

The Implementation of Preschool Teachers of Embedded Executive Function – Supporting Activities in the Classroom

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Abstract

This study used a mixed-methods research design to examine how preschool teachers in Taiwan implement the embedded executive function (EF)-supporting activities within the classroom and the consequent effects on children's EF and oral language. Twelve teachers and 82 children from two preschools participated in the study. All teachers received training and developed a set of strategies employing embedded EF-supporting activities within the classroom. The study measured children's EF and oral language after a 12-week period. Although significant effects on children's EF were not observed for the overall sample, significant improvement in children's oral language was indicated by the markedly higher scores compared with the pretest. Further analysis indicated that the effects were driven by the preschool with lower EF and oral language. The results demonstrated that EF-supporting activities can enhance the quality of the classroom, including increasing the speed of clean-up, encouraging children to focus on a goal and be responsive to the teachers' directions, and more time for group discussion. The results recommend that teachers need more coaching support. Researchers need to facilitate teachers playing a more active role in designing EF-supporting activities and incorporate more time points to examine the long-term effects on children's EF skills and academic learning.

Keywords: executive function, oral language, executive function-supporting activity, preschool teacher

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Introduction

Executive function (EF) abilities are critical in predicting school readiness and the development of socioemotional and cognitive skills in early childhood (Blair & Peters, 2003; Meuwissen, & Zelazo, 2014). They are also more predictive factors of school adjustment and academic achievement (e.g., literacy and math performance) than intelligence (Blair & Razza, 2007). When children have the ability to control their behavior and follow established rules, they can perform well at school. The development of EFs contributes to a child's self-regulation (Hoffmann et al., 2012; Rueda et al., 2005). Empirical evidence indicated that improving children's self-regulation also showed significant effects on children's math and literacy (Blair & Raver, 2014; Tominey & McClelland, 2011). Research found that the relation between EF, literacy, and math may be bidirectional (Schmitt et al., 2017). It suggests that interventions should target the integration of these skills.

Rich evidence has indicated that EF skills can be fostered through relevant school activities (Diamond & Lee, 2011; Shiu et al., 2018; Takacs & Kassai, 2019). These specially designed activities, such as cognitively challenging physical activities (Diamond, 2015) and early childhood school curricula (Blair & Diamond, 2008; Diamond & Lee, 2011; Riggs et al., 2006) can effectively enhance children's EFs and academic performance. However, these early childhood school curricula are difficult to implement because of the intensive teacher training and special materials required (Lillard, 2013). Researchers have argued for more easily implementable EF interventions (Shiu et al., 2018; Tominey & McClelland, 2011).

Tools of the Mind program (Tools) (Bodrova & Leong, 2001) aims to enhance children's EF skills and has been the subject of several studies. The results provide evidence of the effects of children's EFs and emergent literacy. It suggests that EF functions should be embedded in young children's everyday activities. Based on the Tools studies, Shiu et al. (2018) tested several activities that can be easily used to develop young children's EFs in the classroom and reported a positive result. However, the studies in embedded EF-supporting activities are usually implemented by researchers with fixed frequencies and times, there is a need to further examine how teachers would implement the embedded EF-supporting activities in a daily classroom schedule and the effects on young children's EF and pre-academic performance.

Literature Review

Development of EFs

EFs constitute higher-order cognitive and self-regulatory processes that underlie flexible goal-directed behaviors (Miyake et al., 2000). From the three core EFs of attention shifting (also called cognitive flexibility), working memory, and inhibitory control, higher-order EFs such as reasoning, problem solving, and planning are constructed (Collins & Koechlin, 2012). In contrast to operating on ‘automatic pilot’, using EFs requires effort, requiring a child to resist temptation and consider their next action. The development of EFs relies on the prefrontal cortex, which is the last area to develop in the brain (Diamond, 2002). The prefrontal cortex contributes to various EFs, including attention, prediction, impulse control, planning, and the coordination of complex behaviors (Fuster, 2001). EF development is part of children’s rapid neuronal growth between the ages of 2 and 5 years (Diamond, 2002). By stimulating the brain function, EF skills can be trained from an early age. Children’s EF can be improved through repeated practice and challenging EF activities, such as computer-based training, certain school curricula, traditional martial arts, yoga, aerobics, and mindfulness training (Diamond and Lee, 2011). But most of these EF training activities are not fit for young children, they are designed for older children.

Intervention and EFs

Several EF-supporting activities were determined to be effective in improving young children’s EFs; these included computer interventions and the incorporation of EF processes in classroom activities. Computer interventions can be valuable tools for stimulating EF skills (Diamond, 2012; van de Sande & Verhoeven, 2016); however, computer-based training focusing on particular EFs did not promote improvement in untrained tasks. Another concern is that playing computer games in preschool classrooms would not be a good idea for its isolated from other activities and real-life problems. Many researchers call for a social constructivist approach as a way to help young children learn in the natural context (Fish et al., 2011). Instead of a single isolated module, school curricula that embed EF practice in all

activities throughout the day provide more opportunities for repeated practice to improve the various components of EF (Diamond et al., 2007; Lillard & Else-Quest, 2006; Raver et al., 2011). Takacs and Kassai (2019) analyzed 90 studies that incorporated the data of 8,925 children and proposed that activities that implicitly foster EFs are more effective and enjoyable and can be more easily embedded in children's everyday activities than can explicit training.

According to Diamond (2012), one promising intervention approach is curricula specifically designed for EF skills such as Tools (Diamond et al., 2007), Montessori (Lillard & Else-Quest, 2006), PATHS (Riggs et al., 2006), and CSRP (Raver et al., 2011). These programs share common features: aiding children in exercising their EFs in daily life, decreasing stress in the classroom, and emphasizing oral language skills. These programs are used with children aged 3 to 6, with assessment concentrating on inhibitory control. Tools is a curriculum based on the work of Vygotsky (1978) and designed specifically to promote EF skills (Bodrova & Leong, 2001). In Tools, teachers spend 80% of the day supporting EF skills. Practicing these skills through daily activities assists in generalizing these abilities—enabling children to deploy them in new contexts, and the amount of time children spend working on these skills is the key to improving their EFs. Studies on Tools indicated significant improvement of EF in 5-year-old children (Diamond et al., 2007) and especially the growth of emergent literacy skills (Barnett et al., 2008), while some found no effects of Tools on child abilities (Clements et al., 2012; Lonigan & Phillips, 2012; S. J. Wilson & Farran, 2012). When a whole curriculum is implemented in preschools, the effect of EF activities on children's abilities may be influenced by the qualities of teachers' training, reflections, and professional development (Lillard, 2013).

Given the challenges in fully adopting a whole school curriculum for EF, Research suggest that EF-supporting activities should be simple and easy for teachers to implement in the classroom. Tominey and McClelland (2011) selected a series of games (e.g., The Freeze Game) to be implemented in 'circle time' in a kindergarten and preschool. These games are similar to the motor activities employed in Tools curriculum. The intervention was held twice weekly over 8 weeks, and each session was approximately 30 min. All sessions were led by the same researcher to ensure continuity. The research showed no significant difference between the treatment and control groups; however, significant gains were observed in

children with low pretest scores. Hence, the use of a single EF aspect (inhibitory control) and a frequency of twice per week may be insufficient for enhancing the EF of the participants overall. Chien (2020) designed memory-inhibitory control activities and embedded these activities in repeated read-aloud programs, with interventions held by five highly trained college students four times per week for 9 weeks, with each session lasting 30 min. The findings revealed that the treatment group significantly improved in terms of oral language comprehension and EFs compared with the control group. However, these EF activities focus on training children's single ability through repetitive responses to adults' oral directions. It may make teachers and children feel bored and not easy to be implemented daily.

Instead of providing a single EF aspect through repeated practices, researchers (Meltzer et al., 2007) have suggested that by addressing multiple EF processes (such as goal setting, planning, organizing, prioritizing, flexibly shifting strategies, and self-checking) through rational teaching strategies in the classroom, teachers can enhance children's EFs. Based on the Tools, Shiu et al. (2018) incorporated the EF processes of planning, concrete aids, motor activities and storytelling into the daily classroom schedule, and found significant gains in Head Toes Knees Shoulders (HTKS) evaluation. These intervention activities were fitted into the class schedule without substantially changing the basic curriculum. A total of 94 young children participated in the study for 12 weeks, with the researcher holding intervention sessions during school transition time for at least 50 min 3 days per week. By providing multiple embedded EF-supporting activities that teachers can implement flexibly based on their classroom contexts, thus, teachers and young children can engage in meaningful and enjoyable EF practices. Moreover, teachers can encourage young children to plan ahead, to be self-directed and self-regulated.

Some embedded EF-supporting activity interventions focus on a single EF aspect with limited effect, while some interventions emphasized intensive repeated trainings that make children and teachers feel bored, the approaches that implicitly foster EF functions in activities that can be embedded in preschool's daily life seemed more effective and meaningful for young children. However, the embedded EF-supporting activity interventions mostly were conducted by the researchers, whether the interventions would still be effective if teachers implemented these activities in the classroom remains unclear. It is clear that certain EF-supporting activities can enhance children's EFs, but we don't know how teachers

would bring these activities into their classrooms beyond the life of research. Furthermore, when teachers use these interventions in their own ways, there is a need to clarify if the frequency and length of these activities are sufficient to improve children's EFs.

Present Study

The purpose of this study was to explore how teachers can implement embedded EF-supporting activities into their daily classroom schedule and the consequent effects on children's EF and emergent literacy skills. Considering that most preschool children do not formally learn to recognize letter in Taiwan, the study focused on measuring children's oral language. Oral language is one of the components of emergent literacy skills measured in preschool. It involved skills such as word knowledge, vocabulary, and understanding grammatical rules and word order (Storch & Whitehurst, 2002). This study introduced the concept of embedded EF-supporting activities to participating teachers through limited training and encouraged teachers to incorporate the activities into the classroom flexibly. The following two research questions guided this study: (a) What are the processes that teachers implement EF-supporting activities in the classroom (frequency, time, and type of activities)? (b) How sufficient is the small-scale intervention implemented by teachers to enhance children's EFs and oral language?

Method

This study used a mixed-methods research design to examine how teachers can implement embedded EF-supporting activities in the classroom and the resultant effects on children's performance. The qualitative component comprised interviews with 12 teachers, and the quantitative measure involved pretest and posttest assessments of EFs and oral language. The teachers completed checklists during the study period.

Participants

Eighty-two children and 12 teachers from two nonprofit preschools located in southern

Taiwan participated in the study. The nonprofit preschools both follow a similar curriculum and instructional design (thematic and learning corners), and to ensure the quality of the teaching, their curricula and instruction are evaluated by outside experts every 3 months. All the teachers received a bachelor degree in early childhood education. Most teachers have less than 5 years of service.

Kindergarten is considered preschool education in Taiwan, with schools accepting children from 2-to-5 years old. Age differences can influence EF task measures, and therefore, only children 4-to-6 years old at the time of enrollment were recruited. The average age of participants was 61.18 months (range = 47–71 months) at the beginning of the study. Preschool One is located in a rural area and had 24 children with an average age of 60.04 months. Preschool Two is located in a suburban area and had 58 children with an average age of 61.66 months. No significant difference in children's age was noted between the two preschools ($t = 1.047, p = 0.298 > 0.05$). Table 1 details the gender makeup of the sample of 82 children, with no significant difference in gender noted between the groups ($\chi^2 = 0.020, p = 0.89 > 0.05$). The maternal education level of the participants is listed in Table 2; 47.6% of mothers had a college degree, 26.8% had a high school diploma, 12.2% had a junior college diploma, and 13.4% had a master's degree. A chi-squared test was applied to examine the differences in maternal education levels among preschools, and a significant difference was observed ($\chi^2 (3) = 10.4, p = 0.15 < 0.05$). Preschool One had a higher percentage of mothers who completed high school than Preschool Two, and suburban Preschool Two had a higher percentage of mothers who completed college than Preschool One.

Table 1. *Gender Makeup of Two Preschools*

Child's gender Preschools	boys		girls		total		Chi-square		
	n	percent	n	percent	n	percent	χ^2	df	<i>p</i>
Preschool 1	12	50.0	12	50.0	24	100	.02	1	.89
Preschool 2	28	48.3	30	51.7	58	100			
Total	40	48.8	42	51.2	82	100			

Table 2. *Highest Maternal Education Level of the Two Nonprofit Preschools*

Preschools	High School Junior College		College		Masters		Total	Chi-square				
	n	percent	n	percent	n	percent	n	percent	χ^2	df	p	
Preschool 1	12	50.0	3	12.2	8	33.3	1	4.2	24	10.4	3	.015*
Preschool 2	10	17.2	7	12.1	31	53.4	10	17.2	58			
Total	22	26.8	10	12.2	39	47.6	11	13.4	82			

*** $p < 0.001$

Procedures

At the beginning of the preschool year (August), consent forms were issued to parents of the two nonprofit preschools, the teachers and directors of which had agreed to participate in this study. A total of 82 consent forms were returned. The study was conducted in three parts, namely a pretest in August, intervention period conducted by teachers, and posttest in November. Each child completed an oral language test and an EF task with two measurements.

The participating teachers received 3 hours of training in July, during which they learned the concepts of embedded EF-supporting activities and incorporated these activities into their classroom daily schedules through teachers' group discussion. The teachers can use these activities flexibly according to their classroom context. The teachers recorded the frequencies of and time spent implementing the embedded EF-supporting activities on a checklist weekly. All teachers were interviewed in December.

Measures

HTKS Task

This study used the HTKS task to measure the EF ability of the participants for the pretest and posttest. The HTKS measurement of children's EFs requires children to pay attention, remember, and respond to four different behavioral commands in which the responses are opposite to the commands (e.g., touch your toes when told to touch your head). The HTKS is a reliable and valid measure of children's EFs. The task is short (about 5min) with good inter-rater reliability ($\kappa = 0.90$; Ponitz et al., 2009; McClelland and Cameron, 2012). During

the task, children were asked to touch their head (toes) when asked to touch their toes (head) in the first 10 questions. In the next section, children were asked to remember opposing rules involving four body parts (head, toes, knees, and shoulders) in the second 10 questions. The possible score for each item is 0, 1, or 2. Zero is an incorrect response; 1 is a self-correct; and 2 is a correct response. The scores range from 0 to 40. A child with higher scores represents higher levels of EFs.

Preschool Oral Language Syntax Comprehension Test

To measure the oral language of the participants, this study employed a preschool oral language syntax comprehension test from Preschool and Elementary School Oral Language Syntax Diagnostic Tests designed for Taiwanese children (Yang et al., 2006). The test was used to assess the oral language, comprehension, and grammar development of 5-to-8-year-old children. The test is divided into phonology, semantics, and syntax with 8 sets of questions for preschool children. The test is about 15 minutes.

Designated Activities

The study applied a set of activities that can fit into a classroom schedule and have proved effective for children's EF development (Shiu et al., 2018). These embedded EF-supporting activities consisted of planning before entering learning corners, playing songs for clean-up time, using concrete aids in group discussion to signal the speaker, peer storytelling, and seven motor activities (Chewing Gum Game; Red Light, Green Light; Falling, Falling Down; Freeze Game; Simon Says; Drum Beats Game; and Poker Card Game). These cognitive tools or external mediators serve to remind children and facilitate adequate behaviors during the activities and contain EF components to foster attention, working memory, and inhibitory control. Children must remember several instructions and follow them by paying attention to continually changing signals.

Data Analysis

For research purposes, the checklists were analyzed to determine the weekly frequencies with which the activity types were implemented. The teachers' interview data were analyzed

by documenting the methods through which they implemented each type of activity and how much time was assigned to each. Data were coded by data source, role, and date. Ex., The teacher from Preschool One classroom 3 interviewed in 12/12/2018 was coded as A3 121318.

An independent-samples *t* test was applied to analyze the initial and follow-up HTKS measurements and oral language data between two preschools to understand the group differences prior to and after the intervention. The chi-squared test was also applied to examine group differences relating to children's gender and maternal education. Furthermore, a dependent-sample *t* test was used to analyze the time effect of initial and follow-up HTKS measurements and oral language for each preschool.

Results

The results are presented in three sections. We first present the frequency of embedded EF-supporting activities on a weekly basis. Second, we discuss the application of every type of activity. Then, we present the descriptive statistics of child assessment data to illustrate the picture that teachers bring the EF activities into their classrooms and the effects on children's abilities.

Frequency of Embedded EF-Supporting Activities

The participating teachers reported the frequencies with which they implemented the various embedded activities by checklists weekly. According to the checklist results (Figure 1), the teachers used planning and clean-up songs in their classrooms prior to the teachers' training and continued to use them after training. The frequency of motor activities increased from twice per week to 3 or 4 times per week after the teacher training. The frequency of concrete aid uses mildly increased, and teachers reported implementing storytelling only in mid-November; therefore, storytelling frequency exhibited a reduction during data collection. Based on this data, teachers increased the frequency with which they implemented the designed activities after their training and tended to implement activities that already existed in the classroom more often.

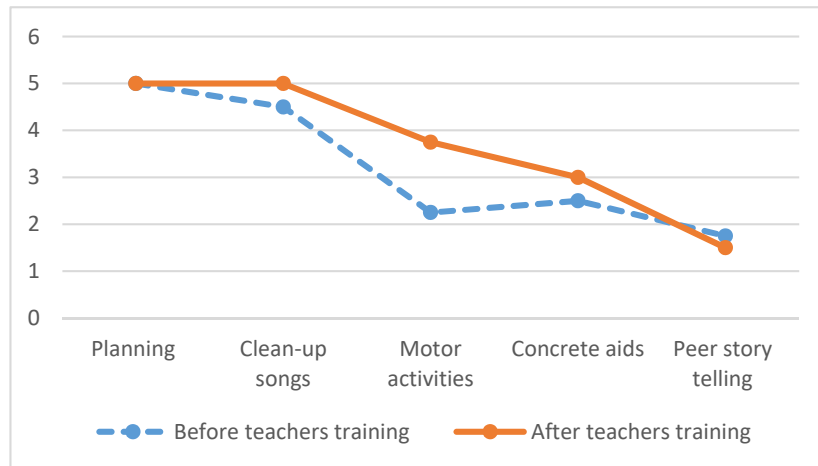


Figure 1. Weekly frequencies of implementing embedded EF-supporting activities

Application of Activity Types

The embedded EF-supporting activities were designed to be implemented during transition time without altering the preschool curriculum. According to teachers' interview data, they developed rational teaching strategies to implement these activities in the classroom. They did not implement all embedded EF-supporting activities at the beginning of the school term in August; concrete aids, clean-up songs, and motor activities were used in August, planning was adopted after September, and peer storytelling was employed in mid-November.

Planning Sheets Remind Children to Engage in Purposeful Activities

The teachers allowed children to engage in planning before entering the learning corners. After the teacher training, they understood the functions of planning and changed their format. They added more information to the planning sheet, including the date and the names of peers. Moreover, the planning sheets were given to children by month. Teacher A1 said,

I feel planning is different for our students now. They would look over the monthly planning sheets and think "who played with me in the block area yesterday?" Then, they would invite their friend by saying "are we going to the block area again?" When they looked at the previous planning sheet, they were reminded" (A1 121318).

Many other teachers had similar feedbacks. The teachers discovered that adding the date and peer information to the planning sheet and binding the sheets monthly encouraged the children to engage in more purposeful and extensive activities.

Clean-Up Songs Encourage Children to Complete Required Tasks Timely

Prior to teacher training, no teacher had a fixed time for clean-up. The teachers played clean-up songs once or twice depending on the children's clean-up speed, and some teachers did not have regular songs for clean-up. After the training, they chose regular clean-up songs and a fixed time for clean-up activities. The teachers noticed that children's behavior changed after playing the clean-up songs regularly. Teacher A1 stated that children now clean up more effectively:

The children didn't clean up well before, leaving a lot of objects in the learning corners and running to the circle time area. Now they can follow the music and finish clean-up entirely before the end of the second song' (A1 121318).

Teacher A3 said that the children learned to predict how much time remained to finish their work and aimed to complete clean up before the two songs ended:

During the first song, the children thought they had plenty of time to finish the work but cleaned up more quicker during the second song. They learned to watch the time and plan their actions' (A3 121318).

The teachers observed that a fixed time for clean-up songs allowed children to make a decision about finishing their work, delaying the unfinished work, or cleaning up directly. Teacher B2 noted that children were more willing to clean up when they were allowed to make decision by themselves. She said,

The speed of clean-up increased when the children could choose to finish their work or clean up directly' (B2 121318).

The teachers did not have to vocally remind the children to clean up because the children could plan their own actions according to the length of the clean-up songs.

This information indicated that a fixed time for clean-up songs encouraged children to

build the habits of cleaning up, time control, and decision making. Eventually the children can effectively and timely complete the required tasks.

Concrete Aids: You Don't Have the Microphone; You Can't Speak Now

The application of concrete aids in children's group discussion was a new concept. Teachers could use a microphone, pen, or block to signal who was the speaker; through this, children learned to take turns speaking during group discussion. Teacher A3 observed that

The children began to look at the microphone, thinking about who had it, and when their turn was coming. They would address other children and say "You don't have the microphone; you can't speak now" (A3 121318).

Concrete aids such as a microphone provided a visible sign, guiding children to follow the speaking rule within group discussions. But not every teacher used concrete aids during group discussion. Teacher B2 said,

Our children take turns speaking, so we don't need concrete aids' (B2 121318).

Teachers sometimes chose to use the embedded activities based on their classroom management needs rather than to promote children's EF development.

Motor Activities Help Children Focus on the Goal and Increase the Speed of Gathering

The original design called for the motor activities to be incorporated into circle time for 15 to 30 min (Shiu et al., 2018). However, teachers in this study used the motor activities strategically to attract children's attention before group discussion and outdoor gathering. The teachers would choose one motor activity and play it with the children each time. All teachers agreed that the motor activities encouraged children to gather quickly and pay attention to the teacher's cues. Teacher A4 stated,

We didn't play these games regularly before. After the teacher training, we kept this in mind and played these games before group discussion... we still do it now. It became a routine—clean-up songs and then the motor game, and it can help children focus on the goal and engage quickly in the

activities (A4 121318).

The teachers strategically used the motor activities after the clean-up songs. As Teacher B2 said,

If the children looked overexcited after clean up, we would perform one motor activity. If they were calm and ready to listen to the teachers, we would skip the motor activity (B2 121318).

Most teachers did not use all seven games covered during teacher training but employed games they believed could enhance the children's attention, such as Falling, Falling Down and the Poker Card Game. When the children were required to gather, teachers would say 'falling, falling down,' and the children looked at the teacher, asked 'what is falling down,' and ran to the teacher. This increased the speed and efficiency of gathering.

Moreover, the routine of playing the motor game promoted bonding between teachers and children in the classroom. Some teachers observed that the use of motor activities not only changed the speed of gathering and promoted team chemistry in the classroom but further enhanced the quality of group discussion. Teacher A4 observed that

At first, we needed to spend a lot of time gathering, but 2 months later, we had built a routine and could spend longer in group discussion (approximately 30 min). When we have more time, the quality of the discussion is better (A4 121318).

According to the checklist, teachers increased the frequency of motor activity implementation in the classroom following the teacher training; however, teachers' interview data revealed that teachers only played one motor activity at a time and the amount of time spent on motor activities was approximately 5 min less than in the intervention studies. Similar to the use of the concrete aids, the teachers' use of motor activities depended on classroom management needs.

Peer Storytelling: Not Ready for It

Among the participating teachers, only one teacher implemented peer storytelling during the entire study period. Most teachers implemented peer storytelling from mid-November

because they thought the children were not ready for this activity at the beginning of the school year. Therefore, peer storytelling was not used by most teachers between the two measurements.

Based on the teachers' reports, the application of clean-up songs and motor activities increased the speed of clean up and gathering, and as a result, extended the time for group discussion. With concrete aids, teachers were able to spend less time restoring order in the classroom and focus on the quality of group discussion.

Analyses of Child Assessment Data

Table 3 presents the descriptive statistics of the children's HTKS and oral language measures from the two preschools. The average HTKS score all 82 participants was 32.49 and 31.60 at pretest and posttest, respectively; the average oral language performance scores were 22.99 and 25.73, respectively. An independent *t* test was applied to examine the differences between groups in regards to the HTKS and oral language measurements. These findings revealed a significant difference on the initial tests of HTKS but not on the oral language scores, indicating that the children's oral language performance was similar between the two preschools prior to intervention. However, children's EFs in the two preschools differed, with Preschool Two exhibiting higher EFs (Table 4).

Table 3. *Descriptive Statistics for All Measures*

Measurements	Preschool 1 (n=24)		Preschool 2 (n=58)		Total (n=82)	
	M	SD	M	SD	M	SD
HTKS						
Pretest	27.92	9.36	32.97	4.04	31.49	6.46
Posttest	29.13	5.49	32.62	6.38	31.60	6.31
Oral language						
Pretest	19.92	10.23	24.26	8.18	22.99	8.98
Posttest	26.88	5.70	25.26	8.00	25.73	7.40

*indicates significant difference between two groups

Table 4. *Comparison between Groups of Pretest and Posttest HTKS Measurements*

	Pretest					Posttest			
	N	M	SD	<i>t</i>	<i>Sig.</i>	M	SD	<i>t</i>	<i>Sig.</i>
Preschool 1	24	27.92	9.36	2.55	.017*	29.13	6.38	2.38	.021*
Preschool 2	58	32.97	4.04			32.62	5.49		

Comparison of Group Differences for Posttest HTKS and Oral language

An independent *t* test was applied to examine the group differences in EFs and oral language in the posttest (Table 4). The findings revealed a significant difference in the posttest HTKS scores of the two preschools. The children's follow-up EF scores were also different between the two preschools, with Preschool Two students exhibiting higher EFs.

Comparison of Time Effect on HTKS and Oral language

A paired-samples *t* test was used to examine the differences in EFs and oral language between the pretest and posttest results. No significant difference was observed in the pretest and posttest HTKS scores, with $t = 0.142$, $p = 0.89 > 0.05$. However, a significant difference was noted in the pretest and posttest oral language results, with $t = 2.39$, $p = 0.02 < 0.05$ (Table 5); the children's posttest scores for oral language were significantly higher than those of the pretest.

Table 5. *Comparison between Pretest and Posttest Oral Expression Measurements for All Students and Preschool One*

	N	M	SD	<i>t</i>	<i>Sig.</i>
All Students					
Pretest	82	22.99	8.98	2.39	.02*
Posttest	82	25.73	7.42		
Preschool One					
Pretest	24	19.92	10.23	4.12	.000**
Posttest	24	26.88	5.70		

* $p < 0.05$, ** $p < 0.001$

Comparison of Treatment Effect on HTKS and Oral language

The paired-samples t test was also used to examine the differences in EFs and oral language between the pretest and posttest results of each preschool. The results indicated a significant difference between pretest and posttest oral language results for Preschool One, with $t = 4.12$, $p = 0.000 < 0.001$ (Table 5). These finding indicated that Preschool One students' posttest oral language scores were significantly higher than those of the pretest. However, no intervention effect was observed on the HTKS and oral language performance of Preschool Two students.

Conclusions

This study examined how preschool teachers implemented embedded EF-supporting activities and the consequent effects on children's EFs. The teachers from the two participating preschools shared similar experiences and progress in implementing the embedded EF-supporting activities. The results demonstrated that embedded EF-supporting activities can enhance the quality of the classroom experience, including increasing the speed of clean-up and gathering, encouraging children to focus on a goal and be responsive to the teachers' directions, and fostering team chemistry in the classroom. Consequently, more time was afforded for group discussion. Teachers developed a set of strategies to use embedded EF-supporting activities to facilitate classroom management and improve the quality of group discussion. This study investigated the effects of the teachers' implementation through measurement of the children's EFs and oral language over 12 weeks. Although no significant effects on children's EFs were observed for the overall sample, significant gains were noted in regards to children's oral language, with significantly higher posttest scores than those of the pretest. Further analysis indicated that these effects were driven by the preschool students with lower EFs and oral language.

Discussion

Contrary to our expectation, no direct posttest effect on children's EFs was observed. Researchers (Diamond, 2012; Tominey & McClelland, 2011) have reported that the dosage (i.e., how much time is spent for each individual session) and frequencies of an intervention influence the effects on children's EFs. Unlike school curricula, teachers can spend up to 80% of each day supporting EF skills, and EF intervention studies tend to have intense frequencies and dosages of each activity. For example, Shiu et al. (2018) implemented all types of intervention activities for at least 50 min three times per week for 12 weeks. Chien (2020) held EF interventions four times per week for 9 weeks, with each session lasting 30 min. In the present study, although teachers increased the frequency of implementing the EF-supporting activities to 3-to-4 times per week, they did not use all seven motor activities and only played one motor activity for approximately 5 min each time. Additionally, most teachers did not implement peer storytelling across the study period. Differences in the dosage and frequencies of activities in the teachers' implementation may induce different effects on children's EFs. Therefore, the lack of a posttest effect may be attributed to the implementations being too short to exert direct effects on children's EF skills.

Based on quantitative data, although no direct effects on children's EF measurements were observed, the teachers reported that the strategic implementation of the embedded EF-supporting activities assisted children in controlling their behavior and following the rules. The improvement in classroom quality was reflected in the improvements in children's oral language, especially for children with initially low EFs and oral language. These findings are consistent with research (Blair & Razza, 2007) that demonstrated improved behavioral control in children can enhance their school readiness and academic learning, especially for the children with low self-regulation.

The strength of this study is that teachers implemented the embedded EF-supporting activities in their classrooms. Teachers also expressed preferences in selecting the type of activities and developing a rational routine in the classroom based on classroom management needs. The study design differed from that of other embedded EF-supporting activity studies that provided EF skill training through computer software or outsider intervention. Within a natural classroom context, teachers did not implement these activities as much as in the

intervention studies. Therefore, the effects of the intervention studies can be difficult to generalize directly to natural settings. The study captured the means through which teachers turned intervention activities into a daily classroom routine. It suggests that teachers can play a more active role in designing EF- supporting activities. Researchers should work with teachers to design more attractive and meaningful EF activities that teachers and children will continue to use in everyday life. The study also explored the effects of the dosage and frequencies of different activity types, which indicated that the dosage of motor activities and peer storytelling are crucial to enhancing children's EFs.

A primary limitation of the study is that we only performed two measurements in 12 weeks. To understand the effects of teacher implementations, the study must conduct a third measurement at the end of the school year to further examine the long-term effects on children's EFs. In addition, three-hour teachers training was not enough to ensure the quality of EF activities. Although significant effects were observed, the small sample size of 82 children was another limitation that weakened the statistical power.

Recommendations

Future research should provide more teacher training for EF activities and invite teachers participating in the process of designing the EF tasks with researchers according to their children's needs and classroom context. In addition, researchers must incorporate more time points to examine the long-term effects of teachers' implementation on children's EF skills and academic learning. Moreover, researchers must regularly observe teachers' implementation in classrooms to learn how teachers and children stay engaged in the EF tasks.

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