTAL EVIDENCE SUGGESTS ABOUT PRESCHOOL WORKING MEMORY

Developmental research provides important insights into how WM functions in preschool children and why WM difficulties often emerge during everyday learning activities [2,19]. Two findings are particularly relevant for assessment and intervention planning. First, verbal and visuospatial aspects of WM can be meaningfully distinguished, although both draw on a more general processing and attentional-control system. In a study of children aged approximately 4-11 years, confirmatory factor analyses supported separate verbal and visuospatial storage components alongside a shared processing resource that was engaged when children were required to hold and manipulate information simultaneously [2]. For preschool education teachers and allied practitioners, this distinction helps explain why a child may successfully remember the location of puzzle pieces or complete a visual pattern task yet struggle to follow a series of spoken instructions, while another child may show the opposite profile [2,19].

Next, WM undergoes substantial development throughout childhood, becoming both more efficient and more differentiated over time [25]. As children mature, they become increasingly able to hold information in mind, manage competing demands, and coordinate multiple pieces of information during learning activities [10,11]. In preschool settings, these developmental limitations are often evident when children are expected to remember classroom routines, follow multi-step directions, participate in rule-based games, or retain information long enough to complete a task [19]. A four-year-old, for example, may successfully follow a one-step instruction but struggle when asked to complete three actions in sequence, not because the task is conceptually difficult but because it exceeds current WM capacity [19].

Taken together, the developmental literature suggests three important implications for practice. Firstly, preschool children may demonstrate selective WM weaknesses rather than a generalised difficulty. A child with relatively stronger visual-spatial memory may rely heavily on picture schedules and demonstrations but struggle to remember verbal directions, whereas a child with stronger verbal memory may perform adequately when information is spoken but have difficulty recalling visual sequences or locations [2,19]. Assessment should therefore examine different aspects of WM rather than assuming a single underlying deficit.

Secondly, a child's performance may vary considerably depending on task demands. Small increases in complexity can place disproportionate demands on a developing WM system [10,11]. For example, adding one extra step to a classroom instruction, introducing a delay before responding, or presenting information in a distracting environment may shift a task from manageable to overwhelming. A child who can independently complete “Get your pencil” may struggle with “*Get your pencil, put your name on the article, and sit at the table*” particularly when classmates are moving around the room. Such fluctuations in performance are characteristic of children whose WM resources are easily overloaded by increased processing demands [19].

Thirdly, intervention is most likely to be effective when it addresses both the child's developing WM and/or EF skills and the demands of the learning environment. Strategy instruction may help children learn to rehearse information, verbalise task steps, or use visual reminders, while environmental modifications can reduce unnecessary memory load [19,28]. Examples include breaking instructions into smaller units, providing picture cues, establishing predictable routines, and reducing distractions during learning activities. Such approaches recognize that WM performance reflects an interaction between the child’s cognitive resources (including EF skills) and the demands of the task [10,11]. Consequently, effective intervention focuses not only on strengthening WM processes but also on creating learning environments in which those developing capacities can be used successfully [19,28].

5. A CHC-INFORMED ASSESSMENT-TO-INTERVENTION PATHWAY FOR PRESCHOOL CHILDREN

Building on the theoretical and developmental foundations outlined above, this section translates CHC-informed assessment findings into a practical, participation-focused intervention pathway for preschool settings. The goal is to use assessment not as an endpoint, but as the starting point for intervention planning, implementation, and ongoing evaluation of the child's participation in everyday learning activities [12,17]. Within this framework, assessment findings are interpreted in relation to functional demands rather than viewed solely as test scores. The central question becomes: *How do identified working-memory difficulties affect the child's ability to participate successfully in classroom routines, play, learning, and social interactions?*

The first step is to develop a working profile based on assessment data, classroom observations, teacher reports, and caregiver input. Within a CHC-informed framework, this involves examining relevant broad and narrow abilities, particularly those associated with Gwm, Gwm-Wa, Gwm-Wv, Gwm-Wc and Gwm-AC [12]. The aim is to identify one or two priority needs that are most likely to affect daily functioning. In preschool settings, these priorities should be defined behaviourally rather than solely in cognitive terms. For example, concerns may include difficulty following classroom routines, maintaining engagement during group activities, remembering task instructions, participating in storybook discussions, or completing early literacy and numeracy activities [19].

Once priority needs have been identified, practitioners develop a working hypothesis that links cognitive demands to observable difficulties. A useful hypothesis specifies when difficulties occur, what cognitive processes may be involved, and which environmental conditions increase or reduce the problem. For example, a child with weaknesses in Gwm-Wa may successfully follow one-step instructions during individual play but struggle during circle time when multiple verbal directions are delivered rapidly. Similarly, a child with reduced Gwm-AC may remember instructions accurately in a quiet setting but lose track of task requirements when peers are moving around the room. Framing assessment findings as testable hypotheses helps practitioners move beyond descriptive labels and identify practical intervention targets [17].

The next step is to develop an intervention plan that combines accommodations to reduce unnecessary working-memory load with explicit instruction in simple memory-support strategies. Research suggests that environmental modifications are often more effective than expecting children to compensate independently for working-memory limitations [19,23]. Common accommodations include shortening instructions, providing visual cues, reducing distractions, allowing additional processing time, and breaking complex tasks into smaller steps. Strategy instruction may involve teaching children to repeat directions aloud, use simple self-talk (e.g., “first, then, next”), point to visual reminders, or verbalise the next step in a sequence [28].

Intervention is most effective when embedded within natural preschool activities rather than delivered solely through isolated cognitive exercises. During circle time, teachers may model a “listen-look-do” strategy while pairing verbal instructions with picture cues. During transitions, children may use visual schedules and gesture prompts to support routine completion. During shared reading, teachers can scaffold story recall using prompts such as “first,” “next,” and “last,” while encouraging children to retell events using picture supports. In early numeracy activities, children can be taught a simple “plan-do-check” routine to support counting, sorting, or pattern-building tasks. Embedding supports within authentic learning contexts increases the likelihood that children will generalise strategies across settings [19,28].

The final step is ongoing monitoring of functional outcomes. Progress monitoring should be brief, practical, and focused on participation rather than solely on cognitive performance. Examples include tracking the percentage of multi-step directions completed successfully, monitoring independence during classroom routines, recording engagement during group activities, or assessing improvements in story-retell performance. The primary question is not whether a cognitive score has changed, but whether the child is participating more successfully in situations that were previously challenging. This emphasis on functional outcomes aligns assessment with educational decision-making and allows intervention plans to be adjusted as children's needs change [31]. Table 2 presents examples of common indicators of working-memory vulnerability and corresponding supports that can be implemented within preschool classrooms and therapy settings.

Table 2. Examples of instructional supports/accommodations for preschool children with WM difficulties.

Functional Indicators	Instructional Supports	Accommodations
Forgets multi-step directions	Give 1-2 steps at a time; ask the child to repeat / show the sequence; model simple self-talk ("first …, then …")	Use picture direction cards; point to materials; repeat key words; allow extra processing time
Loses place during routines or transitions	Teach the routine as a short, consistent script; practice with songs or gestures; reinforce each completed step	Use a visual schedule; provide a consistent cue point; reduce competing noise
Difficulty recalling sounds, actions or story events	Use imitation games; prompt with "first/next/last"; scaffold brief retells with structured prompts	Provide picture prompts; use a three-picture sequence strip; use peer-assisted recall where appropriate
Difficulty retaining new vocabulary or phonological sequences	Use slow, clear modeling; practice in short bursts; introduce one new word at a time and revisit it	Pair words with objects or pictures; reduce simultaneous instructions; check understanding before moving on
Becomes overwhelmed during whole-group instruction	Preview instructions individually; teach a "listen-look-do" routine; prompt the child to ask for repetition	Provide preferential seating; use a visual anchor chart; break tasks into smaller parts
Loses track of counting or construction steps	Use "plan-do-check" language; provide a goal picture; prompt the child to verbalize the next step that follows	Provide step cards or a model; reduce the number of pieces or steps initially; allow extra completion time

5.1 Practitioner Vignette

Consider a four-year-old child who is eager to participate during morning circle time but frequently struggles to follow a two-step direction such as, "*Find your name card and sit on the blue mat*." The child retrieves the name card but then wanders around the room without completing the second step. Assessment findings indicate relative weaknesses in Gwm-Wa and Gwm-AC. A CHC-informed hypothesis proposes that the verbal working-memory load becomes too great when instructions are delivered within a busy group environment. The intervention response is therefore twofold: reduce memory demands by pairing instructions with a two-step picture cue and teach the child to repeat the instruction using a simple "first-then" strategy. Progress is monitored by recording the number of days the child completes the routine independently. Over time, the child completes the sequence more consistently and requires fewer prompts, demonstrating improved participation rather than merely improved test performance.

A similar process can be applied to other preschool concerns. For example, a child who repeatedly loses track of counting steps during a block-building activity may demonstrate weaknesses in Gwm-Wc. Rather than repeatedly correcting errors, the teacher may introduce a visual goal card and encourage the child to verbalise each step before acting. Likewise, a child who struggles to remember story events during shared reading may benefit from picture-sequence supports and guided retell prompts that reduce storage demands while strengthening active recall. In each case, assessment findings are translated into targeted supports that enable the child to participate more successfully in meaningful learning activities.

6. INTERVENTION ACTIVITIES ALIGNED WITH WORKING-MEMORY DEMANDS

WM support for preschool children is most effective when embedded within everyday teaching and play rather than delivered as a stand-alone training program [19,28]. In early childhood settings, learning is more likely to be sustained when practice is brief, frequent, and directly connected to situations in which difficulties occur. The primary goal is not to improve performance on isolated memory tasks but to increase successful participation in everyday activities such as following instructions, completing routines, engaging in group discussions, and participating in early literacy and numeracy experiences [11,19].

From a CHC-informed perspective, intervention should focus on two complementary approaches: reducing unnecessary working-memory demands and explicitly teaching simple strategies that children can apply during meaningful activities. Effective supports include visual schedules, picture cues, step cards, gesture prompts, and additional processing time, alongside strategies such as repeating instructions, verbal rehearsal, chunking information into smaller units, and using self-talk [19,28]. Adults play a critical role by modelling the strategy, guiding the child in its use, and providing opportunities for practice across multiple contexts such as circle time, transitions, guided play, and shared reading.

Current evidence suggests that WM interventions should be interpreted cautiously. Improvements are typically strongest on trained or closely related tasks, whereas transfer to broader cognitive outcomes is often limited [32,33]. This does not diminish the importance of intervention in preschool settings; rather, it highlights the value of embedding supports within authentic learning activities. Interventions that combine WM support with mediated learning, self-regulation coaching, and sustained adult-child interaction appear more developmentally appropriate and are more likely to produce meaningful functional gains [28].

6.1 Auditory and Verbal Working Memory (Gwm-Wa)

Activities targeting auditory and verbal WM focus on helping children retain and use spoken information. For example, a teacher or an educational therapist may present a sequence of two words, sounds, or actions for the child to repeat and gradually increase the number of items as success improves. During play, children can practice following simple "first-then" directions such as "Feed the teddy, then put it to bed," with picture cues available when needed. Shared-reading activities can also support verbal WM by asking children to listen for a target word, character, or event and recall it when the page is turned. These activities strengthen the ability to maintain verbal information while remaining engaged in a meaningful task [19].

6.2 Visual-Spatial Working Memory (Gwm-Wv)

Visual-spatial WM activities require children to hold and reproduce visual information. For example, a teacher may briefly display a simple block pattern, cover it, and ask the child to recreate it. Similarly, children can arrange picture cards to represent the sequence of events in a familiar story and then retell what happened first, next, and last. During construction or drawing activities, visual models and step cards can reduce memory demands while supporting successful task completion. Such activities help children remember locations, patterns, and sequences that are important for classroom learning and play [2].

6.3 Working-Memory Capacity and Attentional Control (Gwm-Wc and Gwm-AC)

Many preschool activities require children to hold information in mind while simultaneously focusing attention and managing competing demands. Action songs involving two or three sequential movements (e.g., clapping, stomping, and turning) encourage children to remember and execute a sequence while monitoring their performance. Pretend-play scenarios (e.g., playing shopkeeper and customer) require children to maintain roles, follow simple rules, and remember what comes next in the interaction. Guided-play activities can incorporate a simple "plan-do-check" routine in which children state a goal, carry out an action, and evaluate the result. These activities support the active manipulation of information and the regulation of attention, both of which are central components of WM and EF [28,30].

6.4 Progress Monitoring

Progress monitoring should remain practical and focused on participation outcomes. One or two everyday situations (e.g., following two-step directions, transitioning between activities, or completing a clean-up routine) can serve as anchor tasks. Teachers and/or educational therapists can record whether the child completes the activity independently, after one prompt, or only after repeated support. Progress is reflected in increased independence, reduced prompting, greater engagement, and lower frustration rather than perfect task performance [19]. Consistent with a CHC-informed intervention model, the ultimate outcome is improved participation in everyday preschool activities rather than improvement on isolated memory exercises alone.

7. CONCLUSION

The CHC framework can support a meaningful assessment-to-intervention pathway for preschool WM difficulties when practitioners do three things clearly. First, CHC labels must be interpreted in functional terms rather than left at the level of test terminology. Second, assessment findings must be translated into specific and observable risks to participation in everyday preschool situations. Third, intervention should focus on a small number of high-frequency supports that can be embedded within daily routines rather than treated as isolated training activities.

Developmental evidence supports the relevance of this approach. Research suggests that core components of WM can be meaningfully assessed during the preschool years and that these components continue to develop substantially across childhood [2,25]. For this reason, early intervention should not be framed as an attempt to “fix” a static deficit, but as a way of reducing unnecessary load, teaching simple and usable strategies, and preserving the child’s sense of competence during everyday learning.

From this perspective, CHC-informed WM support is best understood as part of good early teaching rather than as an additional burden placed on children or educators. When memory demands are made more manageable and support is embedded within ordinary preschool activities, children are more likely to participate successfully, remain engaged, and experience themselves as competent learners.

Further research is needed to strengthen the empirical basis of CHC-informed, participation-based WM support across different preschool settings, including inclusive classrooms and play-based curricula. Longitudinal and mixed-method studies would be especially valuable in examining whether early reductions in WM load and explicit strategy coaching influence children’s engagement, self-regulation, and learning trajectories over time. In addition, implementation-focused research is needed to identify effective dosage, adult instructional practices, and environmental supports, as well as to understand how educators and therapists can sustain assessment-to-intervention cycles within routine practice. Such work would strengthen the evidence base for CHC-informed intervention while preserving its developmental and ecological relevance.

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9. COMPETING INTERESTS

The authors have declared that no competing interests exist.

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12. DATA AVAILABILITY STATEMENT

Not applicable. No primary data were generated or analysed in this study.

13. ETHICS APPROVAL

Not applicable. This study did not require ethics approval.

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