DEVELOPING HIGHER ORDER EXECUTIVE FUNCTION SKILLS THROUGH PLAY

Part 1: The LOGICO 2.0 Smarti Bear Games

George Ghanotakis, Ph.D.

At last, a creative tool to empower parents' role as effective educators while having fun! Brilliant!

—Dr. Denis Destrempes

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Executive Function Skills are a better predictor of children's success than IQ.[1]
— Center on the Developing Child, Harvard University

INTRODUCTION

What Are Executive Functions?

Executive Functions (EFs) are cognitive processes such as good working memory, inhibitory control and cognitive flexibility. These mental processes make possible to execute efficiently tasks by managing information, resisting distractions and staying focused.

We are not born with EFs. They are developed throughout life. However, the age periods from 3 to 6 years and the preteen years are considered a critical time in their acquisition and their strengthening through practice, a window of opportunity not to be missed.[2]

EFs are today recognized by Ministries of Education as essential for mental and physical health, success in school and life, cognitive, social and psychological development.[3]

1. harvardcenter.wpenginepowered.com/wp-content/uploads/2015/05/InBrief Executive-Function-Skills-for-Life
2. Ibid.
3.The Preschool Education Cycle Program of Quebec (2023) p.9. https://cdn contenu.quebec.ca/cdn contenu/education/pfeq/prescolair e/Programme-cycle-prescolaire.pdf

EFs, IQ and Thinking Skills

Executive Functions refers to a set of cognitive processes that are crucial for managing oneself and one's resources in order to achieve a goal. EFs are mental processes carried out in the prefrontal cortex of the brain, such as good working memory, inhibitory control and flexibility, which are necessary to execute and implement thinking skills, whereas IQ (Intelligence Quotient) is a measure of a person's cognitive abilities and potential. It is typically derived from standardized tests designed to assess various aspects of intelligence.

Thinking skills are the cognitive processes that enable us to understand, analyze, and evaluate information, solve problems and make decisions.

The relationship between EFs and Thinking Skills consists in that EFs enable (execute) the efficient implementation and application of thinking skills throughout the school years.

Importance of Play

Through play, children best develop their EFs as they exercise their sensory motor and emotional memory, acquire knowledge and concepts, structure their thoughts and develop their vision of the world to appropriate reality.[4]

4. Ibid

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While playing, children learn to concentrate on something without being distracted and develop their autonomy and relationships with others.

Extensive evidence-based research results on EFs interventions, based on 179 studies from all over the world, at all ages, reveal that computerized and non-computerized games are among the most promising interventions.

They improve selective attention, self-control, working memory (WM), cognitive flexibility (CF) and HOEFs as a higher order function involving relational reasoning.[5]

A. Diamond (2013) describes higher order function involving relational reasoning as a fluid intelligence to problem solving that includes both inductive and deductive logical thinking to see underlying analogies: "It involves being able to figure out the abstract relations and the underlying analogies. It is synonymous with the reasoning and problem solving subcomponents of EFs."[6]

5. A. Diamond, Daphne S. Ling (Review of the Evidence on, and Fundamental Questions About Efforts to Improve Executive Functions, Including Working Memory DOI:10.1093/oso /9780199974467.003.0008 Oxford University Press, 2020. This systematic review of executivefunction (EF) is drawn from results reported in 193 papers

6. A. Diamond (2013) Executive Functions Vol. 64:135 168 Annual Review of Psychology jan. 2013) https://doi.org/10.1146/annurev-psych-113011-143750

Visual and Oral EFs Games: The Smarti Bear Series

It is important to practice EFs both visually and verbally throughout the five areas of development (physical and motor; emotional; social; language; cognitive) in a synergistic and sustained manner in relation to EFs.[7]

Collaborative communication language and social-based thinking games like the *Play Wise* game integrate EFs and HOEFs skills in the mechanics of play, using working memory, cognitive flexibility and inhibitory control by self-regulation.[8]

This guide offers a program of developing and consolidating EFs both in visual (pictorial) and verbal collaborative ways, through the LOGICO 2.0 Smarti Bear games.

EFs and School Success

EFs contribute to school success by being better predictors for academic achievement, in regard to both math readiness and reading competence. They have been shown to be more predictive than high IQ or entry-level

7. The Preschool Education Cycle Program of Quebec (p 11, also 36 ff. https://cdn-contenu.q uebec.ca/cdn-contenu/education/pfeq/presc
8. George Ghanotakis (2024) Higher Order Executiv e Function Through Play, Part 2. The Play Wise Game, Montreal, Institut Philos.

reading or math for knowing their letters and numbers. EFs offer better chances of success and fulfillment in life.[9]

EFs are critical in children's development, as they are associated with academic achievement, problem-solving abilities, and social functioning.[10]

Evidence-Based Results

Extensive evidence-based studies on preschoolers have established positive links between EFs and a variety of developmental outcomes. Studies show that the EFs skills of kindergarten children predicted their reading, math and science achievements later in the second grade of primary school.[11]

Most recently, Spataro et al. (2024) have reported that EFs are positively correlated with language and literacy skills as well as with socio-emotional competence, as adduced by parents vs. teachers reports. They remediate deficits, enhance academic performance, increase productivity and head off slow or reverse cognitive decline, training for selective attention, self-control,

9. The Preschool Education Cycle Program of Quebec (p 11, also 36 ff. https://cdn-contenu.q uebec.ca/cdn-contenu/education/pfeq/presc
10. A. Diamon d (2013), s upra note 6
11. Paul L. Morgan, George Farkas, Marianne M. Hillemeier, Wik Hung Pun, Steve Maczuga (2019) Executive Functions Predict Their Second Grade Academic Achievement and Behavior Child Dev. 2019 Sep First published: 09 June 2018 https://d oi.org/10.1111/cdev.13095.

working memory, cognitive flexibility and higher order relational reasoning.[12]

The Three Core EFs

There is general agreement that there are three core EFs:

*** Inhibition Control (IC)** allows children to self-regulate by resisting temptations from external stimuli, controlling impulses and being able to focus and pay attention. IC is linked to emotional control. The child needs IC for accepting delays, waiting their turn to speak or act and persevering in completing a task.

*** Working Memory (WM)** is distinguished from short-term memory. It is not simply remembering information. WM is holding temporary information in mind in order to manipulate it or use it later for tasks such as:

- making a connection with the information that came before, e.g. recalling a series of numbers, ideas or pictures in reverse order

12. Pietro Spataro, Mara Morelli, Sabine Pirchio. et al. (2024) Exploring the relations of executive functions with emotional, linguistic, and cognitive skills in preschool children: parents vs. teachers reports Eur J Psychol Educ 39, 1045 1067. https://doi.org/10.1007/s10212-023-00749-7

- figuring out what is missing in completing a puzzle or solving a problem
- recalling an instruction or information when engaging in conversation or cooperative play.

Practice in using visual or verbal cues as scaffolding helps improve one's inhibitory control and working memory performance.

*** Cognitive Flexibility (CF),** also called **Shift,** is the process of creative thinking "outside the box". This brain function is involved in:

- seeing anything from a different perspective or angle and flexibly adapting to changed circumstances;
- shifting one's attention from one task or thing to another relatively easily in performing multi-tasking;
- trying a new strategy when problem-solving solitarily or cooperatively with others; for example, in doing a puzzle.[13]

13. See Supra note 2 The Preschool Education Cycle Program of Quebec (2023)

The Brain's "Air Traffic System"

The three core EFs are interrelated and mutually supportive, in that each type draws on elements of the others. Their functioning has been represented as building the brain's"air traffic system" at a busy airport.[14]

WM supports IC in that the child must hold a goal in mind to know what is relevant or appropriate and what to inhibit. CF is developed through WM and IC. To be able to change perspective or tasks the child must retain new information while inhibiting the previously used information.

Higher Order Executive Functions (HOEFs)

From the three Core EFs, higher order EFs such as planning are built through the practice of relational logic and reasoning.

Planning and Organizing

Planning and organizing are HOEFs which refer to the

14. To manage the arrival and departure of the many aircraft on multiple runways, filtering distractions and prioritizing tasks. harvardcenter.wpengine-powered.com/wp-content/uploads/2015/05/InBrief-Executive-Function-Skills for Life

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child's ability to anticipate the steps needed to accomplish a task. It is carried out by proceeding step by step in structuring the order of different actions to produce the next one.

Planning in particular facilitates the integration of sequences of group life routines. For example, when going to play outside, the child remembers the steps to get dressed independently; or when solving a puzzle, the child proceeds sequentially or by elimination reasoning from the known to the unknown elements.

Other examples of HOEFs include:

- Problem-solving and decision-making
- Abstract thinking and reasoning
- Metacognition and self-awareness
- Self-monitoring by being able to track progress towards the solution by making adjustments

ADHD & ADD: EFs Dysfunctions

Struggling with executive function is the cause of many symptoms of learning dif ferences such as dyslexia, ADHD (Attention Deficit Hyperactive Disorder) or ADD (Attention Deficit Disorder.

Examples of Executive Dysfunctions:

- Focusing too much or too little on one element by disregarding other elements or the whole
- Being easily distracted and not finishing the task
- Having problems with motivation or impulse control
- Struggling to switch tasks
- Unable to proceed step by step in order to complete a task efficiently.

15. The kit also referred to as Wisdom for Children Program (2015) was first published in a French version as La Trousse des Apprentis sages, (LEI Publications, Montreal Canada 2000) and won the Trillium award of approved material recommending its use by all teachers and parent educators. It has since been published in various editions and formats, notably by Institut Philos, DC Canada Education Publishing (2015) Pirouette editions, etc. A Ministry of Education evaluation of the pedagogy and strength of the kit and the teacher's guide under the title Comment Eduquer son enfant par le jeu (How to Teach Your Child Through Play) is included in the Trillium award report of the Ministry of Education

Smarti Bear EFs Series

The Smarti Bear series comprises four games and *The Little Thinkers Kit (La Trousse des Apprentis-Sages)* that was developed for the New Preschool Kindergarten Program of the Ministry of Education of Ontario in Canada.[15]

The series consists of a teacher guide and workbooks for training thinking skills and executive function using play pedagogy. The kit is built on the following four mathematical logic-based games for independent or cooperative play with a color die: *Sport Match*, *Zig Zag Logic*, *3D Logic Puzzle*, and *Logic Apron* [16] with various hands-on material including nine adorable little bears.

There is a progression in the problem solving from very easy to increasingly difficult. An answer key provides instant feedback. It is simple and fun to play the games while adopting a Sudoku-like strategy to foster mathematical skills and understanding with three levels

16. The original titles of these four games are Teddyx Mania, Super Teddyx, Cubix and Logicolo published by Éditions LEI Canada, Montreal (2000).

of difficulty which provide entertaining challenges for young children.

In addition to executive function skills, children will develop logical skills and math concepts, as they enjoy discovering the order of nine Smarti Bears racing down the zigzag trail (*Zigzag Logic*), and completing the placement of the bears practicing different sports in a 3x3 grid like a crossword puzzle (*Sport Match*).

Zigzag Logic game sample

Sport Match game sample

The other games involve 3D puzzle construction by completing sequences with interlinkable, easy to manipulate cubes in 2 and 3 dimensions (*3D Logic Puzzle*), and using analogical and inferential reasoning figuring out where geometrical tokens are to be found in a 2x3 size grid by following the track of various animals,

with scaffolds inferring with positive and negative clues (*Logic Apron*).[17]

17. The rules of these multiple award-winning games are available in English, French, Spanish, German and Chinese. See website www.dc canada.ca for detailed description and videos available on YouTube.

LOGICO The Learning Game

LOGICO The Learning Game is a self-checking system that provides fun learning with hand-eye coordination that uses association skills to match colored movable buttons with the correct answers (provided in visually-known information) to questions provided on the right side of the gameboard. After completing each task children turn over the card and place it in the slot again to check the answers. If the color codes match, the answers are correct.[18]

18. LOGICO is produced by Finken Verlag, Germany and is currently distributed in over 40 countries www.finken.de

LOGICO Game 2.0 and HOEFs

Adapting the range of HOEFs skills of the LOGICO 2.0 Smarti Bear series provides the EFs to support and reinforce association skills of the user-friendly LOGICO system. The HOEFs skills of the Smarti Bear series provide support to the association skills in the following ways:

1. Working Memory:

This EF helps hold and manipulate information allowing the child to make connections between new and existing knowledge.

2. Cognitive Flexibility:

This EF enables the child to switch between different mental ideas and frameworks, facilitating the generation of new associations.

3. Inhibitory Control:

This EF helps suppress irrelevant information, allowing us to focus on r elevant connections.

4. Metacognition or Self Reflection:

This HO EF enables the child to reflect on his/her thinking, monitoring and contr olling the association process.

5. Planning:

This HOEF aids in organizing and structuring information and promoting the formation of meaningful associations.

By developing HOEFs, LOGICO 2.0 empowers learners, strengthening not only their association skills but also their higher-order thinking aptitudes, leading to better memory and enhanced problem-solving and creativity.

Chess VS. LOGICO 2.0 EFs: A Comparison

Playing chess is an excellent example of applying executive function in action. We use chess as an analogy to show how the executive functions are applied in the LOCICO 2.0 Smarti Bear games.

Similarly to playing chess, individuals using the Smarti Bear LOGICO 2.0 games can improve their executive function skills, including planning, problem-solving, working memory, attention, cognitive flexibility, inhibition and self-control.

*** Planning and Problem-Solving**

1. Strategic thinking: Chess players need to plan ahead, thinking about the consequences of their

moves and anticipating their opponent's responses.

In LOGICO 2.0 Smarti Bear games *Let's Have a Race!* and *Who's First? Who's Last?* Players must anticipate how each sequence of colors of bears on the path solves the puzzle to rank the bears in the race.

2. Problem-solving: Chess presents a complex problem to be solved, requiring players to analyze positions, identify patterns and find creative solutions.

LOGICO 2.0 Smarti Bear games, players must solve the ranking puzzle by analyzing positions and identifying patterns or sequences by reasoning based on clues on the position of bears on pathway and outside, using inference from positive and negative clues.

*** Working Memory**

1. Remembering moves: Chess players need to remember their opponent's moves, as well as their own, to plan their strategy.

LOGICO 2.0 Smarti Bear Logic Puzzles players need to remember the relation of the colored bears on the racing pathway as well as in the clues given in the bubbles outside the pathway.

2. Visualizing positions: Chess players must visualize the board and pieces in their mind, using working memory to keep track of the game state.

LOGICO 2.0 players must visualize the gameboard and pieces in their mind, using working memory to keep track of the sequence or positions of bears to solve the puzzle.

*** Attention and Focus**

1. Concentrating on the game: Chess players must maintain focus and attention throughout the game, avoiding distractions and staying engaged.

Similarly, LOGICO 2.0 players must maintain focus and attention throughout the game to solve the puzzle, especially when it must be solved in a five minute time frame.

2. Filtering out irrelevant information: Players need to ignore irrelevant information, such as their opponent's body language or external noise, to stay focused on the game.

LOGICO 2.0 players must ignore the white outfits of the bears in order to identify or infer the right colors

by focusing on the position clues, for example in *Let's Have A Race!*

*** Cognitive Flexibility**

1. Adapting to changing situations: Chess players must adjust their strategy as the game unfolds, responding to their opponent's moves and changing circumstances.

In LOGICO 2.0 games, players must adjust to the progressive level of negative clues using higher level order reasoning.

2. Switching between different mental sets: Players need to switch between different mental sets, such as transitioning from a defensive to an offensive strategy.

LOGICO 2.0 Smarti Bear Logic Puzzles players have to shift from positive clues to negative clues and from different clues making inferences from relational logic with respect to rank and position.

*** Inhibition and Self-Control**

1. Resisting impulsive moves: Chess players must

resist the temptation to make impulsive moves, taking the time to think through the consequences of their actions.

LOGICO 2.0 Smarti Bear games players must resist impulsive moves and stop and think to assess and evaluate the missing colors needed to solve the puzzle.

3. Managing emotions: Players need to manage their emotions, such as frustration or excitement, to maintain a clear and level head during the game.

Similarly, in LOGICO 2.0 Smarti Bear games, players need to manage frustration and self-correct to complete the challenges.

The LOGICO 2.0 series comprises to date three math and relational logic titles:

Logic with Colors, Shapes, and Dots

Let's Have a Race!

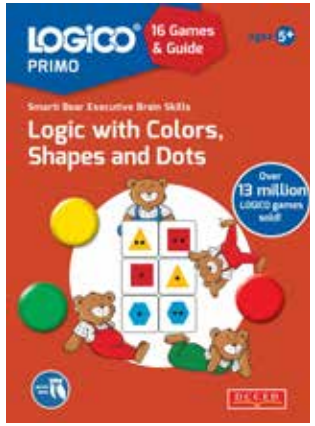
Who's First? Who's Last?

In the following chapters, we shall present the card content of each title, the methodology used and the way the HOEFs are developed.

CHAPTER 1

LOGICO PRIMO 2.0: Smarti Bear Games for Higher Order Executive Functions: Logic with Colors, Shapes and Dots Dots[19] (Ages 3-6)

A. Concept



Logic with Colors, Shapes and Dots[19] is part of the new generation of LOGICO PRIMO titles that trains in addition to mathematical deductive thinking, analogical relational reasoning, which enables fluid intelligence a distinctive characteristic of HOEFs.

The aim of *Logic with Colors, Shapes and Dots* is to help children strengthen HOEFs while fostering critical thinking and proble m solving abilities in fun ways using the LOGICO self-checking gameboard.

19. George Ghanotakis (2023) Logic with Colors, Shapes and Dots, LOGICO PRIMO Smarti Bear Executive Skills, Ottawa Institut Philos/ DCCED.