



## OPEN ACCESS

## EDITED BY

Eduardo Encabo-Fernández,  
University of Murcia, Spain

## REVIEWED BY

Flora Koliouli,  
Aristotle University of Thessaloniki, Greece  
Kyriakoula Rothou,  
Aristotle University of Thessaloniki, Greece

## \*CORRESPONDENCE

Parian Madanipour  
✉ parian.madanipour@griffithuni.edu.au

RECEIVED 29 August 2024

ACCEPTED 30 December 2024

PUBLISHED 16 January 2025

## CITATION

Madanipour P, Garvis S, Cahrssen C and  
Pendergast D (2025) Early childhood  
teachers' understanding of executive  
functions and strategies employed to  
facilitate them.  
*Front. Educ.* 9:1488410.  
doi: 10.3389/feduc.2024.1488410

## COPYRIGHT

© 2025 Madanipour, Garvis, Cahrssen and  
Pendergast. This is an open-access article  
distributed under the terms of the [Creative  
Commons Attribution License \(CC BY\)](#). The  
use, distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in  
this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted  
which does not comply with these terms.

# Early childhood teachers' understanding of executive functions and strategies employed to facilitate them

Parian Madanipour<sup>1\*</sup>, Susanne Garvis<sup>1</sup>, Caroline Cahrssen<sup>2</sup>  
and Donna Pendergast<sup>1</sup>

<sup>1</sup>Griffith Institute for Educational Research, Griffith University, Brisbane, QLD, Australia, <sup>2</sup>School of Education, University of New England, Armidale, NSW, Australia

**Introduction:** Adult-child interactions have a noteworthy influence over how executive functions develop. However, despite recognising the importance of executive functions in a child's success, little research has been undertaken to explore the role of early childhood teachers in facilitating the development of executive functions in children through their teaching practice. The current study thus explored what understanding early childhood teachers have of executive functions and what pedagogical practices they use to contribute to the development of executive functions in 3 to 5-year-old children within preschool settings.

**Methods:** Data were collected through an online questionnaire completed by 58 early childhood teachers across Victoria, Australia. The questionnaire included both closed and open-ended questions, aiming to explore participants' understanding of executive functions and the specific pedagogical practices they employed to facilitate the development of these skills in their classroom. Qualitative data from open-ended responses were analysed thematically to identify recurring practices and perceptions.

**Results:** The results reveal that some early childhood teachers reported strong pedagogical understanding of executive functions. Further, they reported implementing practices in the everyday classroom intended to promote executive functions. Thematic analysis of qualitative data reveals that these early childhood teachers apply five pedagogical practices intended to facilitate executive functions: environment and activity structuring, supporting autonomous behaviours, enacting purposeful classroom organisation, encouraging sustained shared thinking, and conducting activities that support executive functions.

**Discussion:** The self-reported data in this study suggest that some early childhood teachers know much about evidence-based pedagogical practices that facilitate children's executive functions. The reported pedagogical practices employed by such teachers aligned closely with practices recommended in the literature. However, participants' pedagogical understanding was reported to have been gained through experience, drawing attention to the need for a stronger focus on executive functions during initial teacher education courses. As such, this study highlights the need for Australian early childhood initial teacher education courses to ensure that executive functions and executive functions-supportive pedagogical practices are explicitly addressed. The insights revealed here should inform initiatives that raise awareness and understanding of executive functions among early childhood teachers to forefront executive functions during their time spent with preschoolers.

## KEYWORDS

executive functions, early childhood teacher, preschool children, pedagogical understanding, pedagogical practices

## 1 Introduction

The first 3 to 5 years of life, typically known as the preschool years, signify a crucial period in the development of executive functions in children (Carlson, 2005; Garon et al., 2008). This period is typically characterised by the progressive development of several abilities, including keeping multiple pieces of information in mind over a short period of time, choosing thoughtful responses rather than automatic ones, and exploring different perspectives to solve problems (Diamond, 2020). Executive functions are not only foundational building blocks for learning in children, but they also have a significant influence over important developmental outcomes, including school readiness, school performance and social competence (Almy and Zelazo, 2015; Madanipour and Cohrsen, 2024).

Fortunately, executive functions are malleable and can be improved through a stimulating environment (Diamond and Lee, 2011). In fact, there is growing evidence that preschool education can deliver optimal experiences for the development of executive functions in children (Anderson et al., 2020; Schmitt et al., 2018; Thibodeau-Nielsen et al., 2020; Veraksa et al., 2023; Zamzow and Ernst, 2020). It is therefore unsurprising that the rapid growth of executive functions over the years prior to school entry, coupled with the importance of a preschool education, has sparked a surge of attention to the role early childhood teachers might play in facilitating these skills. In Australia, where this study took place, almost 1.4 million children attend early childhood education and care services for up to 50 h every week (Australian Children's Education and Care Quality Authority (ACECQA), 2022). Within the Australian preschool context, early childhood teachers are responsible for facilitating high-quality learning to promote the children's development and wellbeing (AGDE, 2022; Boyd and Garvis, 2021). As such, early childhood teachers can be potential catalysts for lasting change in a child's life (Muir et al., 2024a), providing a rich environment in which children acquire knowledge and skills and develop a disposition toward learning in the day-to-day classroom (Siraj-Blatchford, 2008; MacNaughton and Williams, 2009; National Association for the Education of Young Children, 2021). Moreover, the pedagogical understanding and practices of early childhood teachers are known to influence the learning outcomes of preschool children (Manning et al., 2019; Organisation for Economic and Cooperative Development (OECD), 2018). These understandings not only refer to their knowledge of effective instructional strategies but also to knowing when and how to apply each strategy to foster learning (Guerriero, 2014). The importance of including a focus on executive functions in core content for initial teacher education courses has been emphasised to "provide teachers with an understanding of why specific instructional practices work, and how to implement these practices" (Australian Government, 2023, p. 26). Reflecting this emphasis, the revised Early Years Learning Framework for Australia V2.0 (EYLF; AGDE, 2022) has introduced a focus on executive functions for the first time. Consequently, the goal of this research was to explore what early childhood teachers know about executive functions and about evidence-based pedagogical practices that support the development of executive functions in everyday classrooms.

### 1.1 Executive functions in preschool children

Executive functions refer to a family of interrelated cognitive and self-regulatory skills that are required when an individual is required to focus and persist to achieve a goal (Garon et al., 2008). Often referred to as the brain's 'air traffic control system', these skills help adults and young children to manage a lot of information and avoid distractions (Center on the Developing Child, 2011, p. 1). Despite some variation in how executive functions are defined, most scholars acknowledge three interconnected but distinct features that form the core components of executive functions, these being: (a) working memory, which is the ability to hold and retrieve information in the mind long enough to allow mental manipulation; (b) inhibitory control, which is the ability to suppress instinctive thoughts or behaviours in favour of a predetermined response; and (c) cognitive flexibility, which is the ability to shift attention and adapt to new demands when performing a task (Best and Miller, 2010; Diamond, 2020; Miyake et al., 2000).

The development of executive functions in children does not emerge in isolation. In recent times, a growing body of literature has discussed the influence of contextual processes on the development of executive functions in children, such as parenting behaviours (Castelo et al., 2022; Zvara et al., 2019), family attributes (Blair et al., 2011; Conway et al., 2018), cultural contexts (Howard et al., 2020; Schirmbeck et al., 2020), social groups (Doebel and Munakata, 2018), teacher behaviours (Koşku-Sancar et al., 2023; Bardack and Obradović, 2019); and the classroom environment (Cumming et al., 2020). For example, executive functions in childhood are robustly associated with both the positive and negative dimensions of parental behaviours. A longitudinal study by Hughes and Devine (2019) reports that gains in executive functions during the period from 3 to 4 years of age show specific associations with parental scaffolding, parental language input, and negative parent-child interactions (e.g., criticism, negative affects, and control). Similarly, the evidence shows that parental behaviours that support autonomy, such as offering choices, positive verbalisation, scaffolding and supporting competence, are closely associated with the development of executive functions in early childhood (Carlson, 2003; Carlson, 2023; Castelo et al., 2022). In fact, so extensive is the evidence confirming that parent-child interactions have a noteworthy influence over how executive functions develop, it raises the question as to whether interactions with other role models, such as teachers, may also play a similarly important role.

### 1.2 The influence of pedagogical practices and interventions on executive functions

Within the literature, there is observational evidence to support the idea that the development of executive functions in children is positively associated with good experiences in a rich learning environment. Most of these studies rely on the Classroom Assessment Scoring System (CLASS; Pianta et al., 2008), which assesses classroom quality and teacher-child interactions against three broad domains: emotional support, classroom organisation and instructional support (see Anderson et al., 2020; Early et al., 2018; Goble et al., 2019; Hatfield et al., 2016). For example, Choi et al. (2016) report that emotional support (e.g., teacher sensitivity) and classroom organisation (e.g., sharing behavioural expectations and routines) were, over a 6-month period, positively associated with improvements in preschoolers who initially

showed low inhibitory control skills. Similarly, [Hamre et al. \(2014\)](#) also found that preschoolers displayed gains in working memory and inhibitory control skills when they had teachers who were able to: efficiently respond to the child's perspectives, support their autonomy, and implement strong routines in the classroom (as demonstrated by higher emotional support and classroom organisation).

However, while these two studies demonstrated positive associations between the three CLASS domains and gains in executive functions, subsequent evaluations have not established a relationship between these two variables. For example, [Guerrero-Rosada et al. \(2021\)](#) report that none of the CLASS domains are linked to gains in children's executive functions. They argue that, in high-quality contexts, general measures of process quality are not strong predictors of gains in executive functions.

Researchers have also highlighted that intentionally deploying strategies to support and extend children's language and critical thinking are an important way to stimulate children's executive functions within preschool classrooms. These strategies include, but are not limited to: the use of language to sustain and extend children's thinking ([Muir et al., 2024b](#)); providing opportunities for adult-to-peer and peer-to-peer interactions that require negotiation, problem-solving and flexible thinking ([Early et al., 2018](#); [Goble and Pianta, 2017](#)); promoting children's reasoning and facilitating reflection ([Distefano et al., 2020](#)); encouraging higher order thinking skills through open-ended questions, problem solving and language modelling ([Goble et al., 2019](#)); expanding children's responses and, providing activity narration and questioning ([Moreno et al., 2017](#)). In education, this type of teacher-child interaction is known as sustained shared thinking, "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).

Multiple theoretical perspectives highlight the positive association between the development of children's executive functions and dimensions of autonomy-supportive behaviours by adults ([Carlson, 2023](#); [Distefano et al., 2022](#); [Dias and Seabra, 2015](#)). Autonomy support consists of a range of adult behaviours that are attentive to children's psychological needs, interests and values ([Reeve, 2006](#)). These behaviours involve following the child's pace and lead, scaffolding the child's independent problem solving, providing choices to children that encourage them to reflect on options and make decisions, taking the child's perspective and allowing the child to be an agent in their learning ([Day et al., 2022](#)). In a review of the literature, a few studies show positive associations between teacher behaviours that support autonomy and the development of executive functions in preschoolers. These include: providing open-ended activities where children have the freedom to select what and when they would like to learn through play ([Goble and Pianta, 2017](#); [Moreno et al., 2017](#)); facilitating children's self-directed activities and offering guidance according to the child's competence level ([Distefano et al., 2020](#)); offering individualised attention and tailoring guidance ([Choi et al., 2016](#)); supporting children to make decisions and fostering independence by engaging in open-ended activities ([Early et al., 2018](#)). Notably, a study by [Susic-Vasic et al. \(2015\)](#) also investigated how teachers who support autonomy impact executive functions in children, finding lower error rates in executive function tests for students with teachers that support autonomy. This finding accords with parental studies that consider supporting autonomy to be a strong predictor of executive function development in preschoolers ([Bernier et al., 2010](#); [Carlson, 2023](#); [Castelo et al., 2022](#); [Distefano et al., 2018](#)).

In recent years, intervention studies have also explored the impact of purposefully designed professional learning programs for early childhood teachers that target the development of executive functions in preschool education contexts (see [Dias and Seabra, 2015](#); [Fleer et al., 2020](#); [McClelland et al., 2019](#); [Muir et al., 2024a](#); [Williams et al., 2020](#)). The purpose of these professional learning programs is to deliver in-service professional learning that familiarises teachers with the theoretical and developmental underpinnings of executive functions. These programs also provide support and a repertoire of activities to promote executive functions in preschool children. Additionally, curricula programs such as Tools of the Mind ([Bodrova and Leong, 2007](#)) have been designed to improve preschoolers' executive functions with a focus on language and structured play (e.g., dramatic play, cooperative learning experiences). External mediators, such as visuals and engaging children in shared activities that encourage turn-taking, are among the approaches that have been used by teachers in the Tools of the Mind program ([Bodrova and Leong, 2018](#)). Taken together, these studies show promise for facilitating the development of executive functions in children ([Muir et al., 2023](#)). They demonstrate that a teacher's understanding of executive functions as well as enacting explicit pedagogical practices can lead to positive growth in these abilities. Additionally, studies have demonstrated the effectiveness of certain learning experiences on the development of executive functions in preschoolers, including activities such as: block play ([Schmitt et al., 2018](#)); mindfulness ([Bockmann and Yu, 2022](#); [Zelazo et al., 2018](#)); music ([Shen et al., 2019](#)); role play ([Thibodeau-Nielsen et al., 2020](#)); and, physical activities, such as dance, energetic games and yoga ([Xiong et al., 2017](#)). A guiding document from the [Center on the Developing Child at Harvard University, \(2014\)](#) also provides specific activities that support executive functions by allowing children to practice these skills.

### 1.3 Teachers' knowledge and pedagogical understanding of executive functions

In education, the term 'pedagogy' refers to the intentional actions that teachers use to put curriculum approaches into practice ([Arthur et al., 2015](#)). Examples of these pedagogical practices include purposeful interactions with learners, scaffolding, facilitating, implementing learning experiences and organising learning environments for play and exploration. According to [Siraj-Blatchford et al. \(2002\)](#), pedagogy is an interactive process between a teacher, a learner and the learning environment and defined as a "set of instructional techniques and strategies which enable learning to take place and provide opportunities for the acquisition of knowledge, skills, attitudes and dispositions within a particular social and material context" (p. 28). Hence, teachers apply pedagogical understanding and knowledge of explicit teaching practices to facilitate learning and development in children ([Wilson and Bai, 2010](#)). Further, a teacher's choice of explicit teaching practices can be influenced by their beliefs and awareness of different educational and psychological concepts ([Keenan et al., 2020](#); [Maier et al., 2013](#); [Wilson and Bai, 2010](#)). For example, if teachers know that facilitating executive functions in children is important, it is likely to influence their intentionality, their choice of effective teaching practices and the range of learning opportunities they offer in the classroom. This is evident when receiving in-service professional learning. Indeed, early childhood teachers and educators have demonstrated a high capacity for supporting the development of executive functions in preschoolers ([Fleer et al., 2020](#); [Muir et al., 2024a](#)).

Nevertheless, very little research has explored what teachers know about executive functions in general. The limited research that has been undertaken has been conducted at the primary school level in studies undertaken in Ireland (Keenan et al., 2020), Israel (Rapoport et al., 2016), Sweden (Nyroos et al., 2018), and the United Kingdom (Gilmore and Cragg, 2014). These studies report that primary school teachers recognise the significance of executive functions for academic success but show limited knowledge of executive functions and the importance of their role in promoting executive functions development in learners. Interestingly, teachers with years of extensive classroom experience seemed more able to recognise the importance of executive functions than those simply trained through a formal institution (Gilmore and Cragg, 2014; Keenan et al., 2020; Rapoport et al., 2016). According to the Center on the Developing Child (2011), initial teacher education courses dedicate little or no time to educating future teachers about the development of executive functions. As a result, the extent to which teachers know about executive functions and their pedagogical understanding of the practices needed to grow these skills in learners is unclear, particularly in early childhood education.

## 1.4 The current study

In this study, pedagogical understanding is defined as teachers' knowledge about evidence-based practices that are employed to intentionally facilitate children's learning to create an environment within which their executive functions can develop. Exploring the pedagogical understanding early childhood teachers have of executive functions in preschool children is essential for two reasons. First, there is a growing body of research to show that a teacher's understanding of childhood development along with their knowledge of neuroscience affects the teaching practices they implement in the classroom (Daniels and Shumow, 2003; Dubinsky et al., 2013). Second, studies have not yet investigated early childhood teachers' pedagogical understanding of evidence-based practices that are intended to facilitate children's executive functions in day-to-day preschool classrooms. Thus, the aim of this study is to explore early childhood teachers' understanding of pedagogical practices that positively impact executive functions in preschool children. The research is guided by the following two research questions: First, what do early childhood teachers know about executive functions in preschool children? Second, what do they know about evidence-based practices that support the development of executive functions in preschool children?

## 2 Method

### 2.1 Participants

The inclusion criteria stipulated a full early childhood teacher qualification and current engagement with the profession in Victoria, Australia. Fifty-eight early childhood teachers from sessional kindergartens and long day care services participated in the study. They were recruited through social media platforms including Facebook and LinkedIn via the snowball sampling method (Baltar and Brunet, 2012). All questionnaires were completed anonymously. Demographic information about the participants is provided in the Results section.

### 2.2 Procedure

This research explores early childhood teachers' knowledge of executive functions and their pedagogical practices in support of these skills. The research project was approved by the Department of Education and Training Victoria (approval no. 2022\_004605), and received university HREC approval (approval no. 20230327). The data for analysis were gathered through a modified qualitative questionnaire, originally developed by Keenan et al. (2020), and designed to explore Irish primary school teachers' understanding of executive functions. As previous research in this area has mainly relied on quantitative data in primary school settings (e.g., Gilmore and Cragg, 2014; Rapoport et al., 2016), their questionnaire incorporated both closed and open-ended questions. The questionnaire addressed teachers' experiences in teaching students with executive dysfunctions, their role in shaping the development of executive functions, and their encounters with neuropsychological reports and interventions targeting executive function skills. Based on this, we adjusted the questionnaire to investigate early childhood teachers' pedagogical understanding and practices intended to facilitate children's executive functions in preschool classrooms on a day-to-day basis. Since the original questionnaire did not thoroughly uncover these specific teaching practices, we revised it to focus primarily on open-ended questions related to teachers' knowledge and practices. Hence, we modified closed questions (e.g., Have you ever taught a student who had difficulties remembering what he/she has been asked to do?) to open-ended questions (e.g., please describe specific teaching strategies that support a child to remember what s/he has been asked to do) to gain insight into early childhood teachers' roles in facilitating preschoolers' executive functions development. As a result, this study employed an approach that elicited a mixture of data types: fixed response items to identify the frequency of participants' responses and demographic data, with quantitative data and open-ended response items generating qualitative data to identify and interpret the types of executive functions-supportive pedagogical practices.

The final questionnaire was designed and delivered online using the Qualtrics platform and consisted of 35 closed-and open-ended questions clustered into three categories: (a) demographic characteristics of participants, covered by 10 questions; (b) knowledge of executive functions, addressed by 8 questions; and (c) pedagogical practices to facilitate executive functions, explored with 17 questions (see Table 1). The third section of the questionnaire invited participants to respond to six scenarios as a way of exploring the pedagogical practices they employ to support children's working memory, inhibitory control, and cognitive flexibility skills. These scenarios were adopted from Keenan et al.' (2020) instrument. Thirty-nine respondents completed this section.

The questionnaire was first piloted with two early childhood teachers and peer-reviewed by four early childhood researchers. This led to minor revisions to the structure of the questionnaire, such as the inclusion of page breaks within the categories. The participants received an information sheet about the research project at the beginning of the questionnaire and were informed that they could exit the questionnaire at any point. All participants provided informed consent by checking the relevant box before proceeding. The questionnaire was available for completion for 1 month.

TABLE 1 Description of each questionnaire category adopted from Keenan et al. (2020).

Category	Description
Demographics	Participants were asked about their personal characteristics, such as gender and age, pertinent details about their education and employment as well as teaching experience.
Knowledge of Executive Functions	Participants were initially asked if they had heard of the term “executive functions” before being presented with its definition. Following that, inquiries were made about their training in executive functions, their opinion about the importance of executive functions in children’s social skills, academic achievement and classroom behaviour, and their views regarding the role of teachers in developing executive functions.
Pedagogical Practices to Facilitate Executive Functions	Participants were provided with scenarios involving examples of skills in children that characterise executive functions and were asked to describe specific pedagogical practices that support those skills (e.g., working memory, inhibitory control, cognitive flexibility).

## 2.3 Data analysis

The Qualtrics statistical analysis tool was used to analyse demographic data, providing descriptive statistical information including age, qualifications, and participants’ years of experience. This contextual information was predominantly used to facilitate a deeper understanding of the demographic factors that might influence the identified pedagogical practices.

The data were primarily descriptive in nature and an abductive approach to thematic analysis was used to analyse the qualitative data and thereafter to identify the pedagogical practices that early childhood teachers intended to promote children’s executive functions within their day-to-day classroom. Using thematic analysis helped the authors to “identify patterns within and across data in relation to participants’ lived experience, views and perspectives, and behavior and practices; ‘experiential’ research which seeks to understand what participants think, feel, and do” (Clarke and Braun, 2017, p. 297).

The abductive approach was applied through two iterative cycles using NVivo software (Version 12). The first cycle involved deductive coding informed by existing literature, while the second cycle employed inductive coding derived directly from the data (Miles et al., 2020; Sætre and Van de Ven, 2021). Through this iterative process, the authors refined and aligned themes with both prior literature and the raw data, ensuring that the analysis reflected insights drawn from the participants’ lived experiences.

Within the two cycles, understanding patterned responses and meaning across the dataset involved following the six steps of thematic analysis outlined by Braun and Clarke (2006). The first cycle began with step one: the first author thoroughly reviewed participants’ responses to the open-ended questions and captured initial impressions. This process was complemented by recording memos to document preliminary thoughts on potential links to the literature. In steps two and three, the data were analysed deductively, with existing literature guiding the development of codes applied “in tandem with the raw data to explain the patterns and story behind the data” (Thompson, 2022, p. 1411). Two coding approaches—provisional

coding and concept coding—were used during this cycle (Miles et al., 2020).

The second cycle repeated steps two and three, iteratively refining codes identified in cycle one and developing themes using inductive coding approaches such as pattern coding (Miles et al., 2020). This cycle then progressed to steps four and five, where themes were named and reviewed to ensure alignment with the data. Finally, in the sixth step, the report was developed by synthesising the themes into a coherent narrative that highlighted the main findings.

During both cycles, the coding of qualitative data was led by the first author, who regularly met with the second and third authors to review the data, generate codes, and discuss themes. Iterative discussions enabled the authors to reach a consensus in both cycles, refining their definitions, and ensuring alignment with the raw data and the existing literature. All four authors met to discuss the results and overarching findings.

## 3 Results

Descriptive data drawn from the three categories of the questionnaire are presented: the participants’ demographic information, knowledge of executive functions and, evidence-based pedagogical practices. Each category is discussed in turn, accompanied by illustrative responses from participants. To de-identify participants, each teacher is assigned a code (e.g., T13) along with their working experience.

### 3.1 Demographic information

The questionnaire was completed by 39 respondents. A further 19 participants responded to the first two categories only: (a) demographic characteristics of participants and (b) knowledge of executive functions and did not complete the third category: (c) pedagogical practices to facilitate executive functions. Ninety per cent of the participants were female; this reflects the current gender distribution of the early childhood workforce in Australia<sup>1</sup>. Most respondents (46.55%;  $N = 27$ ) possessed a bachelor’s degree, 20.69% ( $N = 12$ ) a graduate diploma or certificate, and 29.31% ( $N = 17$ ) a master’s degree. Participants had a range of work experience within the early childhood education and care sector, with 19% ( $N = 11$ ) having taught for less than 5 years (‘beginning teachers’), 22% ( $N = 13$ ) having taught for five to 10 years (‘mid-career teachers’) and 59% ( $N = 34$ ) having taught for more than 10 years (‘experienced teachers’).

### 3.2 Knowledge of executive functions

As a whole, 87.93% ( $N = 51$ ) of the participants reported they had heard the term ‘executive functions’ and rated their knowledge about executive functions as *Average* (47%;  $N = 24$ ) or *Above Average* (47%;  $N = 24$ ). Only 12.07% ( $N = 7$ ) of the respondents had not previously heard the term. The participants noted they had heard or learned about

1 <https://www.education.gov.au/early-childhood/early-childhood-workforce#:~:text=In%202021%20over%2016%2C000%20staff,12%25%20have%20a%20bachelor's%20degree.>

executive functions through their own teaching experience (33.77%;  $N = 26$ ), initial teacher education (28.57%;  $N = 22$ ), and in-service professional learning (25.97%;  $N = 20$ ). Fifty-eight per cent of respondents ( $N = 25$ ) stated that none of the teacher qualifications that provided them with early childhood teacher status included a specific focus on topics related to executive functions. Meanwhile, 27.91% ( $N = 12$ ) indicated that their qualifications did include such a focus, and 13.95% ( $N = 6$ ) were unsure. Notably, the participants were asked to define the term executive functions before being presented with a definition in the questionnaire. In analysing the written responses as to how the participants defined the term, 43 responses were provided. Of these responses, 39 participants provided their definitions in both short and long sentences and only 4 participants responded, “I do not know.” Most of the respondents who reported being aware of executive functions were able to deliver definitions that identified skills relating to executive functions. For example, one of the teachers defined the term:

*[E]xecutive functioning is the ability to retain information in our working memory; elicit self-control of our emotions, thoughts & reactions; as well as being flexible in our thinking and actions [...]* (T28, experienced teacher).

Other participants provided more detailed definition from the lens of a child’s executive function skills, such as:

*[T]he ability to control impulse reactions, regulate emotions, ability to plan, ability to work systematically, ability to process information. Very important process for the children to be able to process information and for the child’s brain to be able to deal with reasoning and not react with the flight/fight responses [...]* (T22, experienced teacher).

While participants emphasised executive functions as a “suite of skills and capacities that enable an individual to organise, attend to and complete cognitive tasks” (T49, experienced teacher), the importance of executive functions for young children were also emphasised as “necessary skills for children to develop in order to successfully cope with learning, socialising, and a healthy life” (T45, beginning teacher). This is in line with the nature of the responses from most of the participants who considered: (a) manipulating abstract information; (b) thinking flexibly; (c) focusing and avoiding distractions; and (d) sorting and mentally manipulating information to be extremely important executive function skills that equip children to succeed at school in future. As shown in Figure 1, a majority of the participants rated these skills as either ‘very important’ or ‘extremely important’.

The participants were asked to rate the importance of executive functions for social skills, academic achievement, and classroom behaviour (Figure 2). Of the responses, the following percentages of participants believed executive function skills to be important for: children’s classroom behaviour 63.41% ( $N = 26$ ), academic achievement 58.54% ( $N = 24$ ), and social skills 51.22% ( $N = 21$ ). Only a few considered their importance within the mentioned areas moderately and slightly important. Respondents were also asked to indicate the extent to which they believe their behaviours and pedagogical practices influence children’s executive functions. The majority of respondents (78.79%;  $N = 26$ ) believed their pedagogical practices impact children’s executive functions ‘to a great extent’.

### 3.3 Executive functions-supportive pedagogical practices

Five themes were identified in the participants’ responses, reflecting pedagogical practices that both align with and extend the

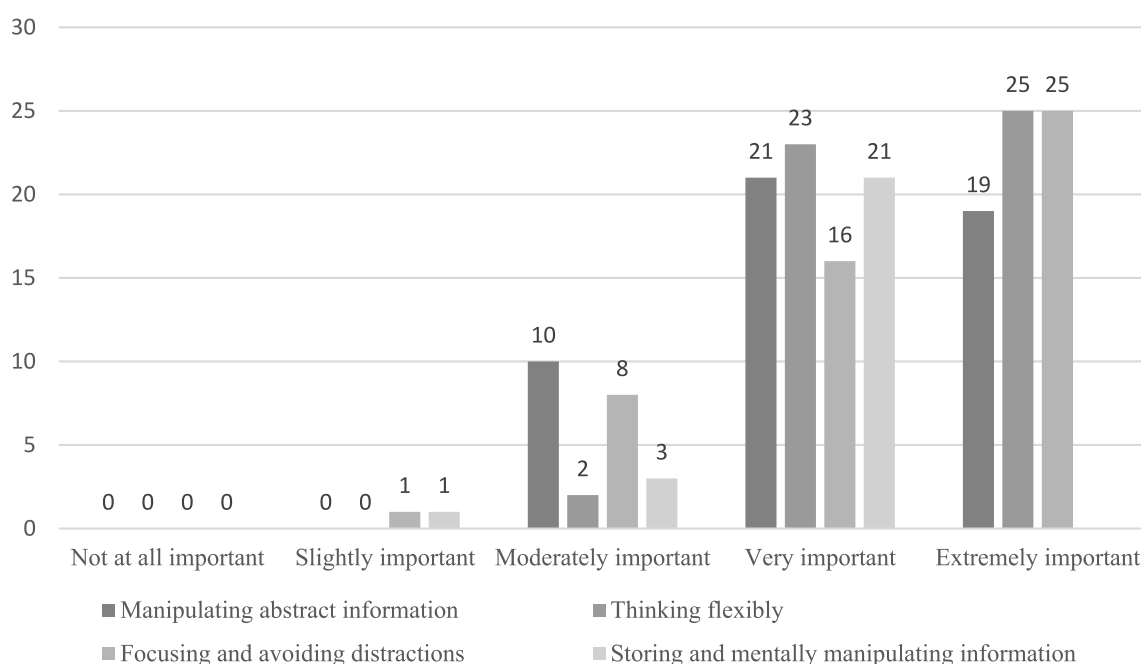


FIGURE 1 Teacher-reported importance of executive functions for children to succeed at school in the future.

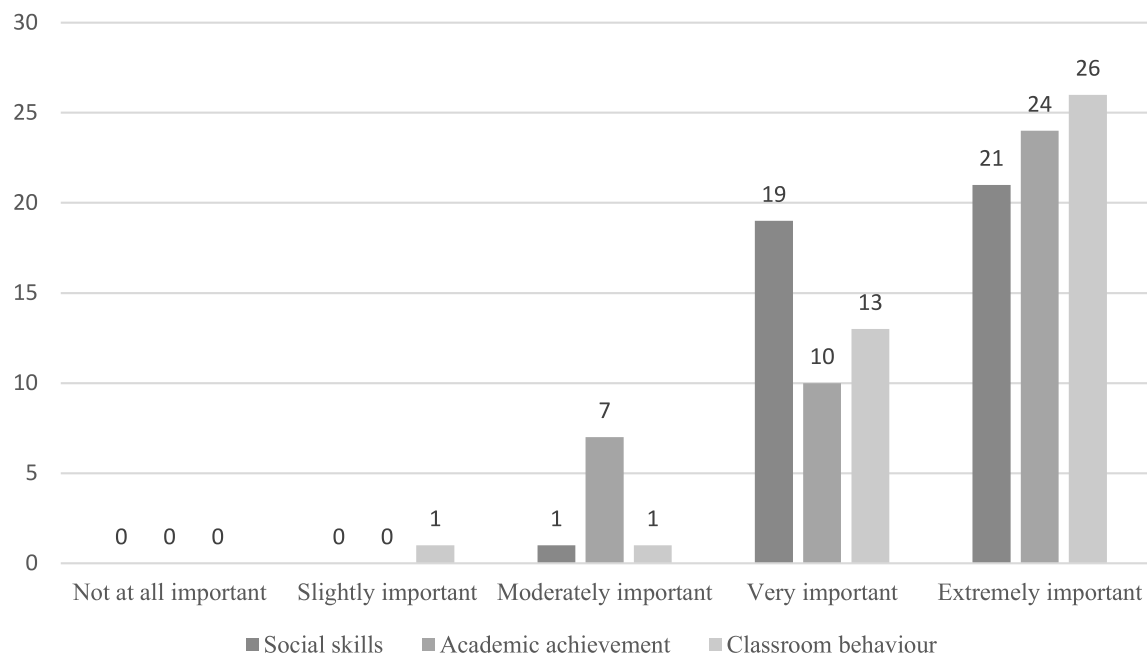


FIGURE 2

Teacher-reported importance of executive functions for children's classroom behaviour, academic achievement, and social skills.

existing literature: (a) environment and activity structuring, where participants highlighted the intentional design of physical space and planned learning experiences to facilitate executive functions; (b) supporting autonomy, highlighting strategies to promote children's competence and independence; (c) classroom organisation, referring to approaches aimed at building positive relationships, promoting desirable behaviour, and managing effective routines; (d) sustained shared thinking, a pedagogical interaction where teachers and children co-construct knowledge through extended interaction; and (e) activities that support executive functions; involving targeted tasks intended to enhance children's executive function skills.

NVivo was used to explore the relationships found in the coded data. Insight was gained into how often particular codes or themes appeared together in the data by creating a matrix of the intersections between different coded sources. Table 2 presents the frequency of identified themes among the beginning, mid-career and experienced teachers. The frequency is portrayed by different shades, with darker shades representing higher frequency and lighter shades signifying lower frequency. In this regard, environment and activity structuring as well as supporting autonomy were reported as the most frequently mentioned practices among experienced teachers. To illustrate the associations between the reported pedagogical practices and the three core components of executive functions, the participants were provided with scenarios involving examples of skills in children that characterise executive functions and were asked to describe specific pedagogical practices that support those skills (e.g., "Please describe specific teaching strategies that support a child to control his/her impulses: for example, interrupting others or not waiting his/her turn"). Table 3 shows the correspondences found. Here, the teachers reported environment and activity structuring as being particularly effective

for supporting a child's inhibitory controls and supporting autonomous behaviours as beneficial for a child's working memory.

The following section discusses each theme in more detail, complemented by illustrative excerpts from participants' written responses.

### 3.3.1 Environment and activity structuring

A prominent recurring theme in the participants' responses was related to learning environment and activity structuring. This refers to the intentional organisation of the learning environment and the provision of educational resources and learning experiences designed to enhance learning. Four practices were identified as commonly used strategies by the 38 participants to support children's executive functions: incorporating visual or symbolic cues; playing games with rules; optimising learning spaces; and using educational resources. Participants describe the desire to use a variety of cues, such as the use of "visual routines for most learning spaces as a cue to support the child when dysregulated" (T22, experienced teacher), "use of visual timers to slowly increase stamina at non-preferred tasks" (T21, experienced teacher), or "visual aids such as the 'Problem Solving Wheel' & 'Wattle Manifesto' as a guide for the chosen processes created by children" (T43, beginning teacher). For one participant, entering a symbolic world as a cue was another strategy to facilitate children's executive functions, as exemplified in their comment:

*[R]e-grouping is vital to gain the attention of children, before embarking on set learning we play focusing games such as singing a song, repeat clapping (beat & rhythm), reading a book. Once children are 'in the group' we begin by putting our thinking brains on and set out the expectations of the learning, such as taking on the role of scientists, investigators, or problem solvers (T44, experienced teacher).*

TABLE 2 NVivo matrix coding showing the association between the identified themes and the teachers' work experience.

Teachers' work experience	Autonomy support	Classroom organisation	Environment and activity structuring	Executive functions-supportive activities	Sustained shared thinking
Beginning Teachers	12	22	12	3	5
Mid-Career Teachers	22	27	41	10	14
Experienced Teachers	94	58	109	19	42

The shading in the table above and below indicates the frequency of identified themes: no shading for 0–10 mentions; light shading for 11–40 mentions; medium shading for 41–60 mentions; and dark shading for 61 or more mentions.

TABLE 3 NVivo matrix coding query showing identified themes for executive function components.

Teachers' work experience	Autonomy support	Classroom organisation	Environment and activity structuring	Executive functions-supportive activities	Sustained shared thinking
Cognitive Flexibility	16	13	27	1	5
Inhibitory Control	60	58	82	20	27
Working Memory	48	33	44	10	29

Playing games with rules that encourage children's turn taking skills was also highlighted by 13 participants. Games that require children to follow rules were specifically emphasised within "small group experiences focusing on building attention and turn taking, like board games" (T35, experienced teacher). Other participants played particular games to provide opportunities for children to practice their planning skills, such as "games that encourage silent parts or are all completed in silence like 'Pass the Squeeze' or 'Detective' or games with a goal that needs to be achieved, like the 'Doggie doggie game', where they need to close eyes and listen to find the item, e.g., bell" (T49, experienced teacher). The participants also underlined the importance of providing an "environment with limited distractions to help children position themselves where they can concentrate and avoid distractions when they want to focus" (T51, mid-career teacher). One participant reflected on the importance of "careful planning of the environment, what do distractions look like for different children? Consideration of social interactions that may help or hinder children to concentrate" (T42, beginning teacher). For another participant, allocating a specific time and place to support children's concentration was another intentional approach: "setting up some focussed activities in ways to reduce distractions (quiet areas away from noisy areas, backs to whole room, 1 or 2 chairs at activity)" (T56, mid-career teacher). One participant mirrored these approaches, while also highlighting the need to be responsive to each child's needs when designing the learning environment. The respondent explained it this way:

*[E]very child has their own needs in regards to sensory processing. The environment then plays a big role. Some might need noise cancelling headphones, some might need a type of music playing. Tuning in to and getting to know the needs of the individual is important (T52, experienced teacher).*

Selecting and integrating a variety of educational resources was also mentioned by the participants to "provide sensory input opportunities at all times so that children can utilise them as they need to regulate their impulses and before they become heightened—swings, sand, clay, water play, headphones with classical music etc." (T28, experienced teacher). For a few participants "providing timers to cooperate and share; fidget and

weighted toys to encourage a calm disposition—there are others, but these would be the main ones I draw on" (T21, experienced teacher). Others used timers "to encourage children to stay at a difficult task for 2–5 min before moving on" (T35, experienced teacher). These were the key resources used to facilitate executive functions.

### 3.3.2 Autonomy support

The second theme in the participants' response relates to autonomy-supportive teaching practice. The early childhood teachers in this study were aware of the significance of this aspect of their pedagogical practices and described several strategies they use to help develop executive functions in children. These include being aware of children's needs and preferences, scaffolding, allowing children to work at their own pace, positive encouragement and celebrating errors, providing interest-based learning activities, allowing choice, and following children's interests. For the participants, autonomy-supporting teaching practices involve respecting and acknowledging children's needs, as described below:

*[K]nowing them [the children] and how to effectively communicate with that child, for example one child may be able to listen and follow instructions with ease where another child may need to be shown, another child may need visual cues and some children may need to have instructions repeated. By adapting to each child's needs, I give them the opportunity to take ownership of their learning by helping them choose the approach that works best for them [...] (T37, experienced teacher).*

For some participants, what played a key role was allowing time for children to work at their own pace and in their own way through "providing opportunities for supported success and then allowing time for the child to try, repeat, explore, and achieve in their own time and manner" (T29, experienced teacher). This notion was reiterated by another participant, who also emphasised the matter of respecting the children's rhythm:

*I try to promote children to participate or finish in their own time rather than moving them onto another task simply because they are*



*slow or stuck. I think it is important to embrace all children's varied capacity for learning and participation. I would rather support them in the existing task (T28, experienced teacher).*

In addition, scaffolding and progress through hints were identified as specific behaviours supporting autonomy. These practices ensure the success of the children by “slowly decreasing the support offered, starting with highly scaffolded instructions and modelling, and making sure the task is broken down into steps where you know they [the children] will succeed” (T21, experienced teacher). The participants also acknowledged the importance of encouraging a child's persistence and effort while scaffolding their learning, a respondent explaining this as follows:

*[A]n educator sits near child and give positive encouragement as appropriate for that child. Varies from minimal body language (e.g. smile, thumbs up) to praise of effort, to comment to support child to continue (e.g. have you tried turning the puzzle piece?) to working together with child to complete (T51, mid-career teacher).*

In view of this, a few of the participants stressed the importance of following the children's interests and crafting learning experiences based on their interests and motivations, as evident in this comment:

*I think focusing on work is a big fear for four-year-olds and distractions are normal. If teachers plan genuine experiences for children based on their observations of current interests, then children will naturally focus on the task at hand (T37, experienced teacher).*

### 3.3.3 Classroom organisation

Many participants highlighted the pedagogical practice of effectively managing the classroom when trying to cultivate executive functions in children. They specifically mentioned building positive teacher-child relationships, explicitly promoting desirable behaviours, and developing predictable and consistent routines. They also highlighted the importance of building trust to meet each individual child's learning needs in a safe classroom environment. One participant shared their opinion on how to support a child to persist and successfully complete activities:

*... a relationship with the child, so they have trust in you and your opinions. If they feel you have their best interests at heart, and they know you wholeheartedly are genuinely supporting them then when you encourage them verbally, they know you are genuine and can trust in your support (T37, experienced teacher).*

Following the importance of building a trusting relationship, a focus on explicitly promoting desirable behaviours and redirection of misbehaviour to support children's executive functions proved to be instrumental for many of the participants. Setting clear expectations, role modelling and positive reinforcing desirable behaviours were reported to be common practices. As one participant mentioned:

*[E]xplicit teaching of expectations through modelling, dramatic re-enactments, e.g., puppets, social stories. Reinforcing positive behaviour, asking support from the group to keep children on track,*

*"When we have something to share, we...?" or use a child who is focused and displaying the desired outcomes, "Emma has her hand up, I can see she is waiting for her turn to share" (T23, experienced teacher).*

Another participant extended the intentional teaching of explicitly promoting desirable behaviour through discussion and explanation to address behaviours that do not meet the expectations:

*[S]top Think-are you making a good choice? Are you being safe? Are you being kind? (Our kinder rules) Act-what could you do instead? How is your body feeling? Feel your heart rate? (T22, experienced teacher).*

Consistency and predictability of the routines were considered as another key practice to provide “familiar environment that children feel safe and secure within” (T45, beginning teacher). As routines must be taught and practiced, the participants highlighted specific approaches to support children in following classroom routines successfully. These include delivering predictable routines in the program, providing clear instructions, and positive acknowledging children when following routines, and supporting those who were not.

### 3.3.4 Sustained shared thinking

While the pedagogical practices of many of the participants were intended to encourage autonomy in the children, in some instances, these early childhood teachers highlighted the importance of encouraging sustained shared thinking to support the development of executive functions. The practices described include engaging in children's initiated play actively and intentionally, supporting children's learning and critical thinking, encouraging children to communicate with peers and educators, asking open-ended questions and supporting children's language use. For some participants, supporting the children's curiosity and problem solving was another approach “by sitting alongside [the children] and talking through what is happening, how we can problem solve and find a way to success” (T25, experienced teacher). In line with this, another participant explained:

*I would try my best to use sustained shared thinking to show the child I am interested in their work, and they should be too, then I would feedback on their work and encourage them to achieve the objectives [...] (T43, beginning teacher).*

Promoting children's learning and critical thinking were among the essential practices early childhood teachers also used to facilitate executive functions. One participant, for example noted how being actively involved in the children's playful experiences extended their learning:

*[E]xtend children's learning using their strengths such as a competent skill or their knowledge base, for example, counting blocks could be extended to taking away some blocks and working out how many have been subtracted - ask open ended questions to elicit their thinking processes "what do you think will happen if we add water to the mixture?" - using descriptive language to provide information to elicit their interest and further participation [...] (T28, experienced teacher).*

Participants also commented on the need for the provision of balanced opportunities for the children to engage in one-to-one interactions with their teachers and peers to support and extend language and communication through “serve and return interactions to build [children’s] vocabulary and language comprehension” (T56, mid-career teacher). In addition to this, supporting children’s social and emotional wellbeing was another discussed practice for promoting executive functions:

*[E]motion coaching, explicit discussion concerning feelings and emotion - what it feels like to wait, the discussion of strategies that are helpful in dealing with uncomfortable feelings such as mindfulness and breathing exercises, discussion about how waiting for one’s turn affects others, and conversely, how not waiting for one’s turn negatively affects others (T42, beginning teacher).*

### 3.3.5 Activities to support executive functions

The final theme identified from the data involves specific learning experiences that provide rich opportunities for children to improve and rehearse their executive functions. The participants described several such activities, most of which involve a sequence of steps, such as memory games, mindfulness, dramatic play, cooking or science activities, quieter activities, and movement to music. Some participants provided rich details of the games they play. For example, one participant shared:

*I also have a strong emphasis on games to help children build their memory skills. I have a game called ‘Categories’ in which I name a category (sea animals, vegetables, colours) and the children go around the circle naming something that fits in the category. They cannot name an item someone else has already said, they must wait their turn, they must be able to think of an item from that category, they must be able to think of a new item if someone says the item they were thinking of [...] (T40, mid-career teacher).*

Similarly, another participant pointed out how “games that practice controlling impulses like Simon Says, Red Light-Green Light, bubble games building to popping when a signal is given, card games like Snap” (T49, experienced teacher) can help to develop executive functions in children. The participants also recognised the significance of role play in supporting a child’s executive functions. To this end, they provided opportunities for:

*... role plays and acting stories where children have specific roles or turns. Try to work in smaller groups as much as possible to increase participation and lessen waiting. Encourage and support pretend play which the children devise for themselves (T33, mid-career teacher).*

In addition, a few participants adopted either mindfulness or social-emotional learning approaches to support children’s awareness of themselves and executive functions through providing “opportunities to participate in yoga practices such as, mindful movement and breathing exercises” (T28, experienced teacher). As one of the participants stated:

*I teach mindfulness techniques, including breathing and touch based experiences, but this is more to calm the group down rather than to*

*help them avoid distractions. I imagine that by giving them this tool, and it being embedded in my curriculum that children would be able to transfer the tools to other contexts (T40, mid-career teacher).*

## 4 Discussion

This study is one of only a few studies conducted to explore what early childhood teachers know about executive functions and evidence-based pedagogical practices that support the development of executive functions in everyday preschool classrooms. In this section, three main findings of the study will be explored in detail, providing insights and recommendations for future studies.

### 4.1 Teachers’ years of experience and executive functions

The findings demonstrate that the early childhood teachers in this study rate their knowledge of executive functions as average and above average and regard executive functions to be extremely important for academic achievement, classroom behaviour and social skills. As with studies conducted in primary school settings (Gilmore and Cragg, 2014; Keenan et al., 2020; Rapoport et al., 2016), many of the participants in this study reported that they have heard or learnt about executive functions through their own teaching experience, rather than in their teacher education program of study. This aligns with reports by the Center on the Developing Child (2011) that teaching programs dedicate little or no time to educating future teachers about the development of executive functions. As a result, it may take many years of experience for teachers to gain a good understanding of executive functions through classroom experiences. Consistent with Gilmore and Cragg (2014), teachers in our study with more than 10 years of experience reported more pedagogical understanding of executive functions compared with those with fewer years of experience. Additionally, themes related to evidence-based practices appeared more frequently in their responses (see Table 2). Notably, the majority of the participating teachers had more than 10 years’ experience. Moreover, their responses included more explicit aspects of how they facilitate the development of executive functions in children. Unlike most of the beginning and mid-career teachers, these experienced teachers provided more specific examples of evidence-based executive functions-supportive pedagogical practices.

In this study, most participants reported that none of their early childhood teacher qualifications had included a specific focus on executive functions or any topics related to executive functions. This finding suggests that providing information to teachers about executive functions and evidence-based pedagogical practices that intended to facilitate them could yield significant benefits for both the teachers and the young learners. According to MacNaughton and Williams (2009), “access to information about a broad and diverse repertoire of teaching methods can increase the likelihood that staff will choose the best rather than the most familiar way to further children’s learning” (p. xiii). The recently-qualified early childhood teachers should not bear the sole responsibility for lacking evidence-based teaching repertoire; rather responsibility

should be shared with early childhood education and care system stakeholders (researchers, regulators, policymakers, initial teacher education providers; [Cohrssen et al., 2023](#)). In the absence of elaboration of executive functions in the EYLF ([AGDE, 2022](#)), highlighting the need for stronger emphasis on executive functions in initial teacher education, the Australian Education Research Organisation (AERO) developed a suite of learning trajectories that draw on empirical research and elaborate on children's emerging executive functions ([Jackson et al., 2023](#)). The learning trajectories and the supporting evidence paper are an attempt to equip early childhood teachers to understand the theory/research behind domains of learning and development including executive functions as well as equip them to recognise, consolidate and extend the domains in practice.

## 4.2 Teachers' role in facilitating executive functions

Another notable finding of this study is that the participating teachers perceive their role to be highly influential in supporting children's executive functions in the day-to-day preschool classroom. They demonstrated this pedagogical understanding by sharing explicit practices that have been suggested in the research literature. These include environment and activity structuring (e.g., [Moreno et al., 2017](#); [Learning Difficulties Coalition, 2021](#)), offering behaviours that support autonomy (e.g., [Carlson, 2023](#); [Dias and Seabra, 2015](#)), enacting strong classroom organisation (e.g., [Hamre et al., 2014](#)), encouraging sustained shared thinking (e.g., [Muir et al., 2024b](#)), and conducting activities that support executive functions ([Center on the Developing Child at Harvard University, 2014](#)). These themes, while aligning with established pedagogical categories, were identified through iterative engagement with the data and theory, offering new insights into their practical application within preschool settings.

Most importantly, the explicit use of pedagogical practices by early childhood teachers shows that a rich preschool curriculum presents many opportunities for early childhood teachers to support and facilitate the development of executive functions whilst simultaneously following children's interests. Within their responses, the participating teachers readily connected the pedagogical practices that support executive function to the components of their preschool curricula, such as play-based learning (e.g., mediated structured play, semi-structured creative play) and socio-emotional approaches (e.g., yoga, mindfulness), interventions that appear to enhance the development of executive functions in preschool settings ([Muir et al., 2023](#)).

In terms of supporting autonomy to promote executive functions, many of the teachers also reported cultivating these skills within a play-based learning approach. Their strategies were multifaceted, including maintaining awareness of each child's needs, interests and preferences, allowing children to work at their own pace, delivering less structured activities where the children can make choices, providing interest-based learning activities, and offering progress-enabling hints when the children seem stuck. A key aspect of these autonomy-supporting practices, as articulated by the participants, is differentiated teaching and learning to meet the needs of every child. Participants explained that one must determine a child's zone of proximal development and then offer just enough support for the child to feel they have successfully accomplished the task on their own

([Vygotsky, 1978](#)) and to enhance their learning disposition as a consequence of experiencing success. As children become more competent at these goal-directed tasks, the teachers suggested encouraging greater autonomy by reducing the level of support provided, thus creating opportunities for children to rehearse their executive functions. Through behaviours that support autonomy, children are more likely to internalise strategies related to executive functions, improving their own ability to solve problems independently ([Koşukulu-Sancar et al., 2023](#)).

Furthermore, the study revealed a link between classroom organisation and pedagogical practices intended to support children's executive functions, indicating that more positive teacher-child relationships and sharing clear and consistent behavioural expectations and routines with the children was vital. The teachers described the strategies they intentionally and explicitly use to support executive functions, such as ensuring regular routines where each child knows what to do throughout the day. These teachers plan their activities to create opportunities for children to engage in goal-directed tasks. They also express approval over a child's behaviour by communicating an appreciation for their efforts, showing warmth and encouragement. Additionally, the teachers intentionally involve themselves in children's play to support and extend their thinking and language through sustained shared thinking with children ([Muir et al., 2024b](#)). Engaging in this type of thinking contributes to a child's thinking by enabling reflection, encouraging analysis and reasoning, and using repetition and extension—approaches that are deemed to be crucial for developing executive functions in children ([Distefano et al., 2020](#); [Zelazo, 2015](#)).

## 4.3 Tailoring pedagogical practices to support executive function skills

Another significant finding of this study is that the participating teachers reported their use of different pedagogical practices to tailor their support of children's working memory, inhibitory control, and cognitive flexibility skills according to their needs (see [Table 3](#)). As described by the early childhood teachers, environment and activity structuring are key for supporting children's inhibitory control skills. These practices highlight the significance of a well-organised and clearly structured learning environment that reduce distractions and facilitates learning progression. According to the participants, supporting autonomy also emerges as a crucial pedagogical practice for promoting children's working memory and inhibitory control skills. This suggests that providing children with opportunities to make choices and have some control over their learning process can be advantageous ([Carlson, 2023](#)). Enacting strong classroom organisation also appears to facilitate inhibitory controls in children. More specifically, establishing predictable and consistent routines and communicating clear expectations for behaviour and participation contributes greatly to a child's ability to control their impulses and keep attention ([Hamre et al., 2014](#)). Encouraging sustained shared thinking was also reported to facilitate children's inhibitory controls and working memory by expanding their critical thinking and language ([Goble et al., 2019](#)). But this is not thought to be as strong an influence as environment and activity structuring, or approaches that promote autonomy.

## 4.4 Limitations and future directions

This research has some limitations. First, 58 early childhood teachers elected to participate in the study. Their willingness to participate may be indicative of greater self-efficacy in supporting executive functions than the broader population of early childhood teachers and thus may bring into question the generalisability of the results. Most participants in this study were experienced teachers. Less experienced teachers may still be developing their teaching repertoire, which might impact their self-reported efficacy. Also, data were missing from 19 teachers who did not fully complete the questionnaire. Hence, expanding the sample to include a larger population of early childhood teachers would strengthen this line of research.

Second, knowledge of children's executive functions does not necessarily lead to the use of executive functions-supportive pedagogical practices in classrooms. Consequently, future research could employ interviews and classroom observations. A third limitation is that we did not evaluate the extent of teachers' actual knowledge about executive functions or the effectiveness of the self-reported executive functions-supportive pedagogical practices. It would be of value to examine the effectiveness of the identified pedagogical practices and their relationships with working memory, inhibitory control, and cognitive flexibility.

Despite these limitations, to the best of our knowledge, this may be the first study to explore early childhood teachers' pedagogical understanding of executive functions in Australian preschool settings. As such, and in light of the inclusion of executive functions in the EYLF (AGDE, 2022), this work is timely and highlights important implications for early childhood initial teacher education in Australia.

## 5 Conclusion

More research exploring early childhood teachers' knowledge about executive functions and how they facilitate those skills in Australian preschool classrooms on a day-to-day basis is needed. The self-reported data in this study suggest that some early childhood teachers know much about evidence-based pedagogical practices that facilitate children's executive functions, which the authors refer to as 'pedagogical understanding' (Wilson and Bai, 2010). Moreover, the reported pedagogical practices employed by such teachers align closely with practices recommended in the literature.

The pedagogical practices intended to facilitate executive functions demonstrate how early childhood teachers are incorporating certain practices into their everyday preschool curricula. By shedding light on these practices, early childhood education and care system stakeholders may be encouraged to provide greater clarity on how to cultivate executive functions in day-to-day classrooms. As such, this study highlights the need for Australian early childhood initial teacher education courses to ensure that executive functions and executive functions-supportive pedagogical practices are explicitly addressed. The insights revealed here should inform initiatives that raise awareness and understanding of executive functions among early childhood teachers to forefront executive functions during their time spent with preschoolers. Executive functions were reported to have received little if any attention in participants' teacher preparation courses, and participants

reported having gained understanding of executive functions and executive functions-supportive teaching practices with classroom experience. In agreement with the proposed core curriculum for initial teacher education (Australian Government, 2023) and the updated EYLF (AGDE, 2022), we recommend that initial teacher education courses urgently dedicate more time to educating future teachers about facilitating the development of executive functions, as the teachers in our sample have taken years of experience to develop their practices that intended to facilitate executive functions.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

The studies involving humans were approved by Griffith University and Research in Victorian government schools and early childhood settings (RISEC). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

PM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. SG: Supervision, Validation, Writing – review & editing. CC: Supervision, Validation, Writing – review & editing. DP: Supervision, Validation, Writing – review & editing.

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Acknowledgments

The authors would like to thank the early childhood teachers who participated in this study. Additionally, we wish to acknowledge Lisa Keenan and colleagues for generously providing a copy of their questionnaire.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated

organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Almy, B. K., and Zelazo, P. D. (2015). Reflection and executive function: foundations for learning and healthy development. *Rev. Argentina Ciencias del Comportamiento* 7, 53–59. doi: 10.32348/1852.4206.v7.n1.10574
- Anderson, K. L., Weimer, M., and Fuhs, M. W. (2020). Teacher fidelity to conscious discipline and children's executive function skills. *Early Child. Res. Q.* 51, 14–25. doi: 10.1016/j.ecresq.2019.08.003
- Arthur, I., Beecher, B., Death, E., Dockett, S., and Farmer, S. (2015). Programming and planning in early childhood settings. 6th Edn: Cengage Learning.
- Australian Children's Education and Care Quality Authority (ACECQA). (2022). National Quality Framework Annual Performance Report 2022, ACECQA. Available at: <https://www.acecqa.gov.au/APR> (Accessed June 20, 2024).
- Australian Government (2023). Strong beginnings: Report of the teacher education expert panel: Department of Education.
- AGDE (2022). Belonging, being & becoming: The Early years learning framework for Australia V2.0: Australian Government Department of Education for the Ministerial Council.
- Baltar, F., and Brunet, I. (2012). Social research 2.0: virtual snowball sampling method using Facebook. *Internet Res.* 22, 57–74. doi: 10.1108/10662241211199960
- Bardack, S., and Obradović, J. (2019). Observing teachers' displays and scaffolding of executive functioning in the classroom context. *J. Appl. Dev. Psychol.* 62, 205–219. doi: 10.1016/j.appdev.2018.12.004
- Bernier, A., Carlson, S. M., and Whipple, N. (2010). From external regulation to self-regulation: Early parenting precursors of Young Children's executive functioning. *Child Dev.* 81, 326–339. doi: 10.1111/j.1467-8624.2009.01397.x
- Best, J. R., and Miller, P. H. (2010). A developmental perspective on executive function. *Child Dev.* 81, 1641–1660. doi: 10.1111/j.1467-8624.2010.01499.x
- Blair, C., Granger, D. A., Willoughby, M., Mills-Koonce, R., Cox, M., Greenberg, M. T., et al. (2011). Salivary cortisol mediates effects of poverty and parenting on executive functions in Early childhood. *Child Dev.* 82, 1970–1984. doi: 10.1111/j.1467-8624.2011.01643.x
- Bockmann, J. O., and Yu, S. Y. (2022). Using mindfulness-based interventions to support self-regulation in Young children: A review of the literature. *Early Childhood Educ. J.* 51, 693–703. doi: 10.1007/s10643-022-01333-2
- Bodrova, E., and Leong, D. J. (2007). Tools of the mind: The Vygotskian approach to early childhood education. Upper Saddle River, N.J: Pearson/Merrill Prentice Hall.
- Bodrova, E., and Leong, D. J. (2018). Tools of the mind: the Vygotskian-based Early childhood program. *J. Cogn. Educ. Psychol.* 17, 223–237. doi: 10.1891/1945-8959.17.3.223
- Boyd, W., and Garvis, S. (2021) in International perspectives on Early childhood teacher education in the 21st century. eds. W. Boyd and S. Garvis (Singapore, Springer Singapore).
- Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101. doi: 10.1191/1478088706qp0630a
- Carlson, S. M. (2003). Executive function in context: development, measurement, theory, and experience. *Monogr. Soc. Res. Child Dev.* 68, 138–151. doi: 10.1111/j.1540-5834.2003.06803012.x
- Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. *Dev. Neuropsychol.* 28, 595–616. doi: 10.1207/s15326942dn2802\_3
- Carlson, S. M. (2023). Let me choose: the role of choice in the development of executive function skills. *Curr. Dir. Psychol. Sci.* 32, 220–227. doi: 10.1177/09637214231159052
- Castelo, R. J., Meuwissen, A. S., Distefano, R., McClelland, M. M., Galinsky, E., Zelazo, P. Z., et al. (2022). Parent provision of choice is a key component of autonomy support in predicting child executive function skills. *Front. Psychol.* 12. doi: 10.3389/fpsyg.2021.773492
- Center on the Developing Child. (2011). Building the brain's "air traffic control" system: How early experiences shape the development of executive function (Working Paper No. 11). Cambridge, MA: Center on the Developing Child, Harvard University. Available at: <http://www.developingchild.harvard.edu> (Accessed March 17, 2024).
- Center on the Developing Child at Harvard University. (2014). Enhancing and practicing executive function skills with children from infancy to adolescence. Harvard University. Available at: <https://www.developingchild.harvard.edu> (Accessed March 17, 2024).
- Choi, J. Y., Castle, S., Williamson, A. C., Young, E., Worley, L., Long, M., et al. (2016). Teacher-child interactions and the development of executive function in preschool-age children attending head start. *Early Educ. Dev.* 27, 751–769. doi: 10.1080/10409289.2016.1129864
- Clarke, V., and Braun, V. (2017). Thematic analysis. *J. Posit. Psychol.* 12, 297–298. doi: 10.1080/17439760.2016.1262613
- Cohrsen, C., Rosnay, M., Garvis, S., and Neilsen-Hewett, C. (2023). Assessing the quality of early childhood education and care in Australia: challenges and opportunities. *Front. Educ.* 8. doi: 10.3389/feduc.2023.1147669
- Conway, A., Waldfoegel, J., and Wang, Y. (2018). Parent education and income gradients in children's executive functions at kindergarten entry. *Child Youth Serv. Rev.* 91, 329–337. doi: 10.1016/j.childyouth.2018.06.009
- Cumming, M. M., Bettini, E., Pham, A. V., and Park, J. (2020). School-, classroom-, and dyadic-level experiences: A literature review of their relationship with students' executive functioning development. *Rev. Educ. Res.* 90, 47–94. doi: 10.3102/0034654319891400
- Daniels, D. H., and Shumow, L. (2003). Child development and classroom teaching: A review of the literature and implications for educating teachers. *J. Appl. Dev. Psychol.* 23, 495–526. doi: 10.1016/S0193-3973(02)00139-9
- Day, N., Paas, F., Kervin, L., and Howard, S. J. (2022). A systematic scoping review of pre-school self-regulation interventions from a self-determination theory perspective. *Int. J. Environ. Res. Public Health* 19:4. doi: 10.3390/ijerph19042454
- Diamond, A. (2020). Executive functions. *Handb. Clin. Neurol.* 173, 225–240. doi: 10.1016/B978-0-444-64150-2.00020-4
- Diamond, A., and Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science (New York, N.Y.)* 333, 959–964. doi: 10.1126/science.1204529
- Dias, N. M., and Seabra, A. G. (2015). Is it possible to promote executive functions in preschoolers? A case study in Brazil. *Int. J. Child Care Educ. Policy* 9, 1–18. doi: 10.1186/s40723-015-0010-2
- Distefano, R., Galinsky, E., McClelland, M. M., Zelazo, P. D., and Carlson, S. M. (2018). Autonomy-supportive parenting and associations with child and parent executive function. *J. Appl. Dev. Psychol.* 58, 77–85. doi: 10.1016/j.appdev.2018.04.007
- Distefano, R., Nelson, K. M., and Masten, A. S. (2022). A qualitative analysis of autonomy-supportive parenting in families experiencing homelessness. *Fam. Relat.* 71, 147–162. doi: 10.1111/fare.12626
- Distefano, R., Schubert, E. C., Finsaas, M. C., Desjardins, C. D., Helseth, C. K., Lister, M., et al. (2020). Ready? Set. Go! A school readiness programme designed to boost executive function skills in preschoolers experiencing homelessness and high mobility. *Eur. J. Dev. Psychol.* 17: 6, 877–894.
- Doebel, S., and Munakata, Y. (2018). Group influences on engaging self-control: children delay gratification and value it more when their in-group delays and their out-group doesn't. *Psychol. Sci.* 29, 738–748. doi: 10.1177/0956797617747367
- Dubinsky, J. M., Roehrig, G., and Varma, S. (2013). Infusing neuroscience into teacher professional development. *Educ. Res.* 42, 317–329. doi: 10.3102/0013189X13499403
- Early, D. M., Sideris, J., Neitzel, J., LaForett, D. R., and Nehler, C. G. (2018). Factor structure and validity of the early childhood environment rating scale - third edition (ecers-3). *Early Child. Res. Q.* 44, 242–256. doi: 10.1016/j.ecresq.2018.04.009
- Fleer, M., Walker, S., White, A., Veresov, N., and Duhn, I. (2020). Playworlds as an evidenced-based model of practice for the international teaching of executive functions. *Early Years* 42, 572–586. doi: 10.1080/09575146.2020.1835830
- Garon, N., Bryson, S. E., and Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychol. Bull.* 134, 31–60. doi: 10.1037/0033-2909.134.1.31
- Gilmore, C., and Cragg, L. (2014). Teachers' understanding of the role of executive functions in mathematics learning. *Mind Brain Educ.* 8, 132–136. doi: 10.1111/mbe.12050
- Goble, P., and Pianta, R. C. (2017). Teacher-child interactions in free choice and teacher-directed activity settings: prediction to school readiness. *Early Educ. Dev.* 28, 1035–1051. doi: 10.1080/10409289.2017.1322449
- Goble, P., Sandilos, L. E., and Pianta, R. C. (2019). Gains in teacher-child interaction quality and children's school readiness skills: does it matter where teachers start? *J. Sch. Psychol.* 73, 101–113. doi: 10.1016/j.jsp.2019.03.006
- Guerrero-Rosada, P., Weiland, C., McCormick, M., Hsueh, J., Sachs, J., Snow, C., et al. (2021). Null relations between CLASS scores and gains in Children's language, math, and executive function skills: A replication and extension study. *Early Child. Res. Q.* 54, 1–12. doi: 10.1016/j.ecresq.2020.07.009

- Guerrero, S. (2014). Teachers' pedagogical knowledge and the teaching profession. *Teach. Educ.* 2, 1–7.
- Hamre, B., Pianta, R., Hatfield, B., and Jamil, F. (2014). Evidence for general and domain-specific elements of teacher-child interactions: association with preschool children's development. *Child Dev.* 85, 1257–1274. doi: 10.1111/cdev.12184
- Hatfield, B. E., Burchinal, M. R., Pianta, R. C., and Sideris, J. (2016). Thresholds in the association between quality of teacher-child interactions and preschool children's school readiness skills. *Early Child. Res. Q.* 36, 561–571. doi: 10.1016/j.ecresq.2015.09.005
- Howard, S. J., Cook, C. J., Everts, L., Melhuish, E., Scerif, G., Norris, S., et al. (2020). Challenging socioeconomic status: a cross-cultural comparison of early executive function. *Dev. Sci.* 23:e12854. doi: 10.1111/desc.12854
- Hughes, C., and Devine, R. T. (2019). For better or for worse? Positive and negative parental influence on young children's executive function. *Child Dev.* 90, 593–609. doi: 10.1111/cdev.12915
- Jackson, J., Kovacs, O., Razak, A., Willenberg, I., Johnston, K., and De Gioia, K. (2023). Early childhood learning trajectories: the evidence base. Australian Education Research Organisation. Available at: <https://www.edresearch.edu.au/early-childhood-learning-trajectories> (Accessed July 15, 2024).
- Keenan, L., O'Sullivan, A., and Downes, M. (2020). Teachers' experiences and understanding of executive functions in Irish primary school classrooms: findings from a mixed-methods questionnaire. *Ir. Educ. Stud.* 40, 101–114.
- Koşkulu-Sancar, S., van de Weijer-Bergsma, E., Mulder, H., and Blom, E. (2023). Examining the role of parents and teachers in executive function development in early and mid-career childhood: a systematic review. *Dev. Rev.* 67:101063. doi: 10.1016/j.dr.2022.101063
- Learning Difficulties Coalition (2021). Executive functions: Hot tips for parents and professionals. NSW: Westmead.
- MacNaughton, G., and Williams, G. (2009). Techniques for teaching young children: Choices for theory and practice. 3rd Edn. Australia: Pearson/Education.
- Madanipour, P., and Cohrssen, C. (2024). "Executive functions in Early childhood" in Health & Wellbeing in childhood. eds. S. Garvis and D. Pendergast (Cambridge: Cambridge University Press), 209–223.
- Maier, M. F., Greenfield, D. B., and Bulotsky-Shearer, R. J. (2013). Development and validation of a preschool teachers' attitudes and beliefs toward science teaching questionnaire. *Early Child. Res. Q.* 28, 366–378. doi: 10.1016/j.ecresq.2012.09.003
- Manning, M., Wong, G., Fleming, C., and Garvis, S. (2019). Is teacher qualification associated with the quality of the early childhood education and care environment? *Rev. Educ. Res.* 89, 370–415. doi: 10.3102/0034654319837540
- McClelland, M. M., Tominey, S. L., Schmitt, S. A., Hatfield, B. E., Purpura, D. J., Gonzales, C. R., et al. (2019). Red light, purple light! Results of an intervention to promote school readiness for children from low-income backgrounds. *Front. Psychol.* 10. doi: 10.3389/fpsyg.2019.02365
- Miles, M. B., Huberman, A. M., and Saldaña, J. (2020). Qualitative data analysis: A methods sourcebook (Fourth edition). California: SAGE Publications, Inc.
- Miyake, A. U., Friedman, N. P., Emerson, M. J., Witzki, A. H., and Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex 'frontal lobe' tasks: A latent variable analysis. *Cogn. Psychol.* 41, 49–100. doi: 10.1006/cogp.1999.0734
- Moreno, A. J., Shwayder, I., and Friedman, I. D. (2017). The function of executive function: everyday manifestations of regulated thinking in preschool settings. *Early Childhood Educ. J.* 45, 143–153. doi: 10.1007/s10643-016-0777-y
- Muir, R. A., Howard, S. J., and Kervin, L. (2023). Interventions and approaches targeting early self-regulation or executive functioning in preschools: a systematic review. *Educ. Psychol. Rev.* 35, 1–32. doi: 10.1007/s10648-023-09740-6
- Muir, R. A., Howard, S. J., and Kervin, L. (2024a). Supporting early childhood educators to foster children's self-regulation and executive functioning through professional learning. *Early Child. Res. Q.* 67, 170–181. doi: 10.1016/j.ecresq.2023.12.001
- Muir, R. A., Howard, S. J., and Kervin, L. (2024b). Increasing the odds for success: Applying evidence-based professional learning to foster self-regulation and executive functioning in preschool classrooms. *Australasian. J. Early Child.* 1–14.
- National Association for the Education of Young Children. (2021). Ten effective developmentally appropriate practice (DAP) teaching strategies. Available at: <https://www.naeyc.org/resources/topics/dap/10-effective-dap-teaching-strategies> (Accessed March 20, 2024).
- Nyroos, M., Wiklund-Hörnqvist, C., and Löfgren, K. (2018). Executive function skills and their importance in education: Swedish student teachers' perceptions. *Think. Skills Creat.* 27, 1–12. doi: 10.1016/j.tsc.2017.11.007
- Organisation for Economic and Cooperative Development (OECD) (2018). Engaging young children: Lessons from research about quality in early childhood education and care.
- Pianta, R. C., La Paro, K. M., and Hamre, B. K. (2008). Classroom assessment scoring system: Pre-K. Baltimore, MD: Brookes.
- Rapoport, S., Rubinsten, O., and Katzir, T. (2016). Teachers' beliefs and practices regarding the role of executive functions in reading and arithmetic. *Front. Psychol.* 7, 1–14. doi: 10.3389/fpsyg.2016.01567
- Reeve, J. (2006). Teachers as facilitators: what autonomy-supportive teachers do and why their students benefit. *Elem. Sch. J.* 106, 225–236. doi: 10.1086/501484
- Sætre, A. S., and Van de Ven, A. (2021). Generating theory by abduction. *Acad. Manag. Rev.* 46, 684–701. doi: 10.5465/amr.2019.0233
- Schirmbeck, K., Rao, N., and Maehler, C. (2020). Similarities and differences across countries in the development of executive functions in children: a systematic review. *Infant Child Dev.* 29:1. doi: 10.1002/icd.2164
- Schmitt, S. A., Korucu, I., Napoli, A. R., Bryant, L. M., and Purpura, D. J. (2018). Using block play to enhance preschool children's mathematics and executive functioning: a randomized controlled trial. *Early Child. Res. Q.* 44, 181–191. doi: 10.1016/j.ecresq.2018.04.006
- Shen, Y., Lin, Y., Liu, S., Fang, L., and Liu, G. (2019). Sustained effect of music training on the enhancement of executive function in preschool children. *Front. Psychol.* 10. doi: 10.3389/fpsyg.2019.01910
- Siraj-Blatchford, I. (2008). Understanding the relationship between curriculum, pedagogy and progression in learning in early childhood. *Hong Kong J. Early Childhood* 7, 6–13.
- Siraj-Blatchford, I., Sylva, K., Muttock, S., Gilden, R., and Bell, D. (2002). Researching effective pedagogy in the Early years (REPEY): DfES research report 356. London: DfES, HMSO.
- Sosic-Vasic, Z., Keis, O., Lau, M., Spitzer, M., and Streb, J. (2015). The impact of motivation and teachers' autonomy support on children's executive functions. *Front. Psychol.* 6:146. doi: 10.3389/fpsyg.2015.00146
- Thibodeau-Nielsen, R. B., Gilpin, A. T., Nancarrow, A. F., Pierucci, J. M., and Brown, M. M. (2020). Fantastical pretense's effects on executive function in a diverse sample of preschoolers. *J. Appl. Dev. Psychol.* 68:101137. doi: 10.1016/j.appdev.2020.101137
- Thompson, J. (2022). A guide to abductive thematic analysis. *Qual. Rep.* 27, 1410–1421. doi: 10.46743/2160-3715/2022.5340
- Veraksa, A. N., Veresov, N. N., Sukhikh, V. L., Gavrilova, M. N., and Plotnikova, V. A. (2023). Play to foster children's executive function skills: exploring short- and long-term effects of digital and traditional types of play. *Int. J. Early Childhood* 56, 687–709. doi: 10.1007/s13158-023-00377-8
- Vygotsky, L. S. (1978). Mind in society: The development of higher mental processes. Cambridge, MA: Harvard University Press.
- Williams, K. E., Savage, S., and Eager, R. (2020). Rhythm and movement for self-regulation (RAMSR) intervention for preschool self-regulation development in disadvantaged communities: a clustered randomised controlled trial study protocol. *BMJ Open* 10, e036392–e036311. doi: 10.1136/bmjopen-2019-036392
- Wilson, N. S., and Bai, H. (2010). The relationships and impact of teachers' metacognitive knowledge and pedagogical understandings of metacognition. *Metacogn. Learn.* 5, 269–288. doi: 10.1007/s11409-010-9062-4
- Xiong, S., Li, X., and Tao, K. (2017). Effects of structured physical activity program on Chinese young children's executive functions and perceived physical competence in a day care center. *Biomed. Res. Int.* 2017, 1–7. doi: 10.1155/2017/5635070
- Zamzow, J., and Ernst, J. (2020). Supporting school readiness naturally: exploring executive function growth in nature preschools. *Int. J. Early Childhood Environ. Educ.* 7, 6–16.
- Zelazo, P. D. (2015). Executive function: reflection, iterative reprocessing, complexity, and the developing brain. *Dev. Rev.* 38, 55–68. doi: 10.1016/j.dr.2015.07.001
- Zelazo, P. D., Forston, J. L., Masten, A. S., and Carlson, S. M. (2018). Mindfulness plus reflection training: effects on executive function in Early childhood. *Front. Psychol.* 9, 1–12. doi: 10.3389/fpsyg.2018.00208
- Zvara, B. J., Keim, S. A., Boone, K. M., and Anderson, S. E. (2019). Associations between parenting behavior and executive function among preschool-aged children born very preterm. *Early Child. Res. Q.* 48, 317–324. doi: 10.1016/j.ecresq.2019.01.012