What is the potential of mathematics in stimulating executive functioning of a weak learner?

Alena Prídavková Juraj Kresila

DEPARTMENT OF MATHEMATICS EDUCATION
FACULTY OF EDUCATION
UNIVERSITY OF PRESOV
SLOVAKIA

INTRODUCTION

The existing researches confirm the relationship between executive functioning of pupils and their performance when solving mathematical tasks. The level of executive functions is a predictor of success in mathematics for pupils at any level of education. It appears that one of the reasons for reduced performance in mathematics may be an underdeveloped execu-tive function. In other words, inadequately developed conceptual and procedural competences in mathematics can be the result of poorly func-tioning cognitive and executive mechanisms such as work memory or visual-spatial information processing. As reported by Geary (2004), 5-8 % of school-aged children have some form of cognitive deficit that interferes with the ability to learn mathematics.

Smith & Mancy (2018) reported that metacognitive interventions can also have a positive impact on math performance. In their study, they confirm that metacognitive strategies can be learned, and pupils can benefit from this knowledge when solving mathematical problems.

The poster presents results of a research into executive functioning of a weak pupil. The overall objective of the research was to develop and experimentally verify a mathematical programme for stimulating the selected range of executive functions in a low performing pupil.

Subsequently, the task was to determine the impact that such domain-specific intervention programme might have on a weak learner in the areas of his/her:

(1) executive functioning and (2) mathematical ability.

PRE-INTERVENTION

RESEARCH QUESTION *What is the potential of mathematics in stimulating executive functioning of a weak learner?*

VARIABLES

INDEPENDENT VARIABLE

MODULES
ORIENTATION IN SPACE AND PLANE
MENTAL ROTATIONS
SEQUENCES
COMBINATORICS
LOGIC
CONCEPT OF NUMBER

EXEFUN-MATH PROGRAMME

The programme is designed to be used for pair stimulation. It contains both mathematical tasks and metacognitive instructions. To develop the programme's modules, it was first necessary to analyse curriculum of mathematics. Its tasks are graded into difficulty levels following the criteria of cognitive processes involved in solving (e.g., memory, comprehension and application of a rule) and type of concept representation (e.g., specific, symbolic, abstract). The tasks correspond with the achievement standard and ability characteristics of the pupils participating in the research.

DEPENDENT VARIABLE — EXECUTIVE FUNCTIONING

KNOWLEDGE CONSTRUCTION FUNCTIONS:

1. EXECUTIVE FUNCTIONING ⟷ EXECUTIVE FUNCTIONS (EF)
2. COGNITIVE OPERATION
3. METACOGNITIVE SKILSS

- WORKING MEMORY
- ATTENTIONAL CONTROL AND INHIBITION
- COGNITIVE PLANNING
- COGNITIVE FLEXIBILITY

executive functioning/executive functions are the mental processes controlling cognitive function. McCloskey, Perkins and Van Divner (2008) refer to the ability to control the meaningful, organized, regulated, strategic and targeted processing of stimuli of perception, emotion, thoughts, and actions. Their role is to organize and reorganize attention-related activities (controlling and filtering sensory inputs), the child's intentions (controlling behavioral outputs) and thinking (memory and thinking tools) (Pribram, 1997; Bernstein – Waber, 2007).

SAMPLE

PUPILS FROM SOCIALLY DISADVANTAGED BACKGROUND - 4TH YEAR OF BASIC SCHOOL (FINAL YEAR OF THE PRIMARY STAGE OF EDUCATION)

	intervention	boys	girls	∑
experimental group	EXEFUN-MATH	19	21	40
control group 1	Playful Mathematics	19	23	42
control group 2	Waiting list group	19	21	40
∑		57	65	122

METHODS AND MEASURES

This study was structured as a pre-post-test experimental vs. control-group design. Test measures were taken before and after the intervention in order to detect changes in children's cognitive and executive function processes. Quantitative data include measures of pupils' pre- and post-test performance in attentional control, cognitive flexibility, inhibition, and in mathematical skills.

D-KEFS (Delis, Kaplan, & Kramer, 2001)
- The Color-Word Interference Test
- The Verbal Fluency Test
- The Trail Making Test
- The Design Fluency Test

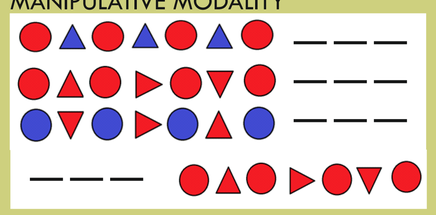
Cognitive Abilities Test R.L. Thorndike, E. Hagen, N. France. Quantitative Battery (Czech adpatation : J. Vonkomer, J. Jílek)

ZAREKI - Neuropsychological Test Battery for Number Processing and Calculation in Children (M. Aster, M. Weinhold, L. Maršálová)

INTERVENTION

PRINCIPLES OF INTERVENTION

MANIPULATIVE MODALITY



INSTRUCTION

Look carefully at how the objects are arranged.
Lay down three missing objects.

Describe your process of thinking.
Why did you use this object to complete the row?

SYMBOLIC REPRESENTATION

A) Look carefully at this sequence of numbers. Write down three missing numbers that would follow.

20, 71, 20, 71, 20, 71, 20, 71, 20, ___, ___, ___

20, 21, 20, 22, 20, 23, 20, ___, ___, ___

12, 358, 15, 338, 18, 318, 21, 298, ___, ___, ___

B) Look carefully at this sequence of numbers. Write down three missing numbers.

___, ___, ___, 12, 358, 15, 338, 18, 318, 21, 298

13, 35, ___, 38, 15, 41, 16, ___, ___, 47, 18, 50

Describe your process of thinking.
Why did you use these numbers to complete the row?

Tell me the rule.

AUDITIVE MODALITY

Listen to what I am going to tell you and then continue (verbal instruction)

table, apple, table, apple, table,___, ___, ___
table, apple, table, pear, table, apple, table, pear, ___, ___, ___
la, li, la, li, la, ___, ___, ___
la, la, li, la, la, li, la, ___, ___, ___

Listen to what I am going to tell you and then continue (verbal instruction)

METACOGNITIVE ACTIVATION (BEFORE, DURING, AFTER) TASK ADMINISTRATION

Repeat what you should do.
Do you think you can manage that?
What do you have to pay attention to?
Tell me how you are going to proceed.
Do it.

Do you think you did it right?
Explain it.
Advise your friend how to proceed to solve the task.

Have you ever faced such task? Where?
Design a similar task for a friend.
Repeat what was important in the solving process?
What have you learned?

POST-INTERVENTION

RESULTS

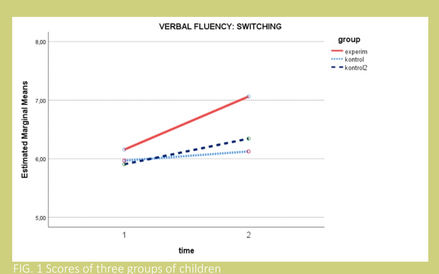


FIG. 1 Scores of three groups of children in D-KEFS: verbal fluency- switching letters and categories

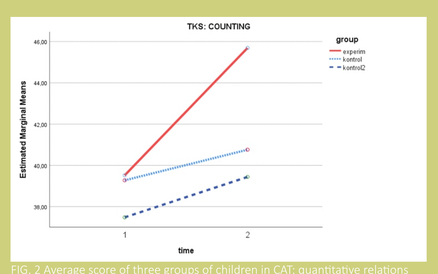


FIG. 2 Average score of three groups of children in CAT: quantitative relations

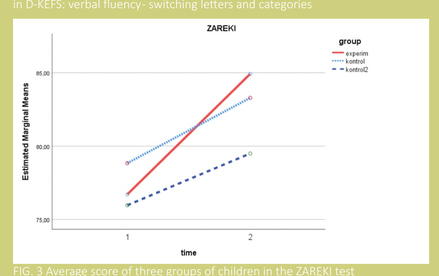


FIG. 3 Average score of three groups of children in the ZAREKI test

DISCUSSION

Executive functions
The results show an increase in executive performance tests in all three groups. On the other hand, the results do not support the assumption that greater progress in the executive function tests will be observed in the experimental group than in the control groups (Fig. 1).

Mathematical abilities
The increase in test score over time is more pronounced for the experimental group than in the two control groups. The performances of the experimental group's children increased in the math tests after training to a greater extent than in the two control groups (Figure 2, Figure 3).

The results of the presented experiment indicate that one of the possibilities for improving the school performance of weak-learners is to focus on how to use executive functions in solving mathematical tasks. Further exploration could be focused on finding the effect of the implemented intervention in the long term.

REFERENCES

1. GEARY, D. C. (2004). Mathematics and Learning Disabilities. Journal of Learning Disabilities, 37 (1), 4–15. DOI: 10.1177/00222194040370010201
2. FROBISHER, L. & FROBISHER. A. (2015). Didaktika matematiky I. Porozumieť. Riešiť. Počítať. Bratislava: Raabe.
3. SMITH, J. M. & MANCY, R. (2018). Exploring the relationship between metacognitive and collaborative talk during group mathematical problem-solving – what do we mean by collaborative metacognition? Research in Mathematics Education, 20 (1), 14-36. DOI: 10.1080/14794802.2017.1410215
4. NCTM- The National Council of Teachers of Mathematics (content standards) https://www.nctm.org/Standards-and-Positions/Principles-and-Standards/Principles,-Standards,-and-Expectations/
5. http://www.nucem.sk/sk/medzinarodne_merania

COLLABORATORS

Ján Ferjenčík
Iveta Kovalčíková
Miriam Slavkovská
Edita Šimčíková
Blanka Tomková

NOTE

This study has been financially supported by APVV (Slovak Research Agency of Ministry of Education, under the contract APVV-15-0273)