PROGRAMME ESKI AND EXECUTIVE FUNCTION TRAINING IN STUDENTS WITH DEVELOPMENTAL LEARNING DISABILITIES

Erik Zovinec – Ema Prostinakova

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Abstract
The study provides a brief theoretical overview of executive functions in the context of pupils with specific learning disabilities and empirically examines the effectiveness of the ESKI training programme. The programme was developed due to the limited availability of comprehensive intervention programmes in the Slovak context. Its content includes the areas of planning, organization, working memory, flexibility, self-monitoring, and self-control. The main aim of the study was to verify the effectiveness of the ESKI training programme at the level of the overall executive function score in pupils with specific learning disabilities. The research sample consisted of eight pupils from two primary schools in the districts of Zvolen and Nitra. The level of executive functions was assessed using the DEF questionnaire by Dawson and Guare (2012) and an author-designed self-assessment questionnaire of executive functions. The results showed a statistically significant improvement in the overall score after completing the training programme in both research instruments. The findings suggest that the ESKI training programme may represent a practically applicable special-pedagogical intervention and counselling tool for supporting pupils with specific learning disabilities in both school and personal contexts.

Key words
executive functions, developmental learning disabilities, training of executive functions, ESKI training program

1 Introduction

In educational practice, it is common to encounter situations in which a student repeatedly experiences failure, loses motivation to learn, appears disorganized or impulsive, and demonstrates difficulties in understanding instructions, planning, and effectively managing academic tasks. These manifestations subsequently have a negative impact on academic performance. Although a comprehensive analysis of all determinants of school failure is beyond the scope of the present study, the focus here is placed on executive functions and their development.

Executive functions (hereinafter referred to as "EF") have been examined in psychological and educational research for several decades (e.g., Sternberg, 2002; Baddeley, 2007; Heretik, 2007; Kassin, 2007; Smith, 2007; Goldstein, 2008; Anderson, 2010; Atkinson et al., 2012; Blair, 2017, among others). Executive functions constitute an umbrella construct referring to a set of higher-order cognitive processes that regulate, coordinate, and organize other mental operations, with current evidence clearly supporting their differentiation into relatively distinct subprocesses at both behavioral and neuroanatomical levels. The primary neurobiological substrate of these processes is the frontal lobes, particularly the prefrontal cortex, which—through extensive intra- and intercortical connectivity, as well as connections with subcortical structures (e.g., the basal ganglia)—enables the integration of multimodal information and the top-down modulation of lower-level cognitive systems (Diamond, 2013). Despite significant advances, the functional architecture of the prefrontal cortex remains only partially understood, especially with regard to lateralization effects and the precise mechanisms by which specific regions mediate distinct cognitive functions. Nevertheless, the integration of methodological approaches such as neuroimaging, neuropsychology,

electrophysiological measurement, and computational modeling has substantially contributed in recent years to a more refined understanding of the structure of executive functions and their neural correlates. Executive functions can be defined as a set of neurocognitive abilities involved in goal-directed problem solving, including working memory, inhibitory control, and cognitive flexibility. Their development progresses from early childhood into early adulthood, shaped by the interaction of biological and environmental factors, and demonstrates considerable plasticity, allowing for targeted intervention. Individual differences in executive function are also recognized as significant predictors of long-term cognitive and social developmental outcomes.

Definitions of executive functions vary considerably across authors, particularly with respect to their conceptual scope, linguistic formulation, and the number of components included within the construct. An overview of selected definitions is presented in the following table.

Table n.1: Overview of definitions of executive functions across different authors

Authors	Year	Definition:
Roberts; Pennington	1996	skills: "planning, goal-directed persistence, impulse control, working memory, and attentional control" (p. 105)
Burgess	1997	activities: "problem solving, planning, task initiation, cognitive estimation, prospective memory" (p. 81)
Anderson	2002	processes: "anticipation, goal selection, planning, activity initiation, self-regulation, mental flexibility, allocation of attention, and the use of feedback" (p. 71)
Hoamack; Donghyung; Riccio	2005	functions: "cognitive flexibility, inhibition, problem solving, planning, impulse control, concept formation, abstract thinking, and creativity" (p. 599)
Ardila	2008	functions: "problem solving, planning, concept formation, strategy generation and implementation, attentional control, working memory, and the coordination of cognition and emotion/motivation" (p. 92)
Meltzer	2010	processes: "goal setting, planning, prioritization, organization, flexible shifting between tasks, holding and manipulating information in working memory, and self-monitoring" (p. 6)
Raskin	2011	cognitive abilities: "higher-order processes that enable flexible and goal-directed behavior by inhibiting inappropriate actions and thoughts, planning future behavior, directing attention, and monitoring one's actions" (p. 233)
Dawson; Guare	2012	"response inhibition, emotional control, working memory, sustained attention, task initiation, planning/prioritization, organization, time management, goal-directed persistence, flexibility, and metacognition" (pp. 8–9)

From a cognitive neuroscience perspective, impairments in executive functions (EF) may arise not only from damage to the prefrontal cortex but also from lesions in brain regions functionally connected to it. Brain lesions, defined as abnormalities in neural tissue, can lead to a range of neurological deficits that may manifest as the so-called

"dysexecutive syndrome" (Cristofori et al., 2019). This syndrome is characterized by disruptions in cognitive processes, emotional regulation, inhibition, planning, social behaviour, and goal-directed activity, and can significantly limit an individual's functioning in everyday life while reducing their level of autonomy. Manifestations of executive dysfunction are not always directly observable and may therefore remain unidentified in a timely manner; consequently, students are sometimes misperceived as lacking effort or as exhibiting behavioural disorders.

Deficits in EF are also observed in students with developmental learning disabilities (hereinafter "LD"). The onset of formal schooling represents a major developmental transition, closely associated with intentional and systematic learning. Demands on students' independence increase substantially, particularly during the transition to lower secondary education, when they are required to adapt to multiple teachers, a greater volume of information, and changes in the organization of instruction. In the presence of EF weaknesses, difficulties may emerge in planning, organization of activities, working memory, attention, inhibition of impulsive responses, strategy formation, and learning from one's own errors (Stuss, 1992). Such students may struggle with completing academic tasks, adhering to deadlines for tests and homework, navigating the school environment, as well as establishing and maintaining social relationships. Poor academic performance in students with LD most commonly manifests in writing, reading comprehension, mathematics, and independent work (Gable, Morin, & Watson, 2016). Similarly, a study by Ji et al. (2021) conducted on an Asian population demonstrated that students with lower achievement in mathematics and reading also exhibited deficits in cognitive flexibility, working memory, planning, task monitoring, and the organization of school materials.

Given the limited availability of comprehensive programs targeting the development of executive functions (EF) in the Slovak context, the present study drew on a Slovenian interventional programme Kako naj naredim to? (Javornik, 2019) focused on five domains of EF. We developed the training program ESKI – Executive Skills in the Context of Intervention. Within this program, the selected strategies were systematically structured into a coherent training protocol aimed at enhancing EF, and its effectiveness was subsequently evaluated through quantitative methodology.

2. Methods

The aim of the present study was to examine the effectiveness of the ESKI training program designed to enhance executive functions in lower secondary school students diagnosed with developmental learning disabilities. In line with this objective, the following hypothesis was formulated:

H1: It is assumed that participation in the ESKI training program will lead to a statistically significant improvement in the level of executive functions among lower secondary school students with diagnosed developmental learning disabilities, as measured by the DEF questionnaire (Dawson & Guare, 2012) and an author-developed executive function self-report questionnaire.

The ESKI training program was designed as a series of 10 sessions, each lasting 45 minutes, conducted once per week in small groups of 3–5 students from grades 5 to 9 of primary school diagnosed with developmental learning disabilities. Each of the five domains of executive functions (planning, goal setting and prioritization in learning, organization, remembering and use of working memory, cognitive flexibility, self-monitoring, and self-control) is addressed across two sessions. The program also allows for flexible adaptation for individual work with a student. The structure of the program includes introductory guidelines for the special education teacher, including a proposal for an initial session, followed by five thematically differentiated sessions with a

consistent internal structure. Each domain begins with a brief brainstorming activity and psychoeducational input regarding the importance of the given EF for learning and everyday functioning. This is followed by specific activities aimed at practicing strategies. These activities take the form of practical tasks in which strategies are either explicitly introduced at the outset or independently identified by the students. Each activity includes a clearly defined objective, time allocation, format of work, required materials, detailed procedure, and, in some cases, suggested discussion questions. The program also includes supplementary materials in the form of printable resources. The topics and activities are designed to be relevant, engaging, appropriately challenging, and applicable to both individual and group work. Additionally, translated activity cards are provided for home practice, offering students structured support for independent work.

Research Sample:
The research sample consisted of eight lower secondary educational level school students diagnosed with developmental learning disabilities (DLD). The participants were recruited from two primary schools, with the study conducted in the districts of Zvolen and Nitra. The selection of the sample was based on a non-probability approach combining convenience and purposive sampling, based on predefined criteria, namely a confirmed diagnosis of DLD issued by a counseling and prevention center and enrollment in the lower secondary level of a mainstream primary school.
In one group, the training program was implemented across ten intervention sessions, while in the second group it was conducted over five intervention sessions, each lasting 45 minutes. The unequal duration of the intervention was taken into account in the interpretation of the results as one of the study's limitations.

Data Collection Methods:
The level of executive functions (EF) was assessed using the Executive Skills Questionnaire (DEF; Dawson & Guare, 2012) and an author-developed self-report questionnaire of EF. Both instruments were administered prior to the implementation of the intervention program (pre-test) and following its completion (post-test). The evaluation focused on the overall EF score as well as the mean scores across individual EF domains. Both questionnaires are positively oriented measures, meaning that higher scores indicate a higher level of EF development.
Data Analysis Methods:
The collected data were analyzed using quantitative methods. As the formulated hypothesis targeted the overall level of EF, primary attention was devoted to the total EF score, while results in specific EF domains were interpreted as supplementary indicators of changes in partial components of executive functioning. Prior to conducting the paired samples t-test, the assumption of normal distribution between pre-test and post-test measurements was verified using the Kolmogorov–Smirnov test and the Shapiro–Wilk test. Given that the normality assumption was met, a paired samples t-test was subsequently employed to compare the results before and after the intervention.

3. Results

The first research instrument administered in both the pre-test and post-test was the Executive Skills Questionnaire (DEF; Dawson & Guare, 2012), which was conducted in person within the school setting using a paper-and-pencil format. Respondents completed 36 items rated on a seven-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"). Given the small sample size, it was necessary to verify the assumption of normality prior to applying the paired samples t-test. This was assessed using the Kolmogorov–Smirnov test and the Shapiro–Wilk test. The results of

both tests indicated no statistically significant deviations from normal distribution ($p > 0.05$), thereby justifying the use of the paired samples t-test.

Table n.1: Results of the paired samples t-test across domains of executive functions.

	Variable		AM	SD	t	df	p	
1	Planning and Prioritization	Pre-test	12,63	4,84	–1,515	7	0,1735	
		Post-test	13,75	3,28				
1.1	Time management	Pre-test	13,88	5,00	– 0,182	7	0,8608	
		Post-test	14,25	4,43				
2	Organisation	Pre-test	12,13	4,67	–5,612	7	0,0008	***
		Post-test	13,63	5,18				
3	Working memory	Pre-test	12,88	2,80	–0,948	7	0,3747	
		Post-test	14,00	3,66				
4	Flexibility	Pre-test	13,63	2,83	0,098	7	0,9246	
		Post-test	13,50	1,77				
5	Self-monitoring and self-control	Pre-test	12,00	2,78	0,000	7	1,0000	
		Post-test	12,00	3,51				
	Total	Pre-test	64,50	10,82	–3,212	7	0,0148	*
		Post-test	67,38	12,01				

In the domains of planning and prioritization, time management, working memory, flexibility, self-monitoring, and self-control, no statistically significant differences were found between the pre-test and post-test measurements ($p > 0.05$). Despite this, an increase in mean scores was observed across all EF domains, with the exception of flexibility, where a decrease was recorded, and self-monitoring and self-control, where no change (stagnation) was observed.

In the domain of organization, a statistically significant improvement was confirmed ($t = -5.612$; $p = 0.0008$; ***), indicating that the intervention had the most pronounced effect in this area. At the same time, a statistically significant improvement was also found in the overall EF score ($t = -3.212$; $p = 0.0148$; *). Although individual domains, with the exception of organization, did not reach statistical significance, the overall results support a positive effect of the ESKI training program on the development of executive functions as a whole.

The second instrument used to assess the level of executive functions (EF) was an author-developed self-report EF questionnaire, administered in person during both the pre-test and post-test phases. The questionnaire consisted of 25 items, with each set of five items corresponding to a specific EF domain. Responses were recorded on a five-point Likert scale, where a value of 1 indicated “strongly disagree” and a value of 5 indicated “strongly agree.”

To verify the assumption of normality of the differences between pre-test and post-test scores, the Kolmogorov–Smirnov test and the Shapiro–Wilk test were applied. The distribution of the data met the normality assumption across all examined domains;

therefore, changes between pre-test and post-test were subsequently analysed using a paired samples t-test.

Table n.3: Results of the paired samples t-test by domains of executive functions

Variable			AM	SD	t	df	p	
1	Planning	Pre-test	16,25	4,37	–3,11	7	0,0171	*
		Post-test	20,13	3,00				
2	Organisation	Pre-test	17,13	5,06	–2,41	7	0,0467	*
		Post-test	18,88	4,32				
3	Working memory	Pre-test	15,75	4,50	–3,26	7	0,0138	*
		Post-test	19,00	3,12				
4	Flexibility	Pre-test	16,50	3,82	–4,93	7	0,0017	**
		Post-test	19,13	3,56				
5	Self-monitoring and self-control	Pre-test	15,75	4,71	–4,71	7	0,0022	**
		Post-test	19,50	3,42				
Total		Pre-test	81,38	19,54	–4,64	7	0,0024	**
		Post-test	96,63	14,97				

The results of the paired samples t-test indicated that statistically significant improvements were observed across all examined domains of executive functions following the intervention. In all cases, the mean post-test scores were higher than the pre-test scores. The negative values of the t-statistics result from the method of calculating differences (pre-test – post-test) and reflect a shift toward higher scores in the post-test.

With regard to the overall EF score across all domains, a positive effect of the ESKI training program can be observed. The total mean score increased from 81.38 in the pre-test to 96.63 in the post-test, with the difference reaching statistical significance ($p = 0.0024$). These findings suggest that the ESKI training program had an overall positive impact on the development of executive functions in the participating respondents.

4. Discussion

Based on the pre-test and post-test measurements obtained through the Executive Skills Questionnaire (DEF; Dawson & Guare, 2012), a statistically significant improvement was demonstrated at the level of the overall EF score, alongside an increase in mean scores across most examined EF domains. The results of the author-developed EF self-report questionnaire indicated a more consistent and pronounced positive trend. All respondents showed an increase in both the mean total score and the median, accompanied by a decrease in standard deviation, suggesting reduced variability in perceived improvement among respondents in the post-test phase.

In contrast to the DEF questionnaire (Dawson & Guare, 2012), statistically significant improvements were observed across all five EF domains in the self-report measure, including those domains in which a decline or stagnation had been recorded in the DEF results. This discrepancy may reflect differences in the sensitivity of the instruments to change, the composition of test items, respondents' interpretation of items, as well as

the distinction between the assessment of observable behaviour and subjective perception of one's own progress.

Findings derived from both quantitative and qualitative measures point to the potential of the ESKI training program to positively influence the development of EF in students with learning disabilities. Although statistically significant improvements were not consistently observed across all partial EF domains, both instruments demonstrated a significant increase in the overall EF score. This result supports the effectiveness of the ESKI training program at the level of overall EF development.

These findings can be interpreted within theoretical frameworks emphasizing the interrelated and coordinated nature of EF domains. Accordingly, the effects of the intervention may not have manifested uniformly across all components but nevertheless contributed to an overall improvement in EF among students with learning disabilities, reflecting their shared underlying basis (Vágnerová, 2020). The uneven pattern of intervention effects across specific EF domains may also be associated with the heterogeneity of EF deficits typically observed in this population. Additionally, the small sample size may have limited the statistical power of the analyses in detecting significant changes within individual EF domains. It is also necessary to consider the relatively short duration of the intervention, which may not have been sufficient to capture more substantial changes across all domains.

The development of executive functions should therefore be understood as a continuous process extending beyond a single intervention and requiring active collaboration among educators, specialists, and families. Although the ESKI program was referred to as a training program within the research context, in practice it can be more broadly conceptualized as a special education intervention and counselling tool applicable in school settings, SEN counselling centres, as well as in cooperation with students' caregivers.

5. Conclusion

Executive functions represent a significant prerequisite for successful functioning of students in the school environment. In students with developmental learning disabilities, deficits in this domain may constitute one of the factors contributing to the persistence and deepening of their academic difficulties. It is therefore essential to focus not only on the development of academic skills, but also on the support of planning, organization, working memory, cognitive flexibility, self-monitoring, and self-control.

The findings of the present study demonstrated a statistically significant improvement in the overall level of executive functions following participation in the ESKI training program. The ESKI program thus appears to be a practically applicable tool for supporting students with developmental learning disabilities. From a pedagogical perspective, it is important that the development of executive functions becomes an integral part of educational practice with students experiencing learning difficulties. Systematic support of these functions may contribute to improved academic performance, increased independence, more effective organization of learning, and enhanced self-confidence among students.

Given the limitations of the study, particularly the small sample size and the unequal duration of the intervention across groups, the findings should be interpreted with caution. Future research should aim to verify the effectiveness of the ESKI training program on a larger sample and under conditions of a standardized intervention duration. Nevertheless, the results suggest that the targeted development of executive functions may represent an important component of support for students with learning disabilities in educational settings.

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doc. PaedDr. Erik Žovinec, PhD.
Department of pedagogy
Faculty of education
Constantine the Philosopher University in Nitra
Dražovská cesta 4, Nitra
Slovak Republic
ezovinec@ukf.sk
ORICID: 0000-0002-1304-9052

Bc. Ema Prostináková
Department of pedagogy
Faculty of education
Constantine the Philosopher University in Nitra
Dražovská cesta 4, Nitra
Slovak Republic
ema.prostinakova@gmail.com
ORCID: 0009-0003-1518-1238