Ranking of Activities in the Zambian Early Childhood Education Syllabus by Executive Function Stimulation Potential

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ABSTRACT

The study assessed the executive function stimulation potential of activities contained in the redesigned Zambian Early Childhood Education Syllabus and ranked them according to their capacity to promote executive function skills among preschool learners in Lusaka Province, Zambia. The purpose of the study was to categorize and rank activities in the Zambian ECE syllabus across the 9 executive function sub domains based on their stimulation potential to overall executive function outcomes. A total sample of 414 participants was recruited in the study. The study employed a mixed-methods approach, specifically utilizing an embedded research design. Data were collected using interview guides, EF was objectively measured using a Standardized Neuropsychological Testing Battery with a precision reliability coefficient of 0.80 (Kabundula, 2022), The Kaufman Pattern Reasoning Test was administered to assess general intelligence as a potential confounding variable, while a Biographical Data Form was used to measure socioeconomic status. The internal consistency of the confounding measures was established using Cronbach's alpha ($\alpha = .85$). The study found that the treatment and control groups demonstrated baseline equivalence across all three core executive function skills (all $p > .05$), establishing comparable starting points. Post-intervention analysis revealed statistically significant improvements in the mean scores for the treatment group across the core executive function skills, working memory ($M = 0.368$ vs. 0.233, $p < .001$, $d = 0.612$), inhibitory control ($M = 0.484$ vs. 0.352, $p < .001$, $d = 0.474$) and cognitive flexibility ($M = 0.394$ vs. 0.272, $p = .007$, $d = 0.335$), demonstrating substantial intervention efficacy with large to medium effect sizes. Analysis of the redesigned Zambian Early Childhood Education syllabus revealed triad levels of executive function stimulation potential across different activity categories. Activities targeting the core executive function skills emerged as the strongest predictors of executive function. Among these, Working Memory activities were the most significant predictor of EF ($\beta = .95$, $r^2 = .47$, $p < .001$), followed by Inhibitory Control activities ($\beta = .93$, $r^2 = .42$, $p < .001$) and Cognitive Flexibility activities ($\beta = .90$, $r^2 = .34$, $p = .004$). The second level category demonstrated moderate EF stimulation potential and included Plan and Organize ($\beta = .88$, $r^2 = .29$, $p = .009$), Emotional Control ($\beta = .85$, $r^2 = .23$, $p = .008$), Initiate ($\beta = .82$, $r^2 = .17$, $p = .030$), Task Monitor ($\beta = .79$, $r^2 = .13$, $p = .040$), and Self-Monitor ($\beta = .75$, $r^2 = .10$, $p = .040$). Organization of Materials activities fell in the third level and exhibited the lowest and non-significant EF predictive stimulation potential ($\beta = .70$, $r^2 = .04$, $p = .154$). The findings suggest that activities targeting core executive function skills, particularly Working Memory, Inhibitory Control and Cognitive Flexibility, should be prioritized by education stakeholders in the implementation of the redesigned ECE syllabus, as they demonstrated the greatest potential for enhancing executive function development among preschool learners in Zambia. The study further, recommends that curriculum specialists, in collaboration with relevant education authorities in Zambia, should formally adopt and oversee the implementation of this re-designed Zambian Early Childhood Education syllabus in public preschools.

Keywords: Executive function Stimulation potential, Ranking, categorization of ECE activities into executive function subdomains.

INTRODUCTION

Executive function (EF) refers to the set of higher-order cognitive processes and regulatory mechanisms that enable children and adults to engage in intentional, goal-directed behavior and self-control (Anderson, 2002; Diamond, 2002). These critical skills form the foundation for academic achievement, social-emotional development, and long-term success across multiple life domains (Ahmed et al., 2019; Blair & Razza, 2007). The three core skills of executive function namely working memory, inhibitory control and cognitive flexibility undergo rapid developmental changes during early childhood, making this period particularly sensitive for intervention and educational support (Best & Miller, 2010; Garon et al., 2008) Empirical evidence has consistently demonstrated that children with well-developed executive function exhibit superior academic performance, particularly in literacy and mathematics (Ahmed et al., 2019; Cantin et al., 2016; Wolf & McCoy, 2019). Furthermore, early childhood experiences that foster executive function development have shown to predict school readiness and facilitate successful transitions to formal schooling (Kaani, 2006, Blair & Razza, 2007; McClelland et al., 2014). Given the significant implications of executive function for child development, educators and policy makers increasingly recognize the importance of incorporating intentional EF promoting activities into early childhood education curricula (Diamond & Lee, 2011; Zelazo & Carlson, 2012).

In low and middle income countries, including Zambia, early childhood education systems are expanding rapidly, yet curriculum implementation often lacks explicit consideration of cognitive development mechanisms such as executive function (Chansa-Kabali, 2014; Zuilkowski et al., 2012, Kaani, Mulubale and Mulenga, 2016, Kaani, 2019, Kaani and Machila, 2022). The Zambian Early Childhood Education syllabus provides a broad framework for learning experiences; however, the extent to which current prescribed activities meaningfully stimulate executive function development remains unclear. Understanding which activities within this syllabus are most effective at promoting executive function would enable educators to optimize classroom time and resources (Howard et al., 2017; Jacob & Parkinson, 2015). Numerous intervention studies have documented that various activities including games, music, movement, role-play and structured physical activities can significantly enhance executive function in preschool aged children (Rosas et al., 2019; Suppalarkbunlue et al., 2022; Gibb et al., 2021). However, these studies have typically been conducted in controlled experimental settings or affluent contexts, limiting their applicability to resource constrained Zambian educational environment. Moreover, no systematic investigation has yet examined how activities embedded within Zambia's national early childhood education syllabus map into the empirical evidence regarding EF stimulation potential.

This current study presented a comprehensive ranking of activities in the Zambian Early Childhood Education syllabus according to their evidence based potential to stimulate executive function development among preschool learners. Synthesizing research on executive function development, pedagogy and intervention efficacy by identifying which syllabus-prescribed activities best align with contemporary neuroscientific and educational evidence on EF promotion is cardinal. The ranking done by the current study serves to provide Zambian educators with evidence-based guidance for prioritizing activities that simultaneously meet curriculum requirements and maximize cognitive development and contribute to the growing literature on culturally responsive, context appropriate approaches to early childhood education in African contexts. The findings have implications not only for Zambian early childhood practitioners but also for other African nations developing or revising their early childhood education curricula with a commitment to evidence-based practice and equitable educational outcomes.

Statement Of the Problem

The importance of early stimulation of executive functions (EF) has been widely recognized because of its significant contribution to school readiness, academic achievement, self-regulation, problem-solving and long-term life outcomes (Diamond et al., 2007; Diamond & Lee, 2011; Zelazo & Carlson, 2012; Blair & Raver, 2014; Gunzenhauser & Nückles, 2021; Muir et al., 2023; Kabundula, 2022). In Zambia, several studies have reported deficits in executive function skills among preschool and primary school learners and have highlighted the limited stimulation of executive functions during early childhood (Mwanza-Kabaghe, 2015; Kalumba, 2017; Namushi, 2021; Mutambo, 2022; Kabundula, 2022; Walubita, 2022; Namushi, Kabundula, & Mwanza-Kabaghe, 2023; Kabundula and Namushi, 2023).Although the Zambian ECE syllabus contains a variety of

learning activities, there has been limited evidence regarding the extent to which these activities support different executive function domains and their relative contribution to overall executive function development. The current study addressed this gap as it systematically identified, redesigned and ranked activities in the Zambian ECE syllabus across the 9 executive function sub domains based on their contribution to overall executive function outcomes among preschool learners.

Purpose Of the Study

The purpose of the study was to categorize and rank activities in the Zambian ECE syllabus across the 9 executive function sub domains based on their stimulation potential to overall executive function outcomes among preschool learners in Lusaka Province, Zambia.

THEORETICAL FRAMEWORK

This study was guided by Baddeley's Multi-Component Model (1996). The theory posits that executive function domains operate simultaneously and contribute differentially to cognitive processing and learning. The model identifies the phonological loop, visuospatial sketchpad, central executive, and episodic buffer as interacting components that support the acquisition, retention and integration of information. The relevance of the theory to the current study was based on an assumption that the central executive, which regulates attention, working memory, inhibition, and cognitive flexibility which are core executive functions skills targeted in early childhood education which was the focus for the current study. The model therefore provided a theoretical basis for ranking ECE activities according to their potential to stimulate executive function.

METHODS AND MATERIALS

Research design: The study employed a mixed-methods approach using an embedded research design, allowing for the systematic integration of qualitative data from education stakeholder interviews with quantitative data collected through objective assessments of preschool learners' executive function skills.

Participants and Study Location: Eligible participants were preschool learners, preschool teachers, Head teachers, Standard officers and a Curriculum Specialist recruited from the six districts of Lusaka Province.

Sample size: A total sample size of 414 comprising 269 preschool learners, 120 preschool teachers, 12 Head teachers, 12 Standard officers and 1 Curriculum Specialist were recruited into the study.

Data Collection: Data was collected using Standardized Neuropsychological Testing Battery with precision reliability coefficient of 0.80 (Kabundula, 2022). It served as the objective measure of executive function skills. The Kaufman Pattern Reasoning Test was administered to assess cognitive ability as a potential confounding variable. In addition, a biographical data questionnaire was utilized to measure Socioeconomic status. The internal consistency of the confounding measures was established using Cronbach's alpha ($\alpha = .85$), indicating good reliability.

Data analysis: Statistical analyses were conducted using Stata version 14. Independent samples t-tests were employed to determine whether sample means differed significantly between the control and treatment groups. In addition, linear regression analyses were performed to examine the predictive relationship between each executive function activity category and executive function outcomes. The resulting standardized beta coefficients (β), coefficients of determination (R^2) and p-values were used to rank the activity categories according to their executive function stimulation potential.

Ethics Statement: Ethical clearance for this study was obtained from the University of Zambia Humanities and Social Sciences Research Ethics Committee (UNZAHSSREC; IORG No. 0005376; HSSREC IRB No. 00006464; Ref. No. HSSREC-2025-APR-027). Permission to conduct the research was subsequently granted by the appropriate provincial, district and school authorities within Lusaka Province before data collection commenced. Informed consent was obtained from all participants prior to their involvement in the study.

Throughout the research process, the principles of confidentiality, anonymity, and voluntary participation were strictly upheld. All individuals and institutions involved in the study were assigned unique identification codes, which were used consistently during data collection, analysis and reporting. The twelve participating schools were coded sequentially from SCH-1 to SCH-12. Preschool teachers who participated in the study were assigned individual codes ranging from ECET-1 to ECET-120, while the Standards Officers involved in the study were coded SO-1 to SO-12. Similarly, the Head Teachers from the participating schools were assigned codes ranging from HT-1 to HT-12 and a curriculum Specialist who participated in the study was coded as CS-1.and the six districts included in the study were coded from D-1 to D-6.

RESULTS AND DISCUSSION

The ranking of activities in the Zambian Early Childhood Education (ECE) syllabus according to their executive function (EF) stimulation potential was conducted in three phases. The first phase involved identifying existing syllabus activities that promote executive function, alongside additional activities proposed for inclusion by key stakeholders. The second phase involved testing the redesigned EF model through an eight-month intervention, after which executive function performance was assessed and compared between the treatment and control groups. The third and final phase involved analyzing the intervention outcomes and ranking the executive function domain-specific activities according to their relative EF stimulation potential. This ranking was based on the extent to which activities in each EF domain contributed to improvements in overall executive function performance among preschool learners in Lusaka Province.

Systematic categorization and re-designing of early childhood education syllabus activities according to nine executive function subdomains

This process was addressed through a two-pronged approach. First, semi-structured interviews were conducted with preschool teachers, Head teachers, Standards Officers and a Curriculum Specialist to identify executive function stimulating activities currently embedded within the Zambian Early Childhood Education syllabus. Second, participants were further engaged to propose additional activities they felt foster executive function skills and warranting integration into the Zambian Early Childhood Education syllabus. Activities were included in the study only if they were endorsed by the majority of stakeholders, thereby ensuring that the selected items reflected a broad-based expert, professional consensus and contextual relevance.

Working Memory: The study found that participants perceived existing ECE activities such as rhymes, counting, matching, sequencing, and picture descriptions as supporting working memory development by requiring children to retain, recall information which in turn support working memory. However, participants also indicated that proposed activities would provide more deliberate opportunities for strengthening preschool learner's ability to remember and manipulate information while completing tasks.

Regarding working memory activities currently existing in the Zambian ECE syllabus, one Preschool Teacher from SCH-1 explained that:

When preschool learners recite rhymes, identify patterns, and follow counting activities, they are constantly using their memory to recall information. Although I do not call it working memory, that is what they are practicing (ECET-120: 2025).

Regarding proposed activities to be included under working memory sub domain, one Standard Officer from D-1 stated that:

Activities such as following several craft instructions at once would help preschool learners remember and use information more effectively than simple recall activities (SO-6: 2025).

Cognitive Flexibility: The study found that existing activities such as role play and classroom discussions supported cognitive flexibility by exposing preschool learners to different viewpoints and situations. Participants

further noted that proposed activities would intentionally strengthen preschool learner's ability to adapt their thinking by requiring them to switch rules, perspectives, and problem-solving approaches.

To support this, one Head teacher from SCH-5 stated that:

Role play allows activities existing in the ECE children to think differently because they have to act as someone else and respond to different situations (HT-5: 2025)

Similarly, one Standard Officer from D-3 described the proposed EF activities to be added under cognitive flexibility sub domain and stated that:

When preschool learners sort objects using one rule and then change to another rule, they learn how to adjust their thinking (SO-7: 2025).

Inhibitory Control: The study found that existing classroom activities such as sharing, turn-taking, and imitation games contributed to inhibitory control by requiring learners to regulate their behaviour and responses. Participants also reported that proposed activities would provide more direct opportunities for children to practice self-control and impulse management.

To support this, one Preschool Teacher from SCH-2 explained that:

Sharing and taking turns teach preschool learners that they cannot always act immediately when they want something (ECET-20: 2025).

Regarding proposed EF activities to be included in the Zambian ECE syllabus under inhibitory control subdomain, Another Preschool Teacher from SCH-8 noted that:

Freeze Dance teaches children to control their bodies because they must stop immediately when the music stops (ECET-50: 2025).

Emotional Control: The study found that emotional control was supported through existing activities such as storytelling, singing, and cooperative play, which helped children understand emotions and social interactions. Participants believed that proposed activities would make emotional regulation more explicit by teaching learners to identify and manage their feelings.

One Preschool Teacher from SCH-10 stated that:

Storytelling helps children understand feelings because they discuss how different characters experience emotions (ECET-99: 2025).

Regarding proposed activities to be added under this sub domain, one Standard Officer from D-4 added that:

Emotion charades would help children identify feelings and express them in ways they understand (SO-4: 2025).

Self-Monitoring: The study found that existing activities such as coloring, tracing, matching, and sorting encouraged self-monitoring as learners review their own work and identify mistakes. Participants further suggested that proposed self-assessment activities would strengthen learners' ability to evaluate their performance more intentionally.

One Head Teacher form SCH-12 explained that:

Self-monitoring is supported in the current Zambian ECE syllabus when preschool learners look at their coloring and tracing work to see whether they have done it correctly (HT- 12: 2025).

Concerning proposed activities under this subdomain, another Head teacher form SCH-8 stated that:

The check-my-work routine would encourage children to think about their work before they submit it (HT- 8: 2025).

Initiation: The study found that existing activities such as free play and role play encouraged learners to initiate participation and interactions independently. Participants reported that proposed learner-led activities would further strengthen children's confidence and ability to begin tasks without relying on adult direction.

One Standard Officer from D-2-stated that:

The current activities in the ECE syllabus support initiation during free play activities, preschool learners naturally take the initiative to join games and interact with others (SO-1: 2025).

Regarding proposed activities to be included under this EF subdomain, another Standard Officer from D-1 explained that:

Choice-based activities would encourage preschool learners to make decisions and start tasks on their own (SO-8: 2025).

Planning and Organization: The study found that existing classroom routines and sequencing activities introduced learners to basic planning and organization concepts by helping them understand order and predictability. Participants believed that proposed planning activities would strengthen preschool learner's ability to organize actions and ideas more deliberately.

One Preschool Teacher from SCH-9 explained that:

Sequencing activities embedded in the current Zambian ECE syllabus help preschool learners understand that tasks happen in a particular order and this supports planning and organization (ECET-10: 2025).

On the other hand, one Standard Officer from D-1 proposed additional activities under this sub domain stated that:

Picture sequencing cards would help preschool learners learn how to organize tasks before carrying them out (SO-1: 2025).

Task Monitoring: The study found that existing classroom activities encouraged supporting task completion through existing guided activities and Continuous Progress Monitoring Practices as earners remain focused until tasks were completed. Participants further indicated that proposed activities would help children monitor their progress and evaluate task completion more effectively.

One Preschool Teacher from SCH-3 stated that:

Preschool learners learn to stay focused on activities until they are completed as this is part of what they do in class activities (ECET-30: 2025).

Regarding proposed activities to be added under this sub domain, another preschool teacher from SCH-4 explained that:

Task charts would help preschool learners see how much work they have completed and what still needs to be done (ECET-45: 2025).

Organization of Materials: The study found that existing classroom routines promote organization of materials and encouraged preschool learners to manage learning materials responsibly by returning resources to designated

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places and maintaining tidy workspaces. Participants believed that proposed activities would strengthen children's independence and organizational skills through more structured resource-management practices.

One Standard Officer from D-2 explained that:

In the current Zambian ECE syllabus, preschool learners are encouraged to return materials to their proper places after activities and this supports organization of materials (SO-10: 2025).

Regarding proposed activities to be added under this sub domain, another Standard Officer from D-3 stated that:

Materials checklists would help preschool learners learn how to manage their own learning resources (SO-2: 2025).

Table 1: Systematic re-designing and categorization of early childhood education syllabus activities according to nine executive function subdomains alongside those proposed for inclusion by stakeholders

EF Subdomain	Existing EF Promoting Activities in the ECE Syllabus	Proposed EF Promoting Activities for Inclusion in the ECE Syllabus
Working Memory	Creating imaginary stories and rhymes; Identifying patterns; Classifying items; Counting; Basic arithmetic; Picture description; Sequencing objects; Matching objects; Naming things found in the home and the environment; Identifying syllables; Comprehending instructions; Letter sounds	Following multi-step craft instructions; Chitenge pattern copying game; Cooking steps memory game; Drum and move switch game; Picture-tap memory grid; Market basket challenge
Cognitive Flexibility	Role play; Likes and dislikes; Molding	"Opposite Day" games (e.g., teacher says "touch your nose" and children touch their toes); Sorting games with changing rules (colour → shape → size); Role-switching in pretend play (teacher becomes pupil; pupil becomes teacher); "Think of another way" challenges (finding alternative solutions to problems)
Inhibitory Control	Sharing and taking turns; Tongue twisters; Imitating sounds; Physical exercises	"Freeze Dance" (children dance to music and freeze when it stops); "Red Light, Green Light" and "Stop–Go" games; Delayed gratification games (e.g., waiting to open a covered treat, toy, or food)
Emotional Control	Singing; Home and school rules; Storytelling/listening to stories; Play and games (especially cooperative play)	Emotion charades (acting out happy, sad, angry, scared, surprised); Calm corner or mindfulness breathing area (activities to calm and regulate emotions); Gratitude sharing circle (naming what learners are thankful for); Feelings thermometer (children rate and

		express emotions using visual supports)
Self-Monitoring	Tracing; Coloring objects; Drawing; Figure tapping; Matching and sorting activities	Mirror play (children mimic facial expressions and actions, then reflect on performance); Behaviour check cards (children assess if they followed rules or instructions); "Check my work" routine (children look at their work and identify what they did well or need to improve); Traffic-light self-check (green = doing well, yellow = needs attention, red = needs help); Peer feedback circle (children briefly comment on what they liked about a friend's work)
Initiation	Social initiation activities (asking a peer to play or share toys); Free play/choice time; Group play activities; Role play/pretend play; Classroom routines that require starting tasks (beginning work after instructions)	Independent problem-solving (choosing tools or materials needed for an activity without being told); Idea-generation play (open-ended art or construction activities); "Start the game" tasks (one child initiates an activity or game for others to join); Choice-based learning centres (children select and begin tasks independently); "What will you do first?" prompts (teachers encourage children to plan and start activities)
Planning & Organization	Logical sequence activities; Calendar activities; Seasons and time-awareness tasks (daily timetable, classroom routines)	Picture sequencing cards (ordering images to show correct task sequence); "What comes next?" story planning (predicting and organizing story events)
Task Monitoring	ICT device manipulation; Physical games; ICT-based games; Guided classroom tasks; Play-based learning activities	Task progress charts (using stickers for each step completed); End-of-day reflection songs ("What did I finish today?"); Peer feedback partners (children ask, "Did my friend complete the task?"); "Check your work" routine (stickers or ticks for each completed task)
Organization of Materials	Maintain work areas tidy; Handle materials carefully; Labeling	"Find your missing piece" scavenger hunts; Personal materials checklist (children check and confirm they have all

		required items before and after activities)

The study found that the current Zambian Early Childhood Education (ECE) syllabus does not explicitly articulate executive function (EF) constructs or systematically align classroom activities with specific EF domains. To address this gap, the current study redesigned ECE activities by mapping existing and stakeholder proposed EF learning activities onto nine EF subdomains, thereby developing a theoretically grounded and contextually relevant framework for executive function promotion within Zambian preschool settings. Unlike previous Zambian studies (Mwanza-Kabaghe, 2015; Mwanza-Kabaghe et al., 2015; Kalumba, 2017; Mutambo, 2021; Walubita, 2022), which largely documented executive function deficits among preschool and primary school learners and only recommended the inclusion of EF stimulating activities, the current study moved beyond descriptive findings by actively engaging stakeholders in identifying and proposing developmentally appropriate activities for EF stimulation. These activities were systematically integrated into the proposed ECE syllabus and explicitly aligned with specific executive function domains, resulting in a more coherent and actionable framework for curriculum implementation.

The findings have important implications for early childhood education practice. By linking classroom activities to clearly defined EF sub domains, the framework has provided preschool teachers with practical guidance for intentional instructional planning and implementation. This enables educators to select, adapt and evaluate learning experiences that target specific executive function skills and cognitive processes, thereby enhancing the effectiveness of classroom interactions and promoting holistic executive function development. Furthermore, since this framework is grounded in existing syllabus activities and locally generated stakeholder contributions, it reflects the cultural, social and resource realities of Zambian classrooms, increasing its relevance, acceptability and sustainability. The study also has highlighted the potential of systematic exposure to EF-promoting activities to strengthen foundational cognitive skills associated with school readiness, self-regulation, problem-solving and later academic success. At the policy level, the findings emphasize the need for explicit integration of executive function competencies within National ECE curricula, teacher education programmes and assessment frameworks. This type of integration would support a more deliberate and consistent approach to executive function development during the preschool years when executive function is rapidly developing.

Implementation of eight months intervention

After the systematic re-designing and categorization of early childhood education syllabus activities according to nine executive function subdomains, eight months intervention was conducted to evaluate changes in executive function skills among preschool learners. The study employed Solomon's (1949) two-group design to randomly assign to treatment (n = pretest → intervention → posttest) and control (n = pretest → posttest) conditions. This design enabled measurement of intervention effects while controlling for pretest sensitization effects. The executive function intervention was administered with substantial dosage intensity: five sessions weekly, 30 minutes per session, totaling 2.5 hours weekly implementation. Rather than isolated instruction, intervention activities were embedded within naturalistic classroom contexts integrated into play-based activities, learning centres, transitions, and group activities. Each session incorporated structured executive function tasks targeting all nine subdomains, facilitated by preschool teachers using routine classroom materials and familiar instructional routines. This embedded delivery approach ensured consistent, repeated exposure to executive function practices within developmentally appropriate classroom context while maintaining continuity with standard syllabus coverage and minimizing instructional disruption. Posttest score comparisons between treatment and control groups were used to determine intervention effectiveness.

To ensure stable and consistent results, efforts were made to enhance the reliability of the intervention context through a comprehensive professional development programme for preschool teachers prior to implementation. Teachers received standardized training on executive function theory, the nine targeted executive function subdomains, and uniform procedures for activity delivery, learner engagement, classroom organization, and progress monitoring. The use of detailed implementation guides, demonstration lessons, modelling, guided practice, and collaborative planning promoted consistency in instructional practices across classrooms.

Furthermore, ongoing coaching, classroom observations, reflective meetings, and refresher sessions throughout the eight-month intervention period helped maintain adherence to the intervention protocol and minimize variations in implementation. These measures reduced inconsistencies that could influence children's performance across assessment occasions, thereby strengthening the conditions necessary for obtaining reliable test–retest measurements and increasing confidence that observed changes reflected actual developmental or intervention effects rather than differences in programme delivery.

EF performance of Preschool Leaners before and after redesigning the ECE syllabus

Baseline Results of the Executive Function skills of preschool learners: The baseline assessment was conducted to establish learners' initial levels of executive function skills, specifically working memory, inhibitory control and cognitive flexibility to determine the equivalence of the control and treatment groups at the outset of the study. Establishing baseline performance was essential for contextualizing subsequent changes and ensuring that any post-intervention differences is attributed to the intervention rather than pre-existing group disparities.

Table 2. Pre-test Baseline Group Equivalence on All Variables

Variable	Control (n=135) M (SD)	Treatment (n=134) M (SD)	t(267)	p-value	Cohen's d	Partial η^2
Working memory	0.235 (0.164)	0.231 (0.158)	-0.204	.839	-0.025	<.001
Inhibitory Control	0.345 (0.193)	0.360 (0.201)	0.624	.533	0.076	.001
Cognitive Flexibility	0.268 (0.147)	0.276 (0.141)	0.456	.649	0.056	.001
SES	0.991 (0.180)	0.980 (0.175)	0.416	.678	0.051	.001
General Intelligence	2.238 (0.203)	2.242 (0.199)	0.163	.870	0.020	<.001

Baseline equivalence testing was conducted using independent-samples *t*-tests to examine whether the control and treatment groups differed on three core executive function skills among preschool learners. The study found no statistically significant differences between the control and treatment groups across all three core executive function (EF) domains. Specifically, working memory did not differ significantly between the control group ($M = 0.235$) and the treatment group ($M = 0.231$), $p = .839$. Similarly, no significant group differences were observed in inhibitory control (control: $M = 0.345$; treatment: $M = 0.360$), $p = .533$, or cognitive flexibility (control: $M = 0.268$; treatment: $M = 0.304$), $p = .649$. In addition, analyses of potential confounding variables revealed no statistically significant differences between the two groups. Socioeconomic status did not differ significantly (control: $M = 0.991$; treatment: $M = 0.980$), $p = .678$, nor did general intelligence (control: $M = 2.238$; treatment: $M = 2.242$), $p = .870$. These findings suggest that the control and treatment groups were comparable at baseline across both executive function measures and key covariates, indicating that any subsequent differences are unlikely to be attributable to pre-existing group disparities. These findings aligned with Suppalarkbunlue, 2022, who found comparable group equivalency at the pretest stage. This similarity suggests that the groups were statistically comparable before the intervention was implemented. This baseline equivalence strengthened the validity of subsequent comparisons of treatment effects between the groups.

Post-Test Results of the Executive Function Intervention: The post-intervention assessment evaluated changes in key executive function domains namely working memory, inhibitory control, and cognitive flexibility and compared outcomes between the treatment and control groups. These results provided evidence of the effectiveness of the intervention and form the basis for determining its impact on preschool learners' executive function development. As shown on table 3 below:

Table 3: Post-Test Executive Function and Covariate Outcomes by Group

Variable	Control Group M (SD)	Treatment Group M (SD)	t(267)	p-Value	Cohen's d	Partial η²
Working Memory	0.233 (0.161)	0.368 (0.169)	-6.713	<.001***	0.612	0.189
Inhibitory Control	0.352 (0.197)	0.484 (0.193)	-3.884	<.001***	0.474	0.020
Cognitive Flexibility	0.272 (0.144)	0.394 (0.168)	-2.744	.007**	0.335	0.026
SES	0.991 (0.177)	0.980 (0.207)	-0.948	.344	0.116	0.001
General Intelligence	2.471 (0.201)	2.450 (0.162)	-0.213	.832	0.026	<.001

Table 3 above shows post-intervention analysis which was conducted using independent-samples t-tests to examine whether the control and treatment groups differed on core executive function skills and potential confounding variables following the intervention implementation. At post-test, the results demonstrated statistically significant differences between the control and treatment groups across all mean scores for the three core executive function skills. Specifically, working memory was significantly higher in the treatment group (M = 0.368) compared to the control group (M = 0.233), $p < .001$. Similarly, inhibitory control performance was greater in the treatment group (M = 0.484) than in the control group (M = 0.352), $p < .001$. Cognitive flexibility also showed a statistically significant difference, with the treatment group (M = 0.394) outperforming the control group (M = 0.272), $p = .007$. Furthermore, covariate analyses indicated no statistically significant differences between the control and treatment groups with respect to potential confounding variables. Socioeconomic status did not differ significantly (control: M = 0.991; treatment: M = 0.980), $p = .344$, and general intelligence was also comparable between groups (control: M = 2.471; treatment: M = 2.450), $p = .832$. These findings suggest that the observed post-test differences in executive function performance are not attributable to variations in socioeconomic status or general intelligence, thereby providing support for the effect of the intervention. These findings align with (Jacob and Parkinson, (2015; Suppalarkbunlue, 2022; Howard, 2017), who reported statistically significant post-test improvements in the treatment groups compared to control groups across all core executive function skills such as working memory, inhibitory control and cognitive flexibility. This finding was further supported by Baddeley's Multi-Component Model (1996), which conceptualizes executive functioning as an integrated system comprising the phonological loop, visuospatial sketchpad, central executive, and episodic buffer. These interacting components facilitate the acquisition, retention, manipulation and integration of information, thereby underpinning the development of higher order cognitive processes and executive function skills.

Ranking of activities in the Zambian Early Childhood Education Syllabus activities according to Executive Function Stimulation Potential

The ranking of Executive Function domains was conducted using multiple regression analysis to determine the predictive contribution of each EF activity domain to overall executive function stimulation outcomes. A regression model was specified with the nine EF domains that is Working Memory, Inhibitory Control, Cognitive Flexibility, Plan and Organize, Emotional Control, Initiate, Task Monitor, Self-Monitor and Organization of Materials as independent variables, while the composite executive function score served as the dependent variable. Standardized regression coefficients (β) were computed to compare the relative strength of each predictor across domains measured on different scales. The coefficient of determination (R^2) was used to estimate the proportion of variance in executive function outcomes explained by each domain, thereby providing an index of its stimulation potential. Statistical significance was assessed using two-tailed t-tests at the 0.05 significance level. To facilitate interpretation, EF domains were classified into three stimulation potential levels based on a combination of effect size, explained variance and statistical significance. High Stimulation Potential included domains with $\beta \geq .90$, $R^2 \geq .30$, and statistically significant relationships ($p < .05$). Moderate Stimulation Potential comprised domains with β values ranging from .75 to .88, R^2 values between .10 and .29, and significant associations ($p < .05$). Low Stimulation Potential included domains with $\beta < .70$ and/or $R^2 < .10$, with associations that never reached statistical significance ($p > .05$). This multi-criteria classification framework

integrated effect magnitude, practical significance and statistical reliability to provide a comprehensive ranking of executive function activities domains according to their stimulation potential within the redesigned Zambian Early Childhood Education syllabus, as presented in Table 4 below.

Table 4: Ranking of activities in the Zambian ECE Syllabus according to EF stimulating potential

Ranking	Domain Specific Activities	β	r^2	T	P-Value
1	Working Memory Activities	.95	.47	7.11	<.001
2	Inhibitory Control Activities	.93	.42	6.47	<.001
3	Cognitive Flexibility Activities	.90	.34	5.09	.004
4	Plan & Organize Activities	.88	.29	4.35	.009
5	Emotional Control Activities	.85	.23	3.52	.008
6	Initiate Activities	.82	.17	3.14	.030
7	Task Monitor Activities	.79	.13	2.55	.040
8	Self-Monitor Activities	.75	.10	2.17	.040
9	Organization of Materials Activities	.70	.04	1.44	.154

The study found that the three core executive function skills, working memory ($\beta = .95$, $p < .001$), inhibitory control ($\beta = .93$, $p < .001$), and cognitive flexibility ($\beta = .90$, $p = .004$) were the strongest and most significant predictors of executive function among preschool learners. Among the higher-order executive function domains, planning and organizing ($\beta = .88$, $p = .009$), emotional control ($\beta = .85$, $p = .008$), task monitoring ($\beta = .79$, $p = .040$), and self-monitoring ($\beta = .75$, $p = .040$) emerged as moderate yet statistically significant predictors of executive function. In contrast, organization of materials demonstrated the lowest predictive value among all executive function subdomains ($\beta = .70$, $p = .154$) and was not a statistically significant predictor of executive functioning. These findings suggest that the core executive function processes play a more substantial role in explaining overall executive function improvement than the other six sub domains.

High Executive Function Stimulation Potential: Working memory emerged as the strongest predictor of executive function stimulation ($\beta = .95$, $R^2 = .47$, $p < .001$), explaining 47% of the variance in executive function outcomes. This finding indicates that the redesigned syllabus strongly promotes activities requiring preschool learners to retain, manipulate, and update information. Inhibitory control also demonstrated a substantial contribution ($\beta = .93$, $R^2 = .42$, $p < .001$), suggesting that classroom routines and structured activities effectively support impulse regulation and focused attention. Cognitive flexibility ranked third ($\beta = .90$, $R^2 = .34$, $p = .004$), highlighting the syllabus' emphasis on adaptive thinking, problem-solving, and shifting between tasks or perspectives. The strong effect sizes and statistically significant relationships observed across these domains indicate that the redesigned syllabus is highly aligned with the foundational executive function processes that support later academic achievement, self-regulation, and lifelong learning. These findings suggest that teachers can maximize children's cognitive development by intentionally strengthening working memory, inhibitory control, and cognitive flexibility through everyday classroom interactions, transitions, structured play, and problem-solving activities.

Moderate Executive Function Stimulation Potential: Planning and organizing demonstrated a strong and statistically significant contribution to executive function stimulation ($\beta = .88$, $R^2 = .29$, $p = .009$), indicating that opportunities for planning are embedded within the redesigned syllabus. However, these opportunities may remain largely teacher-directed rather than learner-initiated. Emotional control also contributed significantly ($\beta = .85$, $R^2 = .23$, $p = .008$), suggesting that socio-emotional regulation is supported within classroom environments, although primarily through implicit rather than explicit instructional approaches. Initiation skills demonstrated a moderate effect ($\beta = .82$, $R^2 = .17$, $p = .030$), reflecting limited opportunities for child-led learning and autonomous decision-making. Similarly, task monitoring ($\beta = .79$, $R^2 = .13$, $p = .040$) and self-monitoring ($\beta = .75$, $R^2 = .10$, $p = .040$) were statistically significant predictors, although their effects were comparatively weaker. These findings indicate that metacognitive skills, self-evaluation, and independent regulation of learning receive some attention within the syllabus but are not systematically emphasized. The moderate effect sizes

suggest the need for greater focus on explicit instruction, structured feedback, learner autonomy and metacognitive development. Strengthening these domains may require increased opportunities for child-initiated activities, deliberate emotion regulation instruction, planning conversations, reflective learning practices, and targeted professional development for teachers on executive function pedagogy.

Low and None Significant Executive Function Stimulation Potential: Organization of materials ranked lowest among all executive function domains ($\beta = .70$, $R^2 = .04$, $p = .154$) and did not reach statistical significance. This sub domain explained only 4% of the variance in executive function outcomes, indicating minimal stimulation within the redesigned syllabus. This finding suggests that classroom organization remains largely teacher-controlled, limiting opportunities for children to develop independent organizational skills. The weak performance of this domain may also reflect resource limitations within preschool settings, where restricted access to learning materials reduces opportunities for preschool learners to practice sorting, categorizing, storing and managing resources independently. The findings highlight the need for deliberate integration of organization-focused activities into the curriculum, enabling preschool learners to progressively assume responsibility for managing classroom materials and learning resources.

Originality of the study: Ranking of Activities in the Zambian ECE Syllabus according to Executive Function Stimulation Potential

The systematic redesign and categorization of early childhood education syllabus activities according to nine executive function subdomains, alongside the inclusion of proposed executive function enhancing activities, represents a novel methodological contribution with limited precedent in the international literature. While extensive research has documented the importance of executive function components such as working memory, inhibitory control, and cognitive flexibility in early childhood development and numerous teaching strategies have been identified to strengthen these functions, the field has not previously established an empirically derived quantitative framework for ranking curriculum activities according to their relative contribution to executive function development across multiple subdomains. This study's approach of engaging Zambian educational stakeholders in identifying and categorizing contextually relevant activities, followed by validating their executive function stimulation potential through standardized regression coefficients and variance explained, offers a replicable and innovative methodology for curriculum optimization. By translating theoretical executive function constructs into a measurable, activity based classification system tailored to the Zambian educational context, this investigation moves beyond descriptive accounts of executive function importance and provides educators with evidence-based, locally grounded guidance for intentional instructional design. In doing so, it addresses a significant gap in the early childhood education literature, where systematic activity-level differentiation according to executive function stimulation potential has not previously been reported.

The current study further advances early childhood education curriculum evaluation by systematically assessing and ranking classroom activities according to their executive function stimulation potential across nine executive function sub domains. Although previous research has extensively documented the importance of working memory, inhibitory control, cognitive flexibility and related executive function skills in preschool settings in Zambia, this study has contributed quantitative evidence regarding the differential contribution of curriculum activities to executive function development among preschool learners. Existing literature emphasizes that instructional practices such as supporting child autonomy, promoting sustained shared thinking, encouraging problem-solving, and implementing effective classroom organization can enhance executive function. However, some Zambian studies have not empirically differentiated curriculum activities based on their relative cognitive demands and self-regulatory requirements as demonstrated by the current study. The findings in this study revealed that activities designed to strengthen working memory, inhibitory control, and cognitive flexibility constitute the strongest features of the redesigned ECE syllabus, demonstrating substantial potential to support executive function development. In contrast, organizational skills related to the management of materials received comparatively limited emphasis, highlighting an important area for curriculum enhancement. Furthermore, the findings relating to planning and organizing, emotional control, initiation, task monitoring, and self-monitoring suggest that although these higher order executive function skills are represented within the curriculum, they are not consistently or explicitly scaffolded.

Quantifying the executive function stimulation potential of Zambian ECE syllabus activities through standardized effect sizes and variance explained, the current study has provided curriculum developers, teacher educators and policymakers with a practical and replicable methodology for optimizing early childhood learning experiences. The findings offer a strong evidence base for strengthening executive function development across all nine executive function subdomains, highlighting the urgent need for the adoption and implementation of the proposed redesigned ECE syllabus by education stakeholders in Zambia and resource limited countries. The implementation of the redesigned ECE syllabus has the potential to enhance preschool learner's executive function development which in turn improve school readiness and long-term educational outcomes.

CONCLUSION

This study systematically redesigned and categorized early childhood education activities according to nine executive function subdomains, moving beyond previous descriptive documentation of EF deficits to provide a theoretically grounded and actionable framework for Zambian preschool practice. Through stakeholder engagement, namely preschool teachers, head teachers, standards officers, and a curriculum specialist, the study identified existing EF-promoting activities within the current ECE syllabus and proposed contextually appropriate additions, ensuring expert consensus and local relevance. The intervention conducted by the study demonstrated substantial effectiveness in promoting executive function development. Baseline equivalence testing confirmed comparable control and treatment groups across all measures. Post-test results revealed statistically significant improvements in the treatment group across all three core executive function domains: working memory (treatment $M = 0.368$ vs. control $M = 0.233$, $p < .001$, $d = 0.612$), inhibitory control (treatment $M = 0.484$ vs. control $M = 0.352$, $p < .001$, $d = 0.474$), and cognitive flexibility (treatment $M = 0.394$ vs. control $M = 0.272$, $p = .007$, $d = 0.335$). These gains were not attributable to differences in socioeconomic status or general intelligence, providing evidence for the intervention's efficacy.

Analysis of the redesigned ECE activities revealed a triad structure of executive function stimulation potential. The first level, representing the highest executive function stimulation potential, comprised the strongest predictors of EF development: working memory activities ($\beta = .95$, $R^2 = .47$, $p < .001$), inhibitory control activities ($\beta = .93$, $R^2 = .42$, $p < .001$), and cognitive flexibility activities ($\beta = .90$, $R^2 = .34$, $p = .004$). The second level, representing moderate executive function stimulation potential, included planning and organizing, emotional control, initiation, task monitoring, and self-monitoring activities (β ranging from .75 to .88), which contribute meaningfully to EF development but require greater emphasis and intentional scaffolding. The third level, representing low and non-significant executive function stimulation potential, comprised organization of materials activities ($\beta = .70$, $R^2 = .04$, $p = .154$), which did not reach statistical significance and reflect limited opportunities for independent material management in resource-constrained settings. Based on these findings, the study therefore recommends that activities within the first level of executive function stimulation potential, where core executive function skills emerged as the strongest predictors of EF, should be prioritized by education stakeholders in the implementation of the redesigned ECE syllabus, as they possess the greatest potential for promoting executive function development among early childhood learners in Zambia. The study further recommends that curriculum specialists, in collaboration with relevant education authorities in Zambia, should formally adopt and oversee the implementation of this redesigned Zambian Early Childhood Education syllabus in public preschools.

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The authors declare no potential conflict of interest with respect to the research, authorship or publication of this article.

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