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The impact of an interaction-based classroom program on executive function development in low-SES preschoolers: first support for effectiveness

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Studies have shown that children from a low socioeconomic status (SES) family are likely to have lower academic scores, indicating an SES-achievement gap. This inequality already starts in preschool and persists throughout children's lives. Since executive functions (EFs) have been put forward as contributing factors in this SES-achievement gap, it is crucial to target early EF development to remediate the adverse effects of poverty. In this quasi-experimental study, a classroom program delivered by teachers (i.e., "*Put your EF glasses on*") was implemented to strengthen preschoolers' EFs, consistent with the idea that well-developed EFs can foster school readiness and prevent school failure. The program aimed to boost children's EFs through high-quality teacher-child interactions, EF-supporting activities (e.g., games), and a supportive classroom structure. Teachers (n=24) and children (n=224, M_{age}=52.61months) from 8 Belgian schools participated in this quasi-experimental pilot study and were divided into experimental and control groups. Teachers in the experimental group carried out the program (receiving materials and coaching to support implementation), whereas teachers in the control group practiced teaching as usual. Before and after the program, all teachers filled out the BRIEF-P, a questionnaire about daily executive problems in preschool children. We compared the effect of the classroom program in low-SES versus middle-to-high-SES children on EF problem scores. Results revealed that all low-SES children started with significantly higher EF problems (total problem score, working memory, inhibition, and planning and organizing) scores than middle-to-high-SES children. A positive effect of the program was found among low-SES children. More specifically, EF problems (total problem score, working memory, shifting, and planning and organizing) remained stable over time in the low-SES group in the experimental group, but there was no program effect on emotional control and inhibition. In the control group, these EF problems increased for low-SES children, expanding the gap between low and middle-to-high-SES children. There were no program effects for middle-to-high-SES children. These results show that a teacher-mediated classroom program can support EF development, especially in preschoolers at sociodemographic risk.

KEYWORDS

classroom intervention, preschool children, teacher training, executive functions, teacher-child interactions, socioeconomic status

Introduction

Almost 1 in 4 Europeans is at risk of poverty or social exclusion, and in Belgium 1 in 5 children are at risk, with children and adolescents under 24 being the most affected (Eurostat, 2018, p. 24; Kind en Gezin, 2019). Considering poverty's adverse impact on children's well-being and development, these numbers show that poverty remains a significant social challenge for the European Union. To address this, the current study aims to boost the development of specific cognitive factors that lag in children from poverty-stricken families through an interaction-based classroom program.

Poverty is generally ascertained by one's socioeconomic status (SES), a multidimensional measure of one or more contextual factors, including but not limited to household income, parental education, parental occupation, and parental marital status (Hackman et al., 2010; Letourneau et al., 2013). However, poverty goes beyond a lack of financial means and includes social exclusion in multiple areas of life. For instance, children from low-SES families are more exposed to harmful environmental factors (e.g., exposure to pollutants or lower-quality diets) that can hinder their cognitive and emotional development (Brooks-Gunn and Duncan, 1997; Boyce, 2004; Evans, 2004; Farah et al., 2006; Hackman et al., 2010; Farah, 2017), and lead to poorer physical health or higher rates of illnesses (Chen et al., 2002; Boyce, 2004). Low SES is also linked to overall lower academic achievement scores (Malecki and Demaray, 2006; Sirin, 2016), and more specifically to literacy, language (Noble et al., 2005; Malecki and Demaray, 2006; Letourneau et al., 2013), and math achievement (Starkey et al., 2004). It is important to note that this cognitive inequality is already eminent in preschool years, as preschoolers living in poverty lag on school readiness, preliteracy, and numeracy measures (Brooks-Gunn and Duncan, 1997; Magnuson et al., 2004; Magnuson and Waldfogel, 2005; Reardon and Portilla, 2016; Sabol et al., 2018). Additionally, this inequality seems to persist as children who have experienced poverty at preschool age tend to have lower school completion rates altogether (Brooks-Gunn and Duncan, 1997). Conclusively, since poverty can have adverse effects on development at a young age, early intervention is crucial (Luby et al., 2013).

Children growing up in poverty are shown to have ill-developed EFs (Mezzacappa, 2004; Noble et al., 2005; Farah et al., 2006; Lawson et al., 2018). EFs refer to a family of top-down cognitive processes that allow individuals to engage in goal-directed adaptive behavior and regulate thought, behavior, and emotion (Lezak, 1995; Diamond, 2013). There is a broad consensus that there are three related but separable core EFs, i.e., updating, inhibition, and shifting (Miyake et al., 2000). Updating, also referred to as working memory, is the capacity to maintain task-relevant visual or verbal information in mind and actively manipulate it (Miyake et al., 2000; Baddeley, 2003; Diamond, 2013). Inhibition is the capability to control one's attention, behavior, and emotions; to do what is appropriate or necessary by overriding an internal predisposition or external lure (Miyake et al., 2000; Diamond, 2013). Shifting, also called cognitive flexibility, refers to the ability to switch between tasks or strategies, i.e., disengage from an irrelevant task set and initiate a new, more appropriate set (Miyake et al., 2000; van der Sluis et al., 2007; Diamond, 2013). These core EFs are the foundation for more complex, higher-order EFs, such as reasoning, problem-solving, and planning (Diamond, 2013). All three EFs develop rapidly during preschool years and continue to mature through middle childhood and adolescence, following a canonical non-linear trajectory that stabilizes into adulthood (Anderson, 2002; Luna et al., 2004; Huizinga et al., 2006; Garon et al., 2008; Best and Miller, 2010; Eng et al., 2022). As mentioned above, children from low-SES families are more likely to experience detrimental psychological (e.g., parental stress) and physical factors (e.g., exposure to pollutants). Studies show that these factors associated with low SES could impact brain development, and, consequently, the development of EF as well (Boyce, 2004; Lawson et al., 2013; Farah, 2017). It is through an altered stress response, due to the chronic stress associated with poverty, that children's EFs are compromised (Blair and Raver, 2015).

Research has established a link between EFs and academic achievement (Best et al., 2011) and even overall life success and quality of life (Moffitt et al., 2011; Diamond, 2013). Poor EFs in preschool are associated with problems in emergent literacy and numeracy skills (Welsh et al., 2010), and later poor academic achievement such as reading, writing, science, and mathematics (Blair and Razza, 2007; Blair and Diamond, 2008; Best and Miller, 2010). Also, insufficient acquisition of EFs during early childhood has been associated with developmental psychopathology, such as mental health outcomes (e.g., addictions, conduct disorder, or depression) and also physical issues (e.g., obesity or overeating) in adults (Pennington and Ozonoff, 1996; Snyder, 2013; Snyder et al., 2015; White et al., 2017). Conclusively, due to their association with both SES and academic achievement, EFs are proposed to contribute to the SES achievement gap (Lawson and Farah, 2015; Finn et al., 2017; Rosen et al., 2020; Waters et al., 2021). Accordingly, several studies have explored the role of EFs in the SES achievement gap, and confirming results were found in behavioral (Lawson and Farah, 2015), intervention (Rosen et al., 2020), and neural studies (Finn et al., 2017; Rosen et al., 2018). Therefore, to improve (further) academic achievement, targeting the optimal development of EFs is crucial, especially in young children at risk for poor EF development, such as children from low-SES families.

Even though EF development follows the maturation of the brain, environmental stimulation can promote and support this development (Hughes, 2011). As to the timing of such an intervention, research has shown that EF support training can have effects, even among young preschool children (Thorell et al., 2009). As to the location of such an intervention, research revealed that not all types of interventions impact related behaviors and outcomes in the classroom. More specifically, training (whether computerized or not) focusing narrowly on EFs fails to lead to long-term durable effects (Melby-Lervåg and Hulme, 2013; Melby-Lervåg et al., 2016; Kassai et al., 2019) or, at best, shows small effects in children at risk for poor EFs due to psychopathology (Scionti et al., 2020; Pauli-Pott et al., 2021). In contrast, real-life classroom EF interventions that target EFs in the children's natural environment, directly and indirectly, evoke sustainable transfer effects (Diamond and Lee, 2011). Compared to the minor results of individual computerized training, the long-term effects of classroom intervention indicate that children's developmental context should be considered. The classroom context and contact with the teachers are a significant part of a child's developmental context (Sabol and Pianta, 2012). In line with this view, the Teaching through Interactions (TTI) framework identifies three broad classroom-level interactions important for children's learning: emotional support, organizational support, and instructional support (Downer et al., 2010; Howes et al., 2011; Hamre et al., 2013). Emotional support refers to the degree to which the teacher supports the child's social and emotional functioning in class. Organizational support is how the teacher allows smooth classroom functioning and manages children's behavior (e.g., using lesson plans and materials). Instructional support refers to the interactions that facilitate children's cognitive development to expand learning, such as asking open-ended questions and providing feedback (Downer et al., 2010; Vandenbroucke et al., 2018). In general, by creating a warm, structured, and cognitively stimulating classroom, teachers can positively influence children's EF (Vandenbroucke et al., 2018; Cumming et al., 2020). Moreover, children with low EF skills, often children from low-SES families, benefit most from optimal classroom quality, especially from adequate instructional support (Hamre and Pianta, 2005; Roorda et al., 2011; Cadima et al., 2016). Conclusively, these studies show classroom quality should be considered when aiming to sustainably train EFs in vulnerable preschoolers.

American guidelines for high-quality childhood education targeting EF stress the importance of, among other things, intentional instruction and supportive interactions between teachers and children (Burchinal et al., 2022). Schools are advised to (1) use intentionally designed games to build children's EFs, (2) challenge children by increasing the complexity of games and activities over time, and (3) embed EF activities in literacy, math, art, or other parts of the day (Burchinal et al., 2022). These guidelines for high-quality childhood education can be linked to the TTI framework (Downer et al., 2010; Hamre et al., 2013). For instance, the importance of intentional instruction is an example of instructional support, as this guideline requires teachers to explicitly teach or ask questions that need the children's problem-solving and higher-order thinking. Moreover, teachers are advised to reinforce and praise children, which is an example of emotional support. Last, schools are recommended to use intentionally designed games to improve EFs and embed these games in day-to-day school life, the latter being an example of organizational support.

Several classroom programs exist to stimulate EF development in young children (Diamond and Lee, 2011). For instance, *Tools of the Mind* is a program using make-believe play and language to support EF development, in line with Vygotsky's Socio-Cultural Theory (Vygotsky, 1967). This program focuses on instructional support and scaffolding by emphasizing the intentional development of specific academic skills and self-regulation (Diamond and Lee, 2011; Bodrova and Leong, 2019). More specifically, it provides tools for teachers to focus on broad foundational skills (e.g., self-regulation), preliteracy, and prenumeracy skills through guided play (Barnett et al., 2008). While one review study showed that *Tools* only had positive effects on math outcomes (Baron et al., 2017), another review study did find positive effects on EFs for *Tools* and other classroom programs (Ştefan et al., 2022). *Chicago School Readiness Project (CSRP)* mainly focuses on emotional support, as the teachers train verbal emotion regulation strategies (Raver et al., 2011). A longitudinal study of CSRP's effectiveness shows that the program can prevent future social difficulties (McCoy et al., 2018). A recent review study concluded that universal socio-emotional learning classroom programs can indeed have positive effects on children's socio-emotional learning (Blewitt et al., 2018). Finally, *Red Light Purple Light* is a game-based activity program in which children are assigned to playgroups, including circle-time movement and music-based games that encourage attention, working memory, and self-regulation skills (Tominey and McClelland, 2011; Schmitt et al., 2015). The results of this program show that circle-time games proved effective in enhancing attention, memory, and self-control, especially in children with low self-regulation (Tominey and McClelland, 2011). As such, this program targets instructional and organizational support to improve children's EFs. Diamond and Lee (2011) showed that, specifically, classroom programs can benefit EF development. However, a more recent review by Takacs and Kassai (2019) had the opposite conclusion and found only a very small effect of classroom programs on children's EF skills. Most recently, Muir et al. (2023) suggested that, while there is no consensus or evidence for particular EF programs (being specific trainings or classroom programs), there is evidence that all approaches showed potential for effectiveness.

In this pilot study, we evaluated the first signs of effectiveness of the "*Put your EF glasses on*" program (Feryn, 2017). In line with current insights in the literature, the program consists of three building blocks, each forming a substantial part of the program and implemented one by one: high-quality teacher-child interactions, EF-supporting activities (e.g., games), and a supportive classroom structure. The first building block, i.e., high-quality teacher-child interactions, provides teachers with strategies to support children's EFs. Examples include modeling external speech, stop-think-act strategies, or mirror speech, to help children think and talk about their mental processes (Feryn, 2017; Upshur et al., 2017). This building block challenges children's EF development by focusing on interactions such as scaffolding, i.e., interactions where the teachers gradually increase the complexity of the activity and reduce their help during these activities (Cameron et al., 2005; Cameron and Morrison, 2011; Bardack and Obradović, 2019). This building block is based on instructional support (the teachers model desired behavior) and emotional support (the teachers teach and model different strategies to improve emotion regulation and support socio-emotional development; Downer et al., 2010). The scaffolding and stress regulation activities find their inspiration in the existing *Red Light Purple Light* and *Chicago School Readiness Project*, respectively. The second building block, the EF-supporting activities, uses intentionally designed activities that challenge EF development and have EF development as the explicit goal. This building block integrates specific (reaction, memory, or board) games to boost children's EFs in daily school life, much like the *Red Light Purple Light* and *Tools of the Mind* programs did (Bierman and Erath, 2006; Diamond and Lee, 2011; Tominey and McClelland, 2011; Mattera et al., 2021). Movement exercises are also a part of this building block (Best, 2010; Copeland et al., 2011; Becker et al., 2014). The third and last building block is supportive classroom structure, which is related to organizational support (Downer et al., 2010). In this building block, teachers focus on how to introduce different activities and the organization of transition moments in the class, providing tips and tricks to make existing activities and transition moments more EF-oriented (e.g., avoid redundant visual and auditory stimuli, introduce peer-regulated activities, or use a Montessori mat).

We believe that the implementation of the abovementioned TTI framework and guidelines for high-quality childhood education is precisely what will impact children's EF development through this program. Previous studies have indicated mixed results for existing classroom programs (Takacs and Kassai, 2019; Ştefan et al., 2022), most of which were conducted in North-American contexts. Therefore, the "*Put your EF glasses on*" program aims to contribute to the field by providing a comprehensive, universal classroom program that can be seamlessly integrated into the daily classroom routine in Belgium.

This program is novel in its approach as it focuses on integration in the daily classroom by not only providing specific EF-activities, but also having attention for high-quality teacher-child interactions and supportive classroom organization. Overall, the "*Put your EF glasses on*" program is flexible and can be tailored to meet the needs of teachers and children, rather than being strictly followed as a program or method.

In this pilot study, we examined whether this state-of-the-art classroom program can provide first support for positive outcomes in EF development in preschoolers. Overall, we acknowledge that the preschool period presents an ideal time to influence the development of EF, given the demonstrated plasticity and adaptability of the neural systems that support EF (Garon et al., 2008; Blair and Raver, 2014). Next, a meta-analysis has shown that teachers can impact EF development by creating an emotionally positive, structured, and cognitively stimulating environment (Vandenbroucke et al., 2018). Finally, the most successful approach for enhancing EFs is a combination of direct (such as specific games) and indirect methods (such as improving teacher-child interactions), in a child's natural environment (Diamond and Lee, 2011; Diamond, 2012). Thus, this program is well-suited for stimulating EFs, offering the ideal timing and setting, and an ideal balance of direct and indirect methods.

Current study

Considering the importance of (1) preschoolers' rapid EF development, (2) early intervention to remediate possible adverse effects of poverty on EF, and (3) the teacher-child environment in EF interventions, the "*Put your EF glasses on*" program was created. This teacher-mediated program aims to strengthen preschoolers' EF, consistent with the idea that well-developed EFs in preschoolers can foster school readiness, lay a foundation for future academic achievement, and prevent school failure. By targeting early childhood education, this program could remediate the emerging SES gap in EFs between children living in poverty and children who do not. This way, this program hopes to contribute to long-term poverty reduction by giving low-SES children every opportunity to develop optimally. The current pilot study aimed to provide first support for whether the "*Put your EF glasses on*" program could improve EFs. The study was performed in preschool schools with a high percentage of low-SES children using a quasi-experimental pretest-posttest design. Consistent with previous research, we hypothesized that all children would benefit from the program and that children with low EFs would show the strongest improvements in all EFs (Diamond and Lee, 2011; Diamond, 2012).

Materials and methods

Study design

The Social and Societal Ethics Committee of the research institute approved this study (G-2016 07589). The effect of the "*Put your EF glasses on*" program was examined using a quasi-experimental pretest-posttest design. The program includes curricula with personalized coaching for teachers. The current study had one control condition and two experimental conditions. Teachers in the experimental condition implemented the program using the "*Put your EF glasses on*" didactics for 13 weeks, spanning 5 months, including the pretest and holiday weeks. Before implementation, these teachers participated in a group workshop that provided conceptual insights into EF and information about the program. There are two groups within the experimental condition: the experimental *full* and experimental *light* condition. The teachers of schools in the experimental *full* condition received weekly in-class coaching on the program and peer-to-peer intervision sessions, in addition to the group workshop that the experimental *light* condition only received. The teachers in the control condition did not get any training and practiced teaching as usual.

The current study conducted both a pretest and a posttest in control and experimental conditions. The average time interval between the pretest and the posttest was 6 months ($M = 6.32$, $SD = 0.5$).

Participants

The current study included children and teachers from eight regular preschools in Belgium. These schools were selected based on the number of low-SES children enrolled, i.e., at least 30% were low-SES children. The number of low-SES children in each school is readily available information, as this is necessary for the school's funding by the Flemish government. Children are identified as low-SES children if they meet at least one of two criteria; (1) maternal education level is low (i.e., no secondary education degree), (2) have a low family income and receive a scholarship. Of each school, three randomly selected classes and their head teachers participated; one of the first, second, and third grades of preschool, with children's age ranging from 3.9 to 6.8 years old ($M_{age} = 52.61$ months) respectively. Schools sent out invitations for participation to the children since each school had lists of low and middle-to-high-SES children from enrollment. Researchers performed a stratified random sampling method on each list and randomly selected five low-SES children and five middle-to-high-SES children in each class, based on the alphabetical order of their last names (1, 3, 5, ……), adding up to 10 children per class. Upon receiving parental consent for each child's participation, the researchers obtained the SES information of the participating child, including the SES (low versus middle-to-high), maternal education level, home language, and family composition. The family income or scholarship information was not disclosed (Table 1). If parents did not want to participate, another child further down the alphabetical list was selected from the relevant list. If one specific group (i.e., low SES or middle-to-high SES) was complete, any new participant would be denied if their SES belonged to this already complete group. The selection process would continue down the alphabetical list until all missing conditions were filled. As such, in each school, 30 children could participate in the study. This yielded an initial sample consisting of 228 children. Due to dropout after the pretest, the final sample size dropped to 224 children (i.e., middle-to-high-SES children: $n = 119$, 53.1%; low-SES children: $n = 105$, 46.9%). In the final sample, boys and girls were equally represented (boys: $n = 107$, 48.0%; girls $n = 116$, 52.0%), as were the different grades of preschool (first grade: $n = 72$, 32.1%; second grade: $n = 74$, 33.0%; third grade: $n = 78$, 34.8%). Next to the 224 children, 24 teachers participated. Eligible schools were assigned to the study conditions based on the school's location. Since one city council financed and supported intervention implementation in its city (please note that the researchers had no research funding to finance the project), they required schools in their city to be assigned to the experimental *full* or (waitlist) control

TABLE 1 Characteristics of children in control and experimental groups (n=224).

Characteristics	Total	Conditions			
		Control	Experimental		
	n (%)	*n* (%)	*n* (%)	χ^2	*p*
Child gender				0.374	0.541
Male	107 (48.0)	43 (50.6)	64 (46.4)		
Female	116 (52.0)	42 (49.4)	74 (53.6)		
Year				0.015	0.992
1st year of preschool	72 (32.1)	27 (31.8)	45 (32.4)		
2nd year of preschool	74 (33.0)	28 (32.9)	46 (33.1)		
3rd year of preschool	78 (34.8)	30 (35.3)	48 (34.5)		
SES				2.600	0.107
Middle to high	119 (53.1)	51 (60.0)	68 (48.9)		
Low	105 (46.9)	34 (40.0)	71 (51.1)		
Education mother				3.239	0.072
Middle to high	122 (54.7)	53 (62.4)	69 (50.0)		
Low	101 (45.3)	32 (37.6)	69 (50.0)		
Home language				5.743	0.017*
Dutch	111 (49.8)	51 (60.0)	60 (43.5)		
Other	112 (50.2)	34 (40.0)	78 (56.5)		
Family composition				0.569	0.451
One-parent family	17 (7.6)	5 (5.9)	12 (8.6)		
Two-parent family	207 (92.4)	80 (94.1)	127 (91.4)		

*Significant at 0.05 level (2-tailed).

conditions. Whether a school was assigned to the experimental *full* (n=3) or the control (n=3) conditions was decided randomly. Schools in the neighboring city were assigned to the experimental *light* condition. Schools in the *full* and *light* conditions represented the experimental condition (n=5 schools, 15 teachers, 139 children, of whom 71 were from low-SES families). For this study, other schools in the funder's city were designated as the control group (n=3, 9 teachers, 85 children, of whom 34 were from low-SES families). Please note that (1) on lower levels of recruitment (stratified), random selection took place (i.e., class within school and children with classes), and (2) experimental and control schools had the same student populations, meaning that all of these schools were part of regular preschool education, within the same geographical area, Flemish and municipal schools. Additionally, as the city council aimed to implement this program in the schools with highest needs (i.e., with most children at risk for poor EF skills), all schools had at least 30% indicator students. After the study, parents were not explicitly informed that their child was selected based on SES, but they were notified of the study's general results (i.e., including the reference to the SES differential effect in the findings) through a website included in the informed consent form. The website provided detailed information regarding the study, research questions, and outcomes.

Instrument

Executive functioning was operationalized by a teacher-rated questionnaire, the Behavior Rating Inventory of Executive Functioning – Preschool version (BRIEF-P; Gioia et al., 2000). *The Behavior Rating Inventory of Executive Functioning – Preschool version* is a standardized questionnaire suitable for assessing preschoolers (2–5 years; Gioia et al., 2000). The questionnaire consists of 63 items evaluating everyday behavioral manifestations of executive functioning. In this study, the teachers filled out the BRIEF-P before and after the program implementation. All items are classified into five clinical subscales (inhibit, shift, emotional control, working memory, and plan/organize). These subscales form the summary score labeled the Global Executive Composite (GEC), a total problem score that provides information on general, daily executive dysfunction. Teacher-rated scores were found to be valid and reliable in preschoolers (Ezpeleta et al., 2012). Specifically, the Dutch version showed high reliability and validity in older children (Huizinga and Smidts, 2010). Therefore, we chose this task because of its high ecological validity (Toplak et al., 2013). For distribution and reliability of the scales, see Supplementary Table 6, 7.

Program

The experimental groups were trained in the didactics of the "*Put your EF glasses on*" program, which aims to improve executive functioning in children. These didactics consist of three building blocks: high-quality teacher-child interactions, EF-supporting activities, and supportive classroom structure (Feryn, 2017). The building blocks were introduced to all teachers of the experimental conditions (both *full* and *light*) during the group workshop. All teachers implemented the building blocks one by one every 3 weeks. The last 3 weeks of the program consisted of integrating the different building blocks into their daily activities and interactions. The teachers in the experimental *full* condition received 12 weekly in-class personal coaching and 4 intervision sessions on how to apply the building blocks, while those in the experimental *light* condition did not.

The first building block, i.e., EF interactions, focused on high-quality interactions between the teacher and children. The goal of this block was to support EF development by optimizing the daily interactions between teachers and children. More concretely, teachers were taught to help children think about and explicitly share their mental processes during play or task performance, i.e., an example of instructional support. Among other things, teachers used mirror talk (e.g., "I see you are jumping around. Apparently, you find it difficult to wait for your turn."), the think-aloud strategy (e.g., "I want to eat this cookie now, but I will have to wait until we have finished our song.") or taught the children the stop, think, act strategy (e.g., "I stop, I think and only answer after."; Upshur et al., 2017; Zelazo et al., 2018). These examples helped children to suppress primary, impulsive reactions (inhibition) and become more mindful of their emotions and thoughts, which can help them direct their own behavior accordingly. The presented EF interactions adhere to the domains mentioned earlier of emotional and instructional support (Downer et al., 2010; Hamre et al., 2013). In the domain of emotional support, the program presents different strategies to improve emotion regulation and support socio-emotional development. For instance, the manual describes different techniques to create rest for children when upset and provides tools to teach children to cope with stress (e.g., using pictograms with stress relievers such as "listen to calm music" or "take a deep breath"). In the domain of instructional support, the goal is for the teacher to model desired behavior. The child can then learn by observing and imitating this desired behavior (Bandura, 1977). Other described instructional interactions find roots in Vygotsky's theory, which signifies the importance of make-believe play in the development of EFs (Vygotsky, 1967). Play contributes to developing self-regulatory behaviors and EFs (e.g., planning and monitoring, since children need to plan their play, divide roles and stick to them; Bodrova and Leong, 2019; Doebel and Lillard, 2023). As make-believe play might be challenging for young children, the manual offers interactions that can scaffold and structure children's play.

The second building block zoomed in on specific EF-supporting activities. A wide range of activities, such as (non-)computerized and physical games that have been proven to support the development of EFs are used in daily curricula (Diamond and Lee, 2011). As such, the program provided several non-computerized and physical games to perform in the classroom to improve children's EFs. In addition, several play-based activities were provided. The manual described 78 activities, classified into six categories: EF-reaction games, EF-memory games, EF-board games, EF-movement games, EF-picture books, and EF-puppet play. An example of one of these EF-board games was the game "Candy" (Beleduc, 2017). This game focused explicitly on inhibition and emotional control (Feryn, 2017). In this game, the children are asked to look for and match colored candies, depending on the color of their thrown dice. As the piece of candy had different colors, children were supposed to inhibit distracting colors of their piece of candy, as well as other multicolored pieces. This game can be complicated by increasing the amounts of dice and thus the number of colors to search, thus making working memory crucial for playing.

The last building block is supportive classroom structure, which is related to organizational support (Downer et al., 2010; Hamre et al., 2013). Here the teachers focused on how they introduced existing activities and organized transition moments in the class. Consistent classroom behavior routines and time use support the development of EFs (Hamre et al., 2013). The manual provided different tips and tricks to make existing activities and transition moments more EF-oriented (e.g., avoid redundant visual and auditory stimuli or introduce peer-regulated activities). The aim of these teacher activities was to avoid cognitive overload in the children as this could harm their EF development, by offering them structure, clarity, and predictability.

The weekly in-class coaching of the teachers in the experimental *full* condition consisted on the one hand of individual coaching by an expert trainer (i.e., someone who is a teacher educator and has a degree in teaching as well) and on the other hand of intervision sessions within the teacher team of the school. Individual coaching was provided in 12 sessions. The expert trainer observed the participating teachers, gave feedback, and implemented co-teaching. Note that the expert trainer, in this case, is also the program's author. The program's building blocks were the focus in terms of content of the coaching: EF-interactions were discussed from the first to the third session, EF-activities from the fourth to the sixth session, and supportive classroom structure from the seventh to the ninth session. The last three sessions provided demand-driven support tailored to the teacher. The second part of the coaching consisted of four intervision sessions within the teacher team of the preschool school. During these intervision sessions, practical experiences were exchanged, and teachers were asked about their motivation. The content of the intervision sessions depended on the timing of the program; the first three sessions focused, respectively, on the first, second, and third building block, while the last session provided demand-driven support tailored to the entire teacher team.

Data analysis

The first step was to combine the experimental *full* condition and the experimental *light* condition, as analysis proved no significant differences between these two experimental groups on the dependent variables (p-values ranged between 0.224 and 0.988 on pre-and post-test differences; see Supplementary Tables 2 and 3). Consequently, a new dummy variable, "Condition" (0 = control condition, 1 = experimental condition), was created, whereby both experimental groups (*light* and *full*) were combined into one category. The sample demographics in the three conditions can be found in Supplementary Table 1.

Multilevel analyses were opted to investigate the program's effects on EFs and its interaction with the children's SES status because the current study consisted of hierarchical data of children clustered within teachers. Peugh (2010) states that evaluating the need for multilevel modeling is done by looking at the intraclass correlation (ICC) to capture the variance at level two of the model (e.g., teachers). It is recommended to take multilevel structure into account with ICCs above 0.10 (Byrne, 2013), although ICCs as low as 0.01 are already found to increase the type 1 error (Musca et al., 2011). Next to the ICC, it is also advisable to look at the specific design effects to check

TABLE 2 Pretest differences in BRIEF-P scores between control and experimental groups.

	Control			Experimental			*p*	r
	n	*M*	*SD*	*n*	*M*	*SD*		
WM	80	24.58	7.52	139	24.01	8.27	0.232	0.08
Inhibit	82	23.93	7.68	139	22.54	7.97	0.053	0.13
Plan./Org.	82	15.09	4.63	139	14.02	4.70	0.028	0.15
Shift	79	12.32	3.02	139	12.01	3.26	0.151	0.10
Emot. Contr.	81	13.44	3.98	139	12.91	4.14	0.119	0.10
GEC	76	88.28	20.97	139	85.49	23.47	0.096	0.11

WM, working memory; Inh., inhibition; Plan./Org., planning and organizing; Shift., shifting; Emot. Contr., emotional control; GEC, global executive composite. Please note that the r-coefficient, calculated by the Z-score divided by the square root of N, is used for non-parametric tests. This can be interpreted via Cohen's rules for Cohen's d.

the impact of clusters on the variance compared to a traditional regression model (not accounting for the clustering; Moerbeek and Teerenstra, 2016). Design effects of a value of 2 or higher typically indicate the need to consider clustering (Peugh, 2010). Mplus v8.8 (Muthén and Muthén, 1998-2017) was used to run an empty model. The ICCs at teacher-level ranged from 0.059 to 0.124 (only 0.003 to 0.030 at school-level), and design effects varied between 1.460 and 1.966. Thus, presenting the need to control for clustering (Peugh, 2010; Moerbeek and Teerenstra, 2016; Heck et al., 2022).

Consequently, a fixed effects regression approach within Mplus was used. This approach accounts for the clustering by including it as a fixed effect next to the group effect. This way, the standard errors are corrected for the clustering. Moreover, this approach allows for smaller standard errors when working with little clusters (Galbraith et al., 2010).

Specifically, MLR (maximum likelihood with robust standard errors) was used via the type-complex analysis method, as this included certain advantages. Firstly, MLR is relatively robust against violations of the normality assumption and the independence of observations assumption. Secondly, this estimator allows us to perform multilevel analysis using unbalanced groups (Muthén and Muthén, 1998-2017). Moreover, Mplus also provides the benefit of running a Full Information Maximum Likelihood (FIML) algorithm to use all data available to fit the model as default rather than losing information as done with list-wise deletion of missing data, which, in turn, could lead to parameter estimation being biased and inaccurate standard errors (SEs; Newman, 2014; Heck et al., 2022). Furthermore, the FIML algorithm is a good fit in combination with models using a random intercept (Hox et al., 2017). Depending on the variable, missing data ranged from 1.3 to 5.8% (averages of around 2% pretest and 6% posttest level).

In general, assumptions were checked using the following procedure: first, the independence of residuals was assessed by the Durbin-Watson statistic. Second, data were checked for homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. Third, tolerance values were used to assess multicollinearity. Next, data points were classified as outliers if leverage values were greater than 0.2 and/or values for Cook's distance above 1 were found. In addition, data points should not have studentized deleted residuals greater than +/− 3 standard deviations. As a final step, the assumption of normality was assessed by a Q-Q Plot. Note that small deviations are not a problem since MLR is relatively robust against violation of the normality assumption.

As a sensitivity analysis, all analyses were performed with and without outliers. No differences were found in the significance of the effects, showing the robustness of the found effects. In the rare case that a difference was found after outlier exclusion, the significant p-values of the new analysis without outliers are also reported.

Results

Descriptive statistics

The sample demographics and correlations between outcome variables at pre- and post-measurement are reported in Tables 1, 3, respectively. Concerning the gender distribution, boys and girls were distributed equally across the SES groups. The low-SES group comprised 55 boys (53%) and 49 girls (47%). Moreover, the middle-to-high SES group consisted of 52 boys (44%) and 67 girls (56%). There was no significant association between SES and Gender, χ^2 (1, 224) = 1.877, $p = 0.171$. One child had no gender information available, while another child's mother's education level and home language information were missing.

Pretest differences

As a first step, the pretest differences between the control and experimental groups were analysed (for demographics see Table 1).

Concerning the BRIEF-P components (inhibit, shift, emotional control, working memory, plan/organize, and GEC), the non-parametric Mann–Whitney-U test was used based on the distribution of the data. These analyses showed no significant difference between the control and experimental group at the pretest level except for planning and organizing ($p = 0.028$) and a near-significant result for inhibition ($p = 0.053$), with both problem scores being higher in the control group. Thus, hinting at a careful interpretation of these results (note pretest scores were controlled for in our analyses; see Table 2).

Additionally, the pretest differences in executive functioning problems were compared in the two SES groups. Significant differences based on non-parametric Mann–Whitney-U tests were found on four EF variables, i.e., working memory, planning and organizing, GEC, and inhibition, although the latter showed a near-significant group difference ($p = 0.055$). However, there were no significant group differences on two other EF variables, being shifting and emotional control. In conclusion, children of low SES had higher problem scores on EF variables than children of middle-to-high SES at the pretest level (see Table 4).

Program effects

Global executive composite (GEC)

There was a significant main effect of SES and a significant interaction effect between the condition and SES status on the Global executive composite (GEC) score. However, the program had no significant main effect (see Table 5). Looking more closely at the significant interaction effect, the data showed that the effect of the program depended on the child's SES status. More specifically, there was only a significant intervention effect for the low-SES children. The graphs of the GEC of the pre-and post-measurements (see Figures 1, 2)

TABLE 3 Correlations between BRIEF-P scores at pretest and posttest.

BRIEF-P problem scales	1	2	3	4	5	6	7	8	9	10	11	12
(1) Inhibit PRE	-											
(2) Shift PRE	0.34**	-										
(3) WM PRE	0.68**	0.38**	-									
(4) Plan/Org. PRE	0.62**	0.40**	0.92**	-								
(5) Emot. Contr. PRE	0.56**	0.61**	0.36**	0.35**	-							
(6) GEC PRE	0.87**	0.58**	0.90**	0.87**	0.65**	-						
(7) Inhibit POST	0.78**	0.23**	0.51**	0.45**	0.41**	0.67**	-					
(8) Shift POST	0.29**	0.41**	0.29**	0.28**	0.34**	0.38**	0.37**	-				
(9) WM POST	0.52**	0.22**	0.69**	0.61**	0.23**	0.64**	0.65**	0.45**	-			
(10) Plan/Org. POST	0.50**	0.22**	0.66**	0.63**	0.27**	0.63**	0.60**	0.51**	0.91**	-		
(11) Emot. Contr. POST	0.52**	0.29**	0.25**	0.22**	0.67**	0.47**	0.60**	0.57**	0.31**	0.34**	-	
(12) GEC POST	0.69**	0.31**	0.64**	0.58**	0.45**	0.73**	0.87**	0.63**	0.89**	0.87**	0.65**	-

WM, working memory; Inh., inhibition; Plan./Org., planning and organizing; Shift., shifting; Emot. Contr., emotional control; GEC, global executive composite; pre, measurement at pretest level; post, measurement at posttest level. Higher scores on the BRIEF indicate more EF problems. **Significant at 0.01 level (2-tailed).

TABLE 4 Pretest differences in BRIEF-P scores between SES groups.

	Low-SES group			Middle-to-high SES group			*p*	r
	n	*M*	*SD*	*n*	*M*	*SD*		
WM	104	26.11	8.60	115	22.51	7.01	<0.001	0.23
Inhibit	104	24.06	8.21	117	22.16	7.51	0.055	0.13
Plan./Org.	104	15.36	5.05	117	13.58	4.19	0.004	0.19
Shift	103	12.26	3.30	115	11.99	3.06	0.250	0.08
Emot. Contr.	104	13.05	4.20	116	13.16	3.98	0.855	0.01
GEC	103	90.76	23.36	112	82.54	21.25	0.003	0.20

WM, working memory; Inh., inhibition; Plan./Org., planning and organizing; Shift., shifting; Emot. Contr., emotional control; GEC, global executive composite. Please note that the r-coefficient, calculated by the Z-score divided by the square root of N, is used for non-parametric tests. This can be interpreted via Cohen's rules for Cohen's d.

demonstrate that the low-SES children who participated in the program showed stable levels of EF problems over time, in contrast to the low-SES children in the control group who exhibited an increase in EF problems over time. In conclusion, this outcome suggests that the program can narrow the gap typically observed between children from low and high socioeconomic backgrounds.

Working memory (WM)

When looking at the effect on working memory, there was no significant main effect of the program. However, a significant main effect of SES and a significant interaction effect between the experimental condition and the SES status were found (see Table 5). Looking at the significant interaction effect, the program significantly impacted working memory problem scores, but only in low-SES children. This effect was similar to the effect displayed in Figure 1.

Shifting (shift)

Concerning the program's effect on shifting, there was no significant main effect of the program. However, a significant main effect of SES and a significant interaction effect between the experimental condition and the SES status were observed (see Table 5). Concerning the interaction effect, the program significantly impacted shifting problem scores, but only in low-SES children. This effect was similar to the effect displayed in Figure 1.

Inhibition (inhibit)

No significant main or significant interaction effects were found regarding inhibition (see Table 5). Note the sensitivity analysis revealed that when outliers were excluded from the analysis (3 outliers were removed), a significant main effect of SES was found ($\beta = 0.172$, $SE = 0.071$, $p = 0.015$). In addition, the low-SES children had significantly higher problem scores at the posttest than the middle-to-high-SES children after controlling for the pretest scores.

Planning and organizing (plan/org)

Regarding planning and organizing, again, a significant main effect of SES and a significant interaction effect between the experimental condition and SES status was observed. However, there was no significant main effect of the program (see Table 5). The low-SES group in the intervention condition had significantly lower problem scores on planning and organizing after controlling for the pretest levels. This effect was similar to the effect displayed in Figure 1.

Emotional control (emot. contr.)

For emotional control, no significant main effect of SES or experimental condition was found. Furthermore, there was no observed significant interaction effect.

Discussion

In this first pilot study, we explored the impact of an interaction-based classroom program on preschoolers' executive functioning (EF) skills. The "*Put your EF glasses on*" program emphasized the importance of developing optimal EF skills in this age group, as these EFs develop rapidly and are crucial for current and future well-being and functioning. In addition, research has demonstrated that children from low-SES families often have an early and persistent disadvantage in EFs.

TABLE 5 Prediction of children's EF problem scores at posttest controlled for pretest values by study condition and SES.

	WM			Shift			Inhibit			plan/org			Emot. Contr.			GEC		
	β	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*
(Intercept)	0.76	0.21	<0.001	2.27	0.52	<0.001	0.59	0.19	0.002	1.13	0.32	<0.001	0.86	0.27	0.002	0.89	0.35	0.010
Pretest	0.68	0.05	<0.001	0.40	0.09	<0.001	0.78	0.03	<0.001	0.61	0.07	<0.001	0.68	0.07	<0.001	0.73	0.05	<0.001
Condition	0.09	0.06	0.173	0.06	0.08	0.436	−0.02	0.06	0.769	0.07	0.09	0.455	0.03	0.06	0.649	0.05	0.07	0.473
Low SES	0.31	0.09	0.001	0.32	0.14	0.018	0.15	0.08	0.058	0.38	0.13	0.003	0.12	0.09	0.200	0.29	0.09	0.001
Condition*SES	−0.27	0.10	0.006	−0.31	0.14	0.030	−0.14	0.08	0.088	−0.33	0.13	0.013	−0.14	0.11	0.199	−0.27	0.10	0.005

Condition = 0, control, 1, experimental; SES = 0, middle-to-high, 1, low SES. Higher scores on EF variables indicate more EF problems.

The program aimed to boost children's EFs through high-quality teacher-child interactions, EF-supporting activities (e.g., games), and a supportive classroom structure. This pilot study used a quasi-experimental pretest-posttest design to compare the "*Put your EF glasses on*"program against standard practice, especially in schools with a high proportion of low-SES children. The effects of the program on the EF development of, specifically low-SES, children appear promising.

Effectiveness of the program

The "*Put your EF glasses on*" program positively affected most EF measures, but only in low-SES children. Much like in the study of Tominey and McClelland (2011), there was less room for improvement in the middle-to-high SES group, as they already had low pretest problem scores. Because these children likely come from more stable home environments with less stress and more stimulation, it is possible that the program did not significantly impact on their EF development (Koşkulu-Sancar et al., 2023). For the low-SES group, the program was found to positively influence children's total EF skills, as indicated by a stabilization in total problem scores. Specifically, teachers reported less problem behavior in low-SES children on working memory, shifting, and planning and organizing. This result is in line with other studies on preschool classroom programs (Diamond and Lee, 2011; Tominey and McClelland, 2011; Blair and Raver, 2014; Schmitt et al., 2015; Pauli-Pott et al., 2021). In addition, improving working memory is favorable for further academic success, as it is strongly related to school readiness, reading and mathematics achievement (Blair and Razza, 2007; Brock et al., 2009; De Smedt et al., 2009; Alloway and Alloway, 2010; Christopher et al., 2012; Vandenbroucke et al., 2017). Furthermore, core EFs, such as working memory and shifting, are the foundation of essential skills for future success, like reasoning, problem-solving, and planning (Diamond, 2013). These first indications of the program's effectiveness may be attributed to several plausible factors. The program's three building blocks (i.e., high-quality teacher-child interactions, EF-activities, and supportive classroom structure) can be linked to the Teaching Through Interactions framework (Hamre et al., 2013). The first building block, high-quality teacher-child interactions, was developed in line with the emotional and instructional support interactions. Attachment theorists suggest that children experiencing emotional supportive interactions from their teachers feel connected to and supported by their teachers (Downer et al., 2010; Hamre et al., 2013). This secure base encourages children to take risks and explore the learning environment, which in turn fosters learning and (EF) development (Verschueren and Koomen, 2012; Nguyen et al., 2020). The program also influences instructional support, where the teachers provide rich instructional opportunities by asking open-ended questions, providing feedback, challenging higher-order thinking and problem solving, and scaffolding, positively influencing children's EFs (Downer et al., 2010; Bardack and Obradović, 2019). The second building block, EF-activities provides children with learning opportunities to practice EF-behaviors. The third building block, supportive classroom structure is based on organizational support within the program help promote children's EFs and engagement in the classroom (Rimm-Kaufman et al., 2009). For example, teachers ensure clear directions, rules, and expectations, and manages children's productivity, engagement and behavior (Downer et al., 2010). Overall, the program's effectiveness can be attributed to its three building blocks, aligned with the Teaching

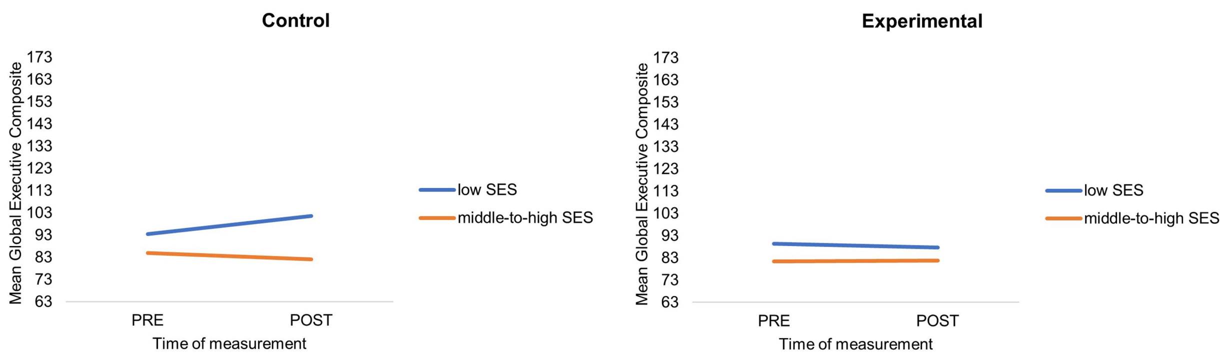

FIGURE 1
Changes in global executive composite problems across groups and timepoints. Higher scores reflect more EF problems.

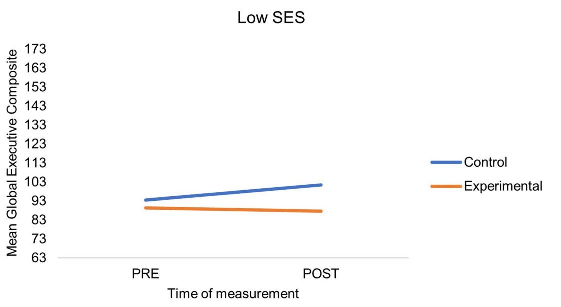

FIGURE 2
Changes in global executive composite problems across conditions and timepoints in low-SES group. Higher scores reflect more EF problems.

Through Interactions framework. By training EFs directly and indirectly, in a child's natural environment (Diamond and Lee, 2011), the program can significantly contribute to children's learning and development by providing emotional and instructional support, explicitly practicing EF behaviors, and creating a supportive classroom environment that promotes EF development. In general, different activities were used to support the development of EFs in children. By providing more structure (building block 3), we believe children are less overloaded, thus providing a more developmentally-appropriate context necessary for optimal cognitive development, including EF development. Along with effective training of EF (building block 2) and teacher scaffolding interactions to support EF development (building block 1), we believe that children have improved in their EF (as reported by teachers). For instance, children were supported by the teachers to inhibit their initial reactions (for example, through the use of stop-think-do strategies), helped become aware of their thoughts and emotions (for example, through the use of think-aloud strategies), and encouraged to find their own solutions. However, future research needs to examine which building block has contributed most to the intervention effect. Although this program affected several EF-problem scales, our results showed no effects on inhibition and emotional control among low-SES children. However, there is a trend where low-SES children showed fewer inhibition problems after the program, but it was not significant, perhaps due to a lack of power ($p = 0.088$). Other preschool classroom programs also did not find an effect on inhibition (Domitrovich et al., 2007; Bierman et al., 2008; Pauli-Pott et al., 2021; Sankalaite et al., 2021). In contrast, the *Tools of the Mind* program did affect inhibition and had even stronger effects for low-SES preschoolers (Diamond et al., 2007; Blair and Raver, 2014). An explanation could be that these studies used performance-based measures instead of questionnaires. Additionally, previous longitudinal research has shown limited internal validity of inhibition in young children (Roebers et al., 2011; Vandenbroucke et al., 2017). As such, this construct might not be ideal for measuring intervention effects.

The program also did not affect emotional control. Emotional control is the child's ability to appropriately modulate an emotional response (Roth et al., 2013). Important to note here is that the program did not explicitly focus on emotional control strategies but embedded emotional control in the three building blocks. For example, as a part of building block 1 (high-quality teacher-child interactions), teachers are encouraged to provide stress relievers to the children. For instance, teachers introduced children to the stop bench. This stop bench is a place for a child to take a moment to reflect on the situation and their behavior and to learn to internalize the stop-think-act strategy. Thus, although the program attended to emotional control, it may not have been enough to improve emotion regulation. Similarly, a review study showed small effects of classroom programs on emotion regulation (Sankalaite et al., 2021). However, preschool programs explicitly focusing on emotional competence only impacted emotion knowledge (Domitrovich et al., 2007; Barnett et al., 2008). On the contrary, another meta-analysis showed that implicit training of self-regulation through mindfulness, for instance, appears more promising than direct training of EFs (Takacs and Kassai, 2019). To nuance, in our pilot study, improving emotional control might be unnecessary because there was no difference at the pretest in emotional control between low-SES and middle-to-high-SES children, suggesting no developmental deficit among low-SES children.

In the control schools (where the teachers practiced teaching as usual), our results suggested that low-SES children developed more EF problems after one school year. In contrast, the EF scores of children from middle-to-high-SES families remained stable, suggesting that their EFs developed normally. As such, there appears to be an expanding gap in the control group in EF problems between children from low-SES and middle-to-high-SES families.

In summary, our promising findings are consistent with earlier research showing that a universal interaction-based classroom program can stabilize the decline of children's EFs in low-SES children (Bierman et al., 2008; Connor et al., 2010; Tominey and McClelland, 2011; Blair and Raver, 2014; Schmitt et al., 2015)., even in the youngest ones (Bierman et al., 2008; Connor et al., 2010; Tominey and McClelland, 2011;

Diamond, 2012; Blair and Raver, 2014; Schmitt et al., 2015). Although positive effects were found among low-SES children, the program reduced but did not eliminate the expanding gap in EFs. Consequently, these results suggest that an EF program spanning over one school year is insufficient to remediate low-SES children's low EF skills fully.

Strengths, limitations, and implications

We acknowledge several limitations of our study. First, given that the schools were selected based on the funder's choice, we applied a quasi-experimental design. Future investigations of the effects of this classroom program should be done in a randomized controlled trial design. This RCT should also include an active control group, in order to minimize the influence of teacher's expectations on their ratings. Second, there was possibly insufficient power to pick up smaller program effects due to the limited sample size. Larger sample size will allow for detecting small or medium effects: roughly 35 clusters of 9 units are needed to have an estimated power of 0.80 (for medium effect size; Scherbaum and Ferreter, 2009). Cohen's d based on post-test scores is added in Supplementary Table 5. Third, the children's EFs were assessed with a teacher-rated questionnaire and not with performance-based measures (Follmer and Stefanou, 2014). It is thought that questionnaires and performance-based measures each evaluate different parts of the same construct: questionnaires assess daily behaviors, while performance-based measures measure the cognitive component (Anderson, 2002). Research has shown that both measures deliver unique information and that combining measures results in the most reliable conclusions (Huizinga and Smidts, 2010; Toplak et al., 2013; Miranda et al., 2015). Moreover, the teacher who carried out the intervention program also evaluated each child's EF development, making this evaluation prone to confirmation bias (Oswald and Grosjean, 2004). Especially since teachers were aware of the study's hypothesis that the program would have a stronger impact for low-SES children, results should be interpreted with caution. However, as there were no effects of the program for middle-to-high-SES children, confirmation bias seems less plausible. Of course, it is also conceivable that the program not only stabilized the occurrence of EF problems in children, but also enhanced teachers' perceived ability to manage them. In this line of thinking, the program could have improved the teachers' self-efficacy beliefs, which research has positively linked to the quality of classroom processes (e.g., instructional support, emotional support and classroom organization; Guo et al., 2010; Zee and Koomen, 2016). Conclusively, improved teacher self-efficacy might lead to improved classroom processes which in turn lead to lower EF problem scores. Fourth, this study had two different experimental groups: an experimental *full* group and an experimental *light* group. The difference between the two groups was that the teachers in the first group received additional weekly in-class coaching on the program and peer-to-peer intervision sessions by an expert trainer (the author of the program). However, our analyses did not reveal different effects of the program for these groups, so the groups were collapsed in further analyses. While information about the optimal implementation model is necessary, this pilot study was not ideal for this research question. Future studies with larger sample sizes and more specific information on the content and form of the personal coaching and the peer-to-peer intervision sessions is necessary. Additionally, a follow-up assessment would possibly reveal differences between the groups, given the additional time for practice with detailed feedback. Fifth, we focused on SES as defined in Belgium. However, we cannot conclude what specific factors related to SES status play a role in the program's effect. Future research should delve more extensively into factors such as home language, income, and family chaos and examine how they influence the effects of interventions. Future research should monitor treatment fidelity (i.e., compliance) and dosage (i.e., the quantity of the program delivered) to ensure an optimal fit between the feasibility and usage of the program (Gottfredson and Gottfredson, 2002; Durlak and DuPre, 2008; Howard et al., 2020). Additionally, insight into the implementation quality through, for example, classroom observations would aid in determining which specific building blocks are most effective. While the program is theoretically supported, it is vital to gain insight into what works and what does not to achieve maximum impact and keep costs as low as possible. Future research should also focus on the program's long-term effects because initially small or absent effects of the program may have a later self-boosting snowball effect (i.e., sleeper effect), or initially positive effects may disappear over time (fading effects; Diamond and Ling, 2016). Last, future research using larger samples should also include analyses of differential effects in specific age groups to assess whether the program benefits young school children of a certain age equally, more or less.

Conclusion

In summary, our pilot study showed that "*Put your EF glasses on*," a classroom-based program targeting teachers' EF-supporting skills, classroom organization and educational activities, positively affected core EFs in preschoolers with low SES. As children at sociodemographic risk (i.e., coming from low-SES families) show an early and persistent disadvantage in EF development (Mezzacappa, 2004; Noble et al., 2005; Farah et al., 2006; Lawson et al., 2018), this program appears to be a protective buffer. However, a randomized controlled trial with sufficient statistical power is needed to confirm these first results.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Social and Societal Ethics Committee of KU Leuven approved this study (G-2016 07 589). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

JS, DB, and JW contributed to the conception and design of the study and oversaw data collection. JS and DB supervised the writing of the manuscript. FD, JS, and DB performed the statistical analyses. SK and FD drafted different sections of the manuscript. All authors contributed to the article and approved the submitted version.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2023.1149977/full#supplementary-material

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