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Teaching strategies to enhance executive functions in early childhood education: A systematic review

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ABSTRACT: Evidence that the classroom environment can influence the development of executive functions in children raises some critical questions about specific teaching strategies in early childhood education. However, there is currently little evidence about which specific teaching strategies enhance the development of executive functions in preschool children. Thus, the purpose of this systematic literature review is to identify teaching strategies that positively promote executive functions in 3-to-5-year-old children. This comprehensive review, guided by the PRISMA methodology, explores the findings of 12 qualitative and quantitative studies that met our inclusion criteria. Through thematic synthesis, we found that preschoolers' executive functions are enhanced by three specific teaching strategies: supporting autonomy in the child, encouraging sustained shared thinking, and effective classroom organisation. These findings are discussed in relation to how early childhood teachers can incorporate certain identified teaching strategies, such as delivering free-choice activities, engaging in back-and-forth conversations, and implementing organised and consistent routines, into everyday preschool curriculums to enhance executive functions. Implications for practice and directions for future research are also discussed.

Keywords: *executive functions, teaching strategies, child-centred pedagogy, preschool children*

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Introduction

Executive functions refer to the self-regulatory and higher-order skills used to consciously control thoughts, actions, and feelings in order to achieve goals (Zelazo et al., 2024). These skills include planning, decision-making, and organisation and serve as predictors of academic success (McClelland et al., 2007), overall physical and mental well-being (Diamond & Lee, 2011), and socioeconomic status later in life (Moffitt et al., 2011). Executive functions develop in early childhood, and acquiring these skills during this period involves a range of developmental and environmental processes (McClelland et al., 2019; Milosavljevic et al., 2023). These processes include children's social-emotional growth, along with parenting behaviours and the dynamics of classroom environments. Hence, executive functions in young children do not emerge in isolation but rather are influenced by various social contexts: home and family (Hughes & Devine, 2019), social groups (Doebel & Munakata, 2018), classroom environments (Cumming et al., 2020), and teacher behaviour (Bardack & Obradović, 2019).

A robust body of literature demonstrates that the ages of three to five years constitute an advantageous developmental period for developing executive functions (Best & Miller, 2010; Garon et al., 2008; Zelazo et al., 2016). Hence, child-centered early childhood educational settings like preschool offer a golden opportunity to foster the development of executive functions (Rhinehart, 2022; Rosas et al., 2019). In these contexts, early childhood teachers serve as a linchpin, promoting and nurturing the learning and sociocognitive development of young children (Australian Government Department of Education (AGDE), 2022). They employ a suite of responsive teaching strategies that include scaffolding, questioning, facilitating, modelling, demonstrating and encouraging sustained shared thinking. Together, these give children the opportunity to practice and improve their executive function skills (Madanipour et al., 2025).

The recent systematic literature review conducted by Sankalaite et al. (2021) emphasises the important role of early childhood teachers in supporting the development of executive functions in children. The review establishes that teacher-child interactions span emotional support, organisational support, and instructional support and that these supports cultivate executive functions. Additionally, Cumming et al. (2020) undertook a comprehensive and systematic review of the literature from 2000 to 2017 to understand how school and classroom characteristics, and dyad-level interactions between teachers and peers, relate to the development of executive functions in students. A high-quality classroom was defined as promoting positive relationships, providing feedback, and facilitating student learning. Across the 20 included studies, the findings indicate that high-quality classrooms are likely to boost early executive functions in students. However, similar to the systematic review undertaken by Sankalaite et al. (2021), most of

the studies reviewed by Cumming et al. (2020) examined only broad components of overall classroom quality, such as emotional and instructional support. No specific teaching strategies to foster executive functions were identified. According to Cumming et al. (2020), further research is needed to uncover specific practices that support the development of executive functions, such as scaffolding or behaviour management. This systematic literature review responds to this call for further research.

We aim to identify teaching strategies in preschool settings that enhance executive functions. These identified strategies are intended to assist early childhood teachers in identifying and implementing evidence-based practices that facilitate the development of executive functions in children. As such, the outcomes of the present study should be highly influential in shaping future research and practice. The next section will operationalise executive functions and describe the importance of executive functions in early childhood as well as the influence of environment.

Theoretical background

Executive functions

Individuals differ in their cognitive ability to regulate thoughts, actions, and feelings (Miyake & Friedman, 2012). Take for example the Marshmallow Test by Mischel and Moore (1973), during which a four-year-old child is offered a marshmallow and asked to resist the temptation to eat it in order to receive a larger reward. Some children can wait patiently, while others eat the treat immediately. These individual differences are shaped by both neurocognitive processes in the prefrontal cortex of the brain – processes linked to resisting temptation, being patient and persistent, sustaining attention, and engaging in goal-directed behaviour – and environmental factors (e.g., researchers), which influence children's delay performance (Miyake et al., 2000; Moffett et al., 2020). Collectively, these skills and abilities are known as executive functions, and they act as the brain's air traffic control system (Center on the Developing Child, 2011). They play a crucial role in human cognition and achievement, enabling individuals to manage their thoughts and behaviours in pursuit of goals, especially when these goals conflict with habits, impulses, or desires (Doebel, 2020). The concept of executive functions has been conceptualised in various ways, particularly within neuropsychological literature, making it challenging to operationalise (Jurado & Rosselli, 2007). In their systematic review, Packwood et al. (2011) identified 68 terms and 98 tasks related to executive functions and highlighted a need for a more unified understanding of executive function components. While there is ongoing debate about the constructs of executive functions, our systematic literature review is grounded in the theoretical framework and practical insights from Garon et al. (2008), Miyake et al. (2000), and Zelazo et al. (2016), which

associate executive functions with three main aspects of human thinking: working memory, inhibitory control, and cognitive flexibility. Working memory refers to our ability to hold incoming information in our minds and work with it as needed for the task at hand, inhibitory control involves the power to regulate one's attention to stay focused on completing a task while deliberately suppressing distractions and automatic responses, and cognitive flexibility is our capacity to purposefully shift attention flexibly between tasks and change perspectives (e.g., Diamond, 2020; Zelazo & Carlson, 2023). While each has a unique definition, these three core components of executive functions work in harmony to form the foundations of higher-order thinking skills, including planning, reasoning, and problem-solving – all of which are imperative for learning (Collins & Koechlin, 2012; Lunt et al., 2012).

The importance of executive functions in early childhood

Research indicates that the first five years of life play a crucial role in forming executive functions, which constitute the building blocks of a range of developmental trajectories (Garon et al., 2008; Griffin et al., 2016). Diamond (2006) suggests that when infants between eight and 12 months of age are prompted to find a hidden object under a cloth, they are demonstrating executive functions in the form of intentional and goal-directed behaviour. These functions scale up during the second year of life when evidence of attention and memory become apparent (Diamond, 2006). Both inhibitory control and cognitive flexibility also advance rapidly from ages three to five years (Carlson, 2005). It is at this time that children begin to participate in the type of playful activities that foster growth in executive functions, such as sociodramatic play (Thibodeau et al., 2016; White & Carlson, 2021). The rule-based nature of these types of play demands that preschoolers think before they act and that they follow specific rules while inhibiting their impulses (Vygotsky, 1978). For example, when pretending to be a superhero, a child must manage their thoughts and feelings in relation to a play scenario that has been developed collaboratively with other peers. Hence, they must consider the perspectives of others to act in a manner relevant to the play (Madanipour & Cohrssen, 2024).

Executive functions are critical for school readiness and early school success (Allan et al., 2014; Blair, 2016; Kalstabakken et al., 2021). Empirical evidence suggests a robust relationship between executive functioning and academic achievement. For example, a study conducted with 310 preschoolers found that children with stronger executive functions demonstrated greater achievements in emergent literacy, vocabulary, and mathematics skills compared with those with less developed executive function skills (McClelland et al., 2007; see also Blair & Raver, 2014). Executive functions are also associated with a better quality of life later in life (Diamond, 2016). Following a cohort of 1,000 children born in the same city and the same year for 32 years, and controlling for intelligence and family background, Moffitt et al. (2011) found three- to 11-year-old

children who demonstrated a lack of persistence, a lack of attention, and more impulsive behaviour (such as weaker inhibitory control) were more likely to experience poor outcomes as adults 30 years later. Such outcomes included poor health (such as weight, alcohol, and drug problems), low socioeconomic status, and a higher incidence of criminality. Given the strength of poor executive functions in childhood as a predictor of undesirable consequences in later years, the implication of these studies is that improving executive functions in the early stages of a child's life is of critical importance.

The influence of the environment on executive functions

The early development of executive functions is closely connected with the development of the prefrontal cortex, which develops gradually throughout the early years of life (Knight & Stuss, 2002). However, growth in executive functions may also be affected by both positive and negative environmental inputs (Johnson & Munakata, 2005). For example, several studies have shown that children from low-income households typically have poorer executive functions than their counterparts in wealthier circumstances (e.g., Conway et al., 2018; Howse et al., 2003; Noble et al., 2005). Notably, there is strong evidence that these adverse effects in the growth of executive functions might be mediated by providing enriching environments with positive adult-child interactions and cognitive stimulation (Blair et al., 2011; Hackman et al., 2010). Researchers have provided insights into the importance of parent-child interactions and parental variables in the early development of executive functions. A longitudinal study by Blair et al. (2014), for example, shows that in low-income settings, parental sensitivity and responsiveness at 36 months led to higher gains in children's executive functions at 60 months. Other studies have identified specific parenting behaviours, including autonomy support and scaffolding, to be uniquely and positively associated with the development of executive functions in three- to five-year-old children (Distefano et al., 2018; Castelo et al., 2022). In fact, so extensive is the evidence that parent-child interactions heavily influence how executive functions develop that it is only reasonable to explore whether interactions with other role models, such as teachers, may play a similarly substantial role (Choi et al., 2016).

To date, studies in the field of education have examined how teacher-child interactions influence executive functions at the classroom level using a global theoretical framework, namely Teaching Through Interactions (Koşkulu-Sancar et al., 2023; Sankalaite et al., 2021). This framework, developed by Hamre and Pianta (2007), emphasises the significance of daily teacher-child interactions that foster children's learning and sociocognitive development. Within this conceptual framework, the term interactions replicate "behavioural exchanges in which information and experience are transmitted between adult and child through channels that operate bidirectionally and transactionally" (Hamre et al., 2014, p. 1258). The classroom-level teacher-child

interactions within the framework are categorised into three domains: (i) emotional support, e.g., being sensitive and responsive to children's emotions and needs; (ii) classroom organisation, e.g., providing clear behavioural expectations and consistent routines; and (iii) instructional support, e.g., building children's understanding and higher-order thinking skills (Pianta et al., 2008).

Aligned with these overarching constructs, observational studies also report positive associations between teacher-child interactions at the classroom level and children's executive functions (for reviews, see Cumming et al., 2020; Sankalaite et al., 2021). For instance, when teachers provide stronger emotional support in the classroom, children demonstrate higher scores in inhibitory control skills, as measured by the Pencil Tap task (Weiland & Yoshikawa, 2013). Moreover, preschool children's positive engagement with their peers and teachers—marked by high emotional connection, shared positive affect, and effective, adaptive communication—was associated with gains in their executive functions development (see Sabol et al., 2018; Williford et al., 2013). Other studies also reveal the association between classroom organisation and gains in executive functions. Hamre et al. (2014), for example, found that children with teachers who manage their classrooms efficiently display gains in working memory. However, if we are to understand how early childhood professionals can best enhance their preschoolers' executive functions, we need to be able to pinpoint specific teaching strategies that cultivate these skills in children, beyond the broader domains of teacher-child interactions conceptualised in frameworks like CLASS. While CLASS captures specific indicators and examples of strategies within its observation process, our focus is on examining the detailed characteristics of these strategies, which may not be fully captured through CLASS scores alone but are often reflected in the observational evidence collected during classroom assessments. Unfortunately, very little is currently known about which specific teaching strategies promote the development of executive functions in children (Cumming et al., 2020; Fuhs et al., 2013; Koşkulu-Sancar et al., 2023; Moreno et al., 2017).

Curricula and approaches to support executive functions in preschool settings

A comprehensive systematic literature review by Muir et al. (2023) indicated four categories of intervention approaches that appear to enhance the development of executive functions in preschool settings. According to the authors, the categories include: (i) play-based approaches, e.g., mediated structured play, semi-structured creative play; (ii) social-emotional approaches, e.g., mindfulness; (iii) curricula and pedagogy, e.g., Tools of the Mind, the Montessori approach, music, mathematics; and (iv) non-routine activities, e.g., digitalised task training. In sum, their findings indicate that all intervention approaches demonstrate some evidence of possible effectiveness. For example, a semi-structured creative play approach such as fantasy-oriented play, where children suspend

reality and engage in a fantastical realm, like traveling to the moon, facilitated the development of executive functions in middle-class preschoolers (Thibodeau-Nielsen et al., 2020). Another study also provides preliminary evidence for the effectiveness of a semi-structured block play approach for facilitating preschoolers' executive functions, particularly for children in low socioeconomic circumstances (Schmitt et al., 2018). As for social-emotional approaches, mindfulness interventions have also appeared to enhance executive functions by engaging preschoolers in activities that comprise body scan, mindful movement or eating and breathing exercises (Berti & Cigala, 2020; Bockmann & Yu, 2022). Notably, other preschool curriculum components including: (a) music, such as singing, music theory, music-making (see Shen et al., 2019); (b) mathematics, such as counting, numeracy games (see Joswick et al., 2019); and (c) structured physical activities, such as dance, energetic games, yoga (see Xiong et al., 2017) can improve executive functions in preschoolers. Notably, however, external facilitators monitored the activities to ensure the fidelity of the interventions in each of these cases (Diamond & Ling, 2016). In other words, all studies in Muir et al.'s (2023) review that reported high efficacy were implemented with external facilitators.

Several preschool interventions and curricula targeting executive functions in preschool children have also been developed. The Tools of the Mind (Tools) curriculum was designed to improve executive functions in children with a focus on language and structured play (Bodrova & Leong, 2007). Initial evaluations of the extent to which the Tools program cultivates executive functions in preschoolers were positive (Diamond et al., 2007), but subsequent evaluations have returned mixed results (Nesbitt & Farran, 2021). Another program, The Chicago School Readiness Project (CSRP) (Raver et al., 2008), was designed to promote the development of executive functions in children predominantly living in poverty. This program provides teachers with training on behaviour management strategies and incorporates consultations with mental health practitioners. The implementation evaluation results from a randomised control trial conducted in 35 Head Start classrooms show that the CSRP intervention positively affects executive functions in children (Raver et al., 2011).

Thus, while such interventions have shown promise in enhancing children's executive functions, they are not without their challenges. Some do not come with a comprehensive curriculum. To implement the interventions, teachers must incorporate complex learning experiences into their regular curriculum and day-to-day practices – a requirement that does not necessarily fit within the typical length of a preschool's daily program (Nesbitt & Farran, 2021; Sankalaite et al., 2021). Further, as soon as a formal intervention is complete, teachers are likely to return to business-as-usual curricula (Lieber et al., 2010). Hence, implementing interventions that are sustained may be problematic (Fleer et al., 2020; Muir et al., 2023). The challenge is therefore to identify how to capitalise on the proven ability of these curricular interventions to strengthen executive functions in a way

that is achievable in the context of daily teaching practices. Hence, this paper specifically seeks to identify the teaching strategies that early childhood teachers can consistently implement in their daily practices to support the development of executive functions in preschool children.

The focus of study

This systematic review was driven by an awareness of how important executive functions are for positive long-term outcomes in children and the need to identify specific practices for cultivating these skills in early life (Cumming et al., 2020). Early childhood professionals (teachers and educators) play a significant role in cultivating executive functions in young children (Early et al., 2018; Williford et al., 2013). Thus, the aim of this systematic review is to investigate the following research question: *Which teaching strategies enhance the development of executive functions in preschool children?* The characteristics of each study and direct measures of executive functions will also be explored. The next section discusses the methods implemented for the systematic review.

Method

Literature search and eligibility criteria

This systematic review was prepared through the following four-step process (Jesson et al., 2011). The process began with identifying the research question and followed on through developing a search strategy, selecting the relevant studies, and extracting pertinent data. A systematic search of peer-reviewed journals was conducted in April, 2022 to locate relevant literature that explored contributions to the development of executive functions in preschool settings and, most specifically, contributions through teaching. The search concentrated on four education-focused academic databases, namely Academic Search Complete, Education Research Complete, ERIC, and the Psychology and Behavioural Science Collection. Using EBSCOhost Research Platform, a comprehensive search was conducted using combinations of different search terms to locate studies relevant to the aim of the review (see Table 1). These bibliographic database search strings used both keywords and controlled terms (e.g., pedagogical approach*) and the Boolean operators 'OR' and 'AND' to combine multiple search terms.

TABLE 1 Search terms and Boolean Operators used in the systematic literature review

Population of interest 1	Population of interest 2	Phenomenon of interest	Mechanisms	Context
Children OR Preschooler*	Teacher* OR Educator*	"Executive function" OR "Executive functioning" OR "Executive control" OR "Inhibitory control" OR "Working memory" OR "Cognitive flexibility" OR "Attention shifting" OR "Cognitive self-regulation" OR “Cognitive regulation” OR "Cognitive inhibition"	"Teacher practice*" OR “Intentional teaching" OR “Pedagogical practice*" OR "Pedagogical approach*" OR Instruction OR "Instructional support*" OR Strategy* OR “Teaching strategy*” OR “Cognitive stimulation” Didactic OR Dyad* OR Pedagogy OR Interaction OR Conversation	"Early childhood" OR "Pre$kindergarten" OR "pre$school" OR Childcare OR Kinder OR Nursery OR "Long day care centre" OR "Early education setting*" OR Foundation

To be included in this systematic literature review, the study had to focus on children aged 3-to-5 years. This was to ensure that the participants were within the preschool age range. Additionally, both children and their teachers needed to be included as primary participants, with the research conducted in a preschool setting. The research must have been based on primary data, and specific teaching strategies needed to be described in detail. Conversely, we excluded studies that focused on children outside of the 3 to 5-year-old age range, used parents as participants, were conducted in primary or high school contexts, did not use primary data, and lacked detailed descriptions of teaching strategies used. While conducting the search, the following generic search filters were applied: scholarly journals, peer-reviewed articles, and studies in English with no specified publication year eligibility criteria.

Study selection

From the above search, 244 studies were retrieved. After eliminating duplicates, 202 articles remained. Figure 1 outlines the search procedure documented in the PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) (Moher et al., 2009). The screening process began with a careful review of the titles and abstracts of the 202 articles to confirm eligibility. In cases of doubt, the study was downloaded and so the full text could be reviewed. From the title-abstract screening process, 42 articles proceeded to the next phase, which was a full-text review. The first author thoroughly reviewed the full text of these 42 articles, screening them against the inclusion and exclusion criteria. Forward and backward citation tracking was also used to scan the reference list of all the articles (Bandara & Syed, 2024). These were also read to determine their suitability for inclusion. From this final screening, 33 articles were excluded, and following forward and backward citation tracking, three further articles were added. A total of 12 studies were thus included in the review. Appendix A provides a sample of the articles excluded during the second round of screening, along with the reasons for their exclusion. Additionally, a complete list of the 33 excluded studies is available in Appendix B (available in the online version). To assess the quality of the included studies, three elements suggested by Newman and Gough (2020) were considered: the appropriateness of the study design in relation to the review question, the quality of the study's methods, and its relevance to addressing the review question.

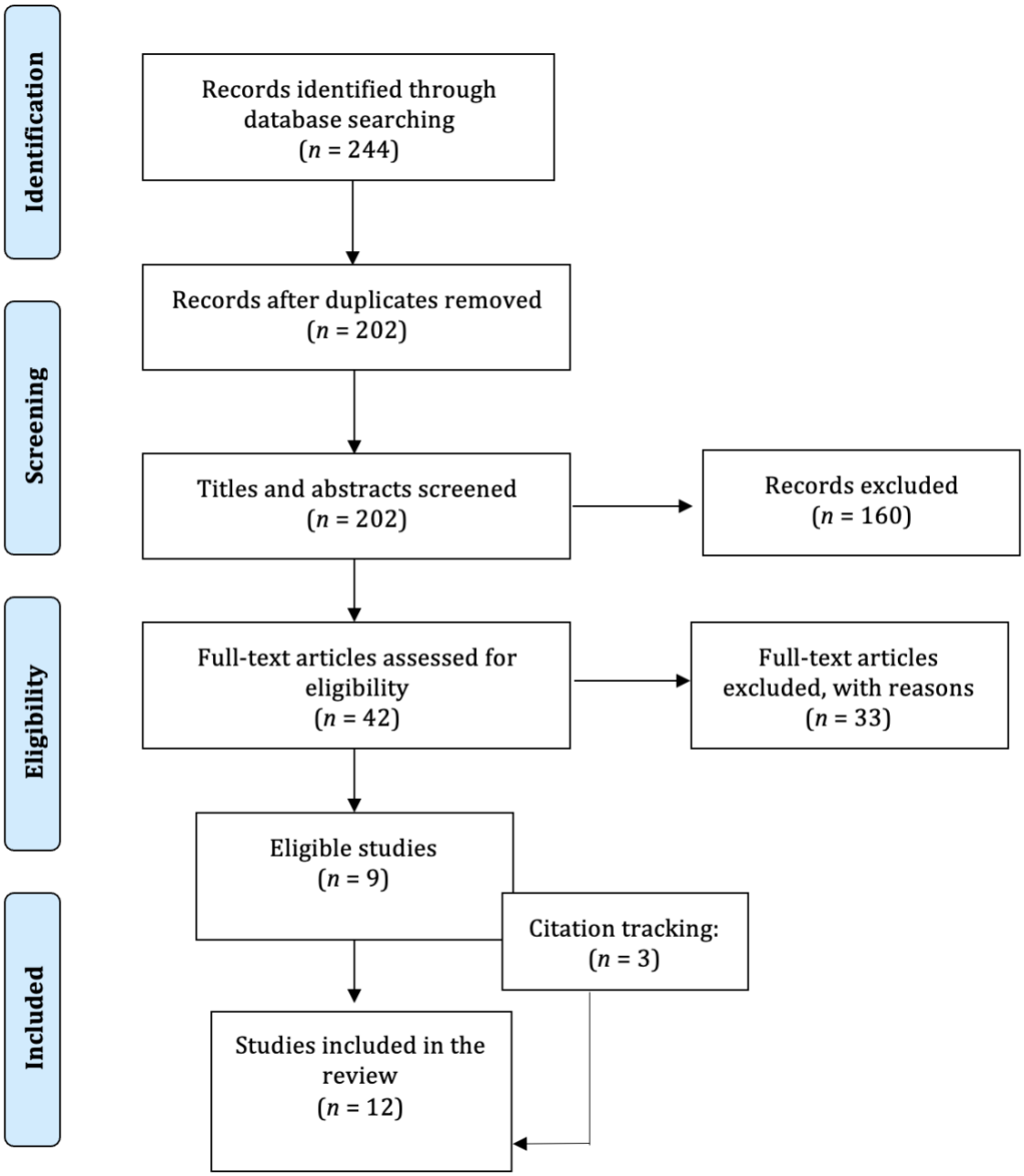

FIGURE 1 Systematic search process represented by PRISMA flow diagram

Data extraction and thematic synthesis

Full-text articles of the 12 eligible studies were obtained and thoroughly reviewed. A data extraction template was developed to collect relevant information that contributed to addressing the review question. This template included the authors' names, the year of publication, the setting (country), the research aims and methodology, the participant characteristics, and the teaching strategies used to enhance executive functions. The first author independently extracted the data, which was then validated by the second and third authors. Any discrepancies encountered were resolved through discussion until mutual agreement was reached. This approach of peer debriefing offers a practical alternative to joint coding or intercoder reliability assessments (van der Linden et al., 2022). A three-step thematic synthesis was then conducted outlined by Thomas and Harden (2008), using an abductive approach to integrate, interpret, and combine the findings of the 12 studies. The first author undertook the three steps of analysis utilising NVivo 12 (QSR International). The steps include line-by-line coding, developing descriptive themes and generating analytical themes (Thomas & Harden, 2008). The unit of analysis included all text found under the "results" and "discussion" subheadings in the study, as aligned with the aim of the review and the research question. Line-by-line coding was performed to create initial codes, which were then grouped into categories to develop descriptive themes. Hence, the findings from each study were merged into a comprehensive summary via a listing of themes that captured specific executive functions-enhancing teaching strategies. The descriptive themes were then compared with the textual data from the 12 studies, which led to the emergence of analytical themes. The three authors refined the analytical themes through collaborative discussions. The synthesised findings were subsequently presented in a narrative format and arranged into thematic groups. Through this process, we identified three themes in relation to our research question: (a) autonomy support, (b) sustained shared thinking, and (c) classroom organisation.

Results

This section conveys the results found from the 12 peer-reviewed articles. First, the characteristics of each study are described, and then the results are reported based on the teaching strategies identified as facilitating executive functions. An overview of each study, including key information relating to the setting (country), research aims, methodology, participant characteristics, and teaching strategies used is detailed in Table 2.

Study characteristics

All included studies were published between 2013 and 2021, and all examine the association between teacher-child interactions and the development of executive functions in early childhood settings. Of the 12 studies reviewed, 10 used quantitative methods, and two used mixed methods, i.e., quantitative methods plus teacher interviews (Fleer et al., 2020; Kuhn et al., 2021). Three papers involved intervention studies (either direct or indirect) with a focus on children (Distefano et al., 2020) or teachers (Anderson et al., 2020; Fleer et al., 2020). Ten studies incorporated observational designs and tools, such as the Classroom Assessment and Scoring System (CLASS; Pianta et al., 2008), the Early Childhood Environment Rating Scale – Third Edition (ECERS-3; Harms et al., 2015), Teacher Observation in Preschool (TOP; Bilbrey et al., 2010), Child Observation in Preschool (COP; Farran & Son-Yarbrough, 2001) or Preschool-Setting Executive Function (PSEF; Moreno et al., 2017).

Eleven studies were undertaken in the United States and one in Australia, all in a mix of urban and rural areas. Most were conducted with centre-based preschools, community-based programs, Head Start providers, or public preschool programs. Table 2 presents the sample characteristics of the participants. All studies focused on teachers and preschool children aged from three to five years (36 to 59 months). Five studies involved samples comprising children from low-income households or living below the poverty line (Choi et al., 2016; Distefano et al., 2020; Early et al., 2018; Goble & Pianta, 2017; Goble et al., 2019).

TABLE 2 Comprehensive overview of included studies in the systematic literature review

REFERENCE	*COUNTRY*	*RESEARCH AIMS*	*METHODOLOGY*	*PARTICIPANTS*	*TEACHING STRATEGIES*
Anderson et al. (2020)	United States	Examines the associations between a teacher's fidelity to the "Conscious Discipline" program and the development of executive functions, social skills and academic skills in children.	Quasi-experimental: pre/post assessments and observations - CLASS - Progress assessments – Conscious Discipline rubric	- 293 children (Mage = 52 months; *SD* = 4.28 months) - 45 early childhood teachers	- Increasing a sense of safety and reducing the environmental stress - Providing children with specific activities that promote their problem-solving skills and encourage sequential behaviour
Choi et al. (2016)	United States	Examines the impact of teacher-child interactions on gains in inhibitory control in preschoolers from predominantly low-income households.	Quantitative: pre/post assessments and observations - CLASS	-169 children (Mage = 56 months; *SD* = 6.38 months) - 60 preschool classrooms (teachers unspecified)	- Providing individualised attention and tailoring guidance - Delivering consistent and predictable interactions with children - Suggesting ways to solve problems - Implementing organised and consistent routines - Maximising children's learning opportunities during nonstructured situations (e.g., transition times)
Distefano et al. (2020)	United States	Examines the implementation outcomes and fidelity of Ready? Set, Go!	Experimental: pre/post/follow up assessments and observations - CLASS	- 75 children (Mage = 51 months; *SD* = not reported) - 67 parents - 5 early childhood teachers - 3 staff members	- Offering activity directions - Using feedback - Scaffolding children's learning - Facilitating reflection - Promoting children's reasoning and analysis - Using repetition and extension

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REFERENCE	*COUNTRY*	*RESEARCH AIMS*	*METHODOLOGY*	*PARTICIPANTS*	*TEACHING STRATEGIES*
Early et al. (2018)	United States	Examines how the quality of classrooms for preschool aged children relates to growth in early academic, executive functions and social skills.	Quantitative: pre/post assessments and observations - CLASS - Early Childhood Environment Rating Scale – Third Edition (ECERS-3)	- 491 children (Mage = 52 months; *SD* = 6.92 months) - 119 preschool classrooms (teachers unspecified)	- Supporting children to make decisions and develop independence within open-ended activities (e.g., fine motor skills, art, dramatic play, blocks, music and movement). - Individualising teaching and learning - Providing opportunities for adult/peer interactions - Being actively engaged with children and encourage learning - Scaffolding of appropriate behaviours within the context of a predictable classroom routine - Encouraging children to use language
Fleer et al. (2020)	Australia	Explores the possibility of improving children's executive functions over 10 weeks through a play pedagogy called Playworlds plus associated activities (e.g., Simon Says).	Mixed methods: pre/post assessments, observations of video recording and structured phone interviews (post intervention).	- 81 children (Mage = 54.7 months; *SD* = 3.94 months) - 8 early childhood teachers	- Sustaining engagement in children's play - Co-constructing knowledge - Developing problems for children to solve - Providing opportunities for children to initiate play and share their ideas and understandings
Fuhs et al. (2013)	United States	Examines the association between executive functions in children and classroom processes like emotional climate, the proportion of time spent in learning opportunities, and the quality of instructions.	Quantitative: pre/post assessments and observations - Teacher Observation in Preschool - Child Observation in Preschool	- 803 children (Mage = 54 months; *SD* = 4 months) - 60 preschool classrooms (teachers unspecified)	- Demonstrating positive affective tone - Expressing approval of children's behaviour and avoid redirecting - Delivering a high quality of instruction by asking inferential questions and including conversational turns - Providing child-directed activities that focus on academic contents (e.g., literacy, mathematics, and code-based activities)

REFERENCE	*COUNTRY*	*RESEARCH AIMS*	*METHODOLOGY*	*PARTICIPANTS*	*TEACHING STRATEGIES*
Goble and Pianta, (2017)	United States	Examines the associations between the proportion of time spent in child-managed and teacher-directed activity settings and children's early literacy, language, and inhibitory control development.	Quantitative: pre/post assessments and observations - CLASS - Emerging Academics Snapshot	- 1,407 children (Mage = 48 months; *SD* = not reported) - 325 early childhood teachers	- Providing children with opportunities to engage in peer interactions that require negotiation, problem solving and flexible thinking - Delivering free choice activities where children can select what and where they would like to play with and learn - Guiding children's self-initiated activities
Goble et al. (2019)	United States	Examines the effect change has on the quality of teacher-child interaction in terms of inhibitory control, language and literacy outcomes given participation in the MyTeachingPartner program for preschool teachers.	Quantitative: pre/post assessments and observations - CLASS	- 1,179 children (Mage = 50.16 months; *SD* = 5.52 months) - 269 early childhood teachers	- Engaging in back-and-forth conversations - Promoting high-order thinking skills through open-ended questions, problem solving, real-world applications, and language modelling.
Hamre et al. (2014)	United States	Examines the associations between teacher-child interactions and the acquisition of children's early academic, social skills and executive functions.	Quantitative: survey, pre/post assessments and observations - CLASS	- 1,407 children (Mage = 50.04 months; *SD* = 5.64 months) - 325 early childhood teachers	- Setting clear and consistent expectations for children's behaviour - Providing positive management and routines - Managing time, behaviour, and lessons effectively - Noticing and responding to children's emotional, behavioural, and cognitive cues - Engaging in children's learning experiences actively and intentionally

REFERENCE	*COUNTRY*	*RESEARCH AIMS*	*METHODOLOGY*	*PARTICIPANTS*	*TEACHING STRATEGIES*
Hatfield et al. (2016)	United States	Examines the associations between the quality of teacher-child interactions and school readiness skills, such as language, literacy, and inhibitory control. The study takes place in a follow-up year after the two phases of the course and coaching interventions for teachers had been implemented.	Quantitative: pre/post assessments and observations - CLASS	- 875 children (Mage = 49.32 months; *SD* = 6 months) - 222 early childhood teachers	- Displaying high levels of responsivity - Encouraging autonomy - Providing emotional warmth and positive expressions
Kuhn et al. (2021)	United States	Examines the correlations between executive functions and challenging behaviour in children, plus adult perspectives on supporting the development of executive functions in children.	Mixed methods: interviews and assessments - Ratings on the Social Skills Improvement System (SSIS) - Ratings on the Behaviour Rating Inventory of Executive Function – Preschool (BRIEF-P)	- 19 children (Mage = 46.8 months; *SD* = 3.6 months) - 11 early childhood teachers - 3 coaches - 4 parents	- Delivering free choice activities - Offering activity directions - Implementing consistent routines - Using transition cues - Providing visual supports of rules and expectations
Moreno et al. (2017)	United States	Examines instances of behaviours related to executive functions in children and behaviours that support executive functions in teachers using a new classroom-level observational protocol called PSEF (Preschool-Setting Executive Function).	Quantitative: observations - PSEF-C (child behaviours) - PSEF-T (teacher support behaviours)	- 13 early childhood teachers - 4 teacher's aids - 9 preschool classrooms (children unspecified)	- Assigning responsibility - Delivering free choice activities - Expanding child-initiated play - Expanding children's responses - Providing activity-related narration and questioning

Executive functions-enhancing teaching strategies

Our systematic literature review has identified three types of teaching strategies, each of which proposes a distinctive but complementary explanation for how children's executive functions could be positively enhanced in preschool classrooms. Figure 2 shows the identified teaching strategies that are grouped into three categories, including autonomy support, encouraging sustained shared thinking, and enacting strong classroom organisation.

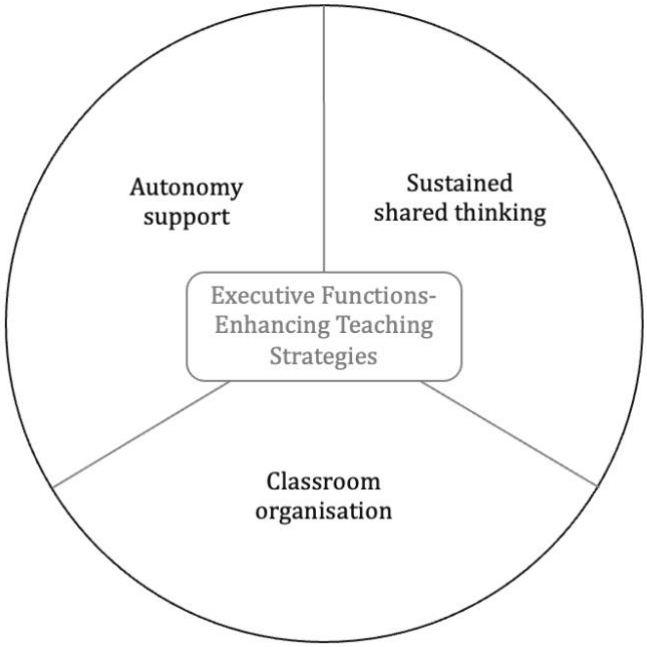

FIGURE 2 Key themes of teaching strategies for enhancing executive functions in preschoolers as identified by reviewed studies (Table 2)

Autonomy support

In the current review, nine studies explore the extent to which specific teacher-child interactions, including autonomy support behaviours, promote executive functions in children. Autonomy support refers to a set of adult behaviours that are responsive to children's psychological needs, interests, and values (Reeve, 2006). These behaviours include following the child's pace and lead, providing an appropriate amount of help, allowing choices, and encouraging children to make decisions (Bernier et al., 2010). Studies have demonstrated that children in autonomy-supportive environments

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experience positive educational outcomes, including greater engagement in learning, better academic performance, and higher executive function capacities (Boggiano et al., 1993; Carlson, 2023; Reeve et al., 2004; Sosic-Vasic et al., 2015). As presented in Table 2, some identified teaching strategies include: (i) providing individual attention and child-directed activities (Choi et al., 2016; Fuhs et al., 2013); (ii) supporting children to make decisions and developing independence within open-ended activities (Early et al., 2018); (iii) guiding children's self-initiated activities and offering directions given the child's abilities (Distefano et al., 2020; Kuhn et al., 2021; Goble & Pianta, 2017); (iv) noticing and responding to children's emotional, behavioural, and cognitive cues (Choi et al., 2016; Hamre et al., 2014); (v) displaying high levels of responsivity, encouraging autonomy, and providing positive expressions (Hatfield et al., 2016); and (vi) delivering free choice activities where children can select what and where they would like to play and learn (Goble & Pianta, 2017; Moreno et al., 2017).

Sustained shared thinking

The reviewed literature highlights that the types of interactions by teachers that support and extend children's language and critical thinking also play a significant role in bolstering the development of executive functions in children. In education, this approach is known as sustained shared thinking. This is a pedagogic interaction "where two or more individuals work (often playfully) together in an intellectual way to solve a problem, clarify a concept, evaluate activities, or extend a narrative" (Siraj-Blatchford, 2008, p. 7). Five of the reviewed studies recognise teaching strategies relating to sustained shared thinking that intend to enhance executive functions by supporting and extending language and communication. These strategies include: (i) providing opportunities for adult-to-peer and peer-to-peer interactions that require negotiation, problem-solving and flexible thinking (Early et al., 2018; Goble & Pianta, 2017); (ii) delivering a high-quality of instruction by asking open-ended and inferential questions (Fuhs et al., 2013); (iii) engaging in back-and-forth conversations (Goble et al., 2019); and (iv) providing activity-related narrations and expanding children's responses (Moreno et al., 2017).

The literature also highlights other teaching strategies that cultivate executive functions by supporting learning and critical thinking. These include: (i) promoting children's reasoning, analysis, and reflection (Distefano et al., 2020); (ii) expanding child-initiated play and engaging in their learning experiences actively and intentionally (Early et al., 2018; Fleer et al., 2020; Hamre et al., 2014; Moreno et al., 2017); and (iii) co-constructing knowledge and developing problems for children to solve (Choi et al., 2016; Fleer et al., 2020). The strategies identified provide insight into the influence of a sustained shared thinking approach to the development of children's executive functions. Moreover, they are pivotal for early childhood teachers to incorporate into their everyday practices to

support the process quality of teacher-child interactions (Hamre et al., 2014; Leyva et al., 2015; Salminen et al., 2021).

Classroom organisation

The literature review reveals a positive association between strong classroom organisation strategies and improvements in children's executive functions. Six studies report that a teacher's ability to provide a safe learning environment, deliver clear behavioural expectations and manage instructional time and routines are a significant contributing factor in helping to develop executive functions in preschoolers. Some of the teaching strategies explored include: (i) reducing classroom stress and increasing a sense of safety (Anderson et al., 2020); (ii) implementing organised and consistent routines (Choi et al., 2016; Hamre et al., 2014; Kuhn et al., 2021); (iii) scaffolding appropriate behaviours within the context of a predictable classroom routine (Early et al., 2018; Fuhs et al., 2013); and (iv) setting clear and consistent expectations for children's behaviour and managing time and lessons effectively (Hamre et al., 2014).

Discussion

The goal of this literature review was to systematically identify publications examining specific teaching strategies that have a positively impact on the development of executive functions in preschool classrooms. The articles we reviewed contained several teaching strategies reported to influence the development of executive functions in preschoolers (see Table 2). These findings deepen our current understanding of teaching strategies that intend to enhance executive functions. Moreover, they provide early childhood teachers and policymakers with evidence of effective teaching strategies, and, from an academic perspective, they also indicate directions for future research.

Executive functions are malleable and responsive to a combination of emotionally supportive and cognitive stimulation experiences (Fuhs et al., 2013; Zelazo et al., 2016). In our review, we found three types of interconnected strategies for strengthening children's executive functions that would be achievable in the context of daily teaching practices.

The first identified teaching strategy relates to specific adult behaviours that constitute autonomy-support. Children use executive functions when undertaking effortful goal-directed tasks (Miyake et al., 2000). Hence, adults who are supportive of child autonomy create opportunities for children to use their executive functions within their zone of proximal development – co-constructed interactions that enable the child to succeed and feel a sense of accomplishment with an appropriate amount of help from someone else

(Diamond & Ling, 2016; Distefano et al., 2018; Vygotsky, 1986). The reviewed studies indicate that children display higher executive functions when their teachers: i) use behaviours that support autonomy; ii) display high levels of responsivity and sensitivity to children's emotional and cognitive cues; iii) provide individualised attention; iv) tailor guidance; and v) offer directions on the activity being undertaken (Choi et al., 2016; Distefano et al., 2020; Goble & Pianta, 2017).

Supporting autonomy also involves considering children's perspectives, following children's lead, and allowing choices (Bernier et al., 2010; Reeve, 2016). When children have autonomy, they have opportunities to make choices in how to act, think, and feel (Carlson, 2023). The time teachers spend in expanding child-initiated play and providing open-ended and free choice activities is positively associated with gains in executive functions. These results suggest that children making decisions regarding what to play with and where to play provide opportunities to develop executive functions (Goble & Pianta, 2017; Kuhn et al., 2021; Moreno et al., 2017). Child-centred approaches which encourage children to make choices, plan, and initiate and indicate preferences, therefore support the development of executive functions. Teacher behaviours that support autonomy appear to be critical for developing executive functions in preschoolers. This finding aligns with empirical studies on the association between executive functions in children and parental support of autonomy (Bernier et al., 2010; Distefano et al., 2018; Meuwissen & Carlson, 2015). This highlights the significance of autonomy support in cultivating executive functions across a wide range of contexts, including both home and preschool classrooms.

The results of the current review also suggest that teachers provide child-centred approaches that involve children in back-and-forth interactions with peers – interactions that require problem-solving, negotiation, reflection, and flexible thinking (Goble & Pianta, 2017). This approach demonstrates a teacher's capacity to engage in sustained shared thinking with children (Siraj-Blatchford & Asani, 2015). Engaging in this type of thinking means contributing to the child's thinking by facilitating reflection, encouraging analysis and reasoning, and using repetition and extension – practices that are viewed theoretically as critical for enhancing the development of executive functions (Distefano et al., 2020; Zelazo, 2015).

A teacher's ability to provide clear behavioural expectations and to manage instructional time and routines in classrooms is another important finding that emerged from this review. More productive teachers tend to provide more opportunities for children to develop executive functions through organised routines (Hamre et al., 2014; Kuhn et al., 2021). Productivity involves "how well the classroom runs with respect to routines and the degree to which teachers organise activities and directions so that maximum time can be spent in learning activities" (Pianta et al., 2008, p. 4). Researchers such as Choi et al.

(2016) have highlighted the importance of organised routines that support children knowing what to do throughout the day: the predictability of routines support children to plan their activities and engage in goal-directed tasks. Moreover, the results show that clear and consistent expectations on the part of the teacher can be an effective way to help children develop executive functions (Hamre et al., 2014). The same is true when expressing approval over a child's behaviour through communicating appreciation for their efforts, showing more warmth and less disapproving behaviours (Fuhs et al., 2013). Within these contexts, children engage in more goal-directed tasks and behaviours, and likewise the feedback they receive from doing so may be more positive to help build their executive function skills.

Implications for practice and future research

Overall, our synthesis of existing research suggests that strategies that support autonomy, sustained shared thinking, and enacting strong classroom organisation play a key role in facilitating executive functions in preschool children. In practice, these insights show how early childhood teachers can incorporate certain identified teaching strategies into everyday preschool curriculums to promote executive functions. By shedding light on these teaching approaches, such as delivering free-choice activities, engaging in back-and-forth conversations, and implementing organised and consistent routines, early childhood teachers will gain valuable insights into how to cultivate executive functions in day-to-day classrooms.

Applicable teaching strategies that could be incorporated into everyday preschool curricula include offering autonomy-supportive behaviours, encouraging sustained shared thinking and enacting strong classroom organisation. Creative arts, such as drama, is one of the curriculum components that an early childhood teacher could use to promote executive functions. For example, when a preschooler engages in fantasy play, the teacher could: (i) encourage the children to make decisions about the narrative of the play, (ii) guide the children's play by designing and planning scenarios, (iii) motivate engagement by asking open-ended questions, and (iv) provide activity-related narrations. These are all constructive strategies that support autonomy and encourage sustained shared thinking. Additionally, these strategies are likely to have a positive impact on the child's planning and problem-solving skills.

Early childhood teachers could also implement strategies that support executive functions within learning experiences underpinned by predetermined learning aims such as math (e.g., counting and number knowledge, or shape composition and decomposition) and emergent literacy (e.g., phonological awareness and print knowledge) (McClelland et al., 2019). Consider, for example, the use of BeeBots. BeeBots are programmable floor robots that help preschoolers learn the alphabet and practice basic counting. A BeeBot is

placed on a mat printed with the letters of the alphabet. A child then chooses a letter, such as Q, and is required to count the steps the BeeBot needs to travel from its current location to the letter Q. The child operates the robot by pressing left/right and up/down buttons to navigate the robot. Hence, in this coding activity, the child needs to: (a) focus on the task; (b) mentally hold information; and (c) remember the number and directions of the steps to take. To help the child learn, the teacher uses strategies such as (i) noticing and responding to the child's cognitive cues; and (ii) offering directions in response to the child's observed abilities. Similar strategies can be used to support the development of executive functions when a child who has four red and six blue counting bears is asked, 'How many blue bears are here? How many bears are red?' (Mulcahy et al., 2021). Such teaching strategies provide opportunities for preschoolers to rehearse executive function skills in ways that are achievable in the context of daily teaching practice.

Further, the insights from our systematic literature review can be used to inform policies about the importance of executive functions for positive long-term outcomes in children. Activities specifically designed to develop executive functions need to be integrated into early childhood curricula. Additionally, professional development can support early childhood teachers in strengthening their knowledge and skills to effectively implement teaching strategies that promote executive functions. Education policy makers can take advantage of these findings to develop initiatives that support and promote such opportunities. This not only aligns well with the current research but should also raise awareness of the fundamental importance of executive functions among early childhood teachers. In turn, this should lead to positive long-term outcomes for preschoolers.

Above all, our research shows that, as a field, we need to develop a more nuanced understanding of the specific characteristics and qualities of teaching strategies and teacher-child interactions that foster executive functions. First, we need to know how teachers can best implement these strategies and, second, we need a deeper understanding of how they mediate the development of real-time executive functions in preschool classrooms. Hence, in future research, scholars might look to evaluating the effectiveness of the identified teaching strategies and their relationships with observed working memory, inhibitory control, and cognitive flexibility. There is not only a need to know what works to promote executive functions in preschoolers, but also how it works, and in what contexts. Most of the papers we reviewed evaluated the influence of teaching strategies on low-income children enrolled in Head Start programs in the United States. Hence, another priority is to understand how these teaching strategies build executive functions in different early childhood contexts internationally, including high, medium, and low socioeconomic circumstances. Qualitative research in this regard is especially needed as there is currently very little information about the extent to which teachers are aware of executive functions or the evidence-based practices that support executive functions in early childhood education (Kuhn et al., 2021).

Limitations

While the present review identifies effective strategies for supporting executive functions in preschool classrooms, this study does have some limitations. Although there is abundant evidence that playful experiences including movement, dance, and physical activities positively contribute to executive functions in children, we chose to search for more general terms, such as "intentional teaching", "pedagogical practices" or "teaching strategy" to capture pedagogical strategies grounded in everyday preschool interactions between the teacher and the children (Moreno et al., 2017). Consequently, this review does not provide insights into targeted interventions such as music, dance or physical activity. Further, while our search did not specifically look for publications in particular countries, 11 out of 12 of the included studies in this review were published in the United States. In this review, the search was limited to specific databases and search engines, which, while comprehensive, may have unintentionally excluded relevant articles that were not indexed in the chosen sources. This limitation raises the possibility that relevant studies, particularly from non-English journals, may not have been captured during the screening processes. Additionally, while abstracts are intended to concisely summarise the key features of a study, they can sometimes overlook significant information or offer a less accurate representation of the study as a whole. Consequently, certain articles that could have been relevant to the review might have been excluded during the abstract screening due to a partial or limited understanding of their content.

Conclusion

The results of this systematic literature review show that everyday teaching practices influence the development of executive functions. The current review reveals that specific teaching strategies, such as autonomy support behaviours, sustained shared thinking, and classroom organisation create opportunities for children to develop and rehearse their executive function skills. It is reasonable to infer that a classroom program that focuses on a child-centred pedagogy, in addition to enacting organised and consistent routines, should produce better outcomes for executive functions. This literature review underscores the significance of early childhood teachers as important contributors for enhancing children's executive functions through the use of specific teaching strategies.

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