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SMARTS Programme and Pupils' Metacognitive Abilities – A Pilot Study

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Abstract

The presented paper focuses on the impact of intervention with the application of the SMARTS program on students' metacognitive abilities. The metacognitive program SMARTS, a product of RILD[1] (Research Institute for Learning and Development, Lexington, Massachusetts, the author Lynn Meltzer), was translated, adapted, and pilot-tested in the Slovak educational context conditions. In the form of qualitative intervention case studies, the paper analyses (1) the diagnostic potential of SMARTS revealing deficits in students' metacognitive abilities (organisation and prioritisation), (2) an intervention to improve a student's specific metacognitive ability, (3) outcome (stagnation/progress/regression) of the intervention. The results obtained by direct participatory observation applied in the intervention point to a possible positive impact of the SMARTS program on the observed metacognitive abilities of students.

Keywords: *metacognitive skills, metacognitive intervention, metacognitive program SMARTS, BRIEF, D-KEFS, case study*

[1] The authors of the article completed training for the SMARTS application; training organized and completed at the Research Institute for Learning and Development, Lexington, USA.

Introduction

The concept of metacognition and metacognitive abilities have often been referred to in literature in the context of pupils' school achievement (Bryce et al., 2015; Lawson & Farah, 2017). Insufficiently developed metacognitive abilities can be observed in pupils' reduced self-regulation, lack of the ability to plan, think strategically, look for alternative solutions, apply effective metacognitive strategies in the task-solving process. Targeted interventions can correct deficits in pupils' metacognitive behaviour. The need for the development of metacognition or metacognitive strategies (Susantini, Indana, & Isnawati, 2018) and effective learning strategies used by pupils (Rodek, 2019) and teachers (Petlák & Schachtl, 2019) has been discussed in the professional literature.

Metacognition

Metacognition contributes to effective learning (Flavell, 1979; Lane, 2009). It is defined as a person's ability to plan, monitor, assess processes s/he uses when learning and acquiring knowledge. Research has confirmed that metacognitive strategies can be acquired by practice, step-by-step learning and training (Diamond & Lee, 2011).

Programs for development of pupils' metacognitive strategies

Metacognitive strategies can be learnt in two ways: 1) intuitively by one's own or mediated experience; 2) explicitly by systematic training. Research in this area (Veenman et al., 2006; Bannert & Mengelkamp, 2008) suggests that pupils' metacognitive strategies are not spontaneously developed to the extent allowing their independent and automatic use when solving various school or out-of-school tasks.

Educational and stimulation programmes for the development of metacognitive functioning have various characteristics. Kovalčíková (2017) distinguishes two programme lines. One line includes programmes characterised by extracurricular approaches unrelated to the content of a specific school subject. They aim to teach generally applicable principles and forms of thinking. In the professional liter-

ature, stimulation programmes of this group are referred to as domain-general. They include, e.g., Bright Start, COGNET, Peer Mediation with Young Children Programme.

The other line includes context-oriented approaches developing specific cognitive aspects in curricular domains (e.g., Slovak Language, Mathematics, Science, etc.). These domain-specific approaches include, e.g., Cognitive Assault Strategy and Connecting Mathematics Concepts (Engelmann & Carnine, 1991; Miles & Forcht, 1995). In Slovakia, domain-specific programmes include a cognitive stimulation programme developed and experimentally tested in the domain of Mathematics and Slovak Language[2] for underachieving pupils.

Metacognitive Programme SMARTS

The metacognitive programme SMARTS develops a school "culture" with foundations built on the awareness of the importance of self-regulation and self-understanding in the process of learning (Meltzer et al., 2004). The programme aims to help pupils understand their strengths and weaknesses in learning and teach them effective metacognitive strategies to solve tasks. The SMARTS Programme was translated, adapted and pilot-tested in the Slovak conditions within the project VEGA 1/0254/20[3]. SMARTS consists of 7 units; 23 lessons target individual areas of metacognitive self-regulation. Meltzer (2014) divides SMARTS into 5 areas: 1) cognitive planning; 2) cognitive flexibility; 3) organising and prioritising; 4) working memory; 5) self-monitoring and self-checking. Below, one part of the SMARTS Programme will be analysed – organising and prioritising.

Organising and Prioritising[4]

Organisation or the ability to systemise and sort information reflects the quality of a person's metacognitive functioning. Prioritisation is necessary when dealing

[2] Project APVV-15-0273, 2016–2019; principal investigator Prof. PhDr. Iveta Kovalčíková, PhD.

[3] VEGA 1/0254/20SMARTS – Slovak adaptation and pilot testing of the programme for stimulation of executive functions and metacognitive abilities in underachieving pupils; principal investigator Prof. PhDr. Iveta Kovalčíková, PhD.

[4] In the text, the terms prioritization and prioritizing are used as synonyms without a semantic change.

with most school but also common life obstacles. Setting one's priorities in the order of importance and organising time, materials, ideas, and activities are important abilities for optimal school achievements. A teacher's task is to teach pupils to use organisation and prioritisation strategies in writing, reading, mathematics, and preparing for classes (Meltzer, 2014). Strategies aimed at organising and prioritising information are the basis for reading with comprehension. We applied the following SMARTS curriculum lessons to stimulate these abilities:

1) *Purposeful Highlighting* – a strategy aimed at identifying key information in the text and inhibiting irrelevant information.
2) *Triple-Note-Tote* – a strategy aimed at developing the abilities to organise and categorise information and look for relationships and connections.
3) *BOTEC*[5] – a strategy aimed at generating topic-related words, sorting words into categories, formulating a key sentence, details and a summarising sentence.

The content of the lessons was adapted to the Slovak curricular context.

Research Methodology

Research question: What is the impact of intervention through the metacognitive programme SMARTS on selected metacognitive abilities (organising and prioritising) of examined pupils?

Research sample: The research sample consisted of pupils meeting the following criteria: pupils of primary education fourth grade (9–10-years old) manifesting deficits in metacognitive and self-regulation abilities. The research sample was selected based on identification by class teachers from a majority group of pupils not diagnosed with any learning and behavioural disorders. Administrators[6] worked with pupils of an elementary school in Prešov. The administration was paired using the *peer mediation* principle; during the unit, the administrator worked with a pair of pupils. Pupils participated in the research based on their parents' informed consent.

[5] The acronym BOTEC – B – Brainstorming, O – Organizing, T – Topic Sentences, E – Evidence, C – Conclusion.

[6] Administrators of the intervention were the authors of the article.

Research tools and procedures. Examined pupils' data were collected by a qualitative pilot probe connected with intervention represented by a multiple case study. The impact of the experimental intervention was examined on the set of dependent variables (ability to organise, prioritise ideas, information, time or materials). In input measurements, diagnostic tools for determining pupils' executive function levels[7] were used, including BRIEF (Behavioral Rating Inventory of Executive Function), teacher version (Gioia et al., 2002). The battery evaluates manifestations of executive and metacognitive function "functionality" in the examined person's everyday setting. Also, tests of higher cognitive (executive) functions were used – Delis-Kaplan Executive Function System (D-KEFS, Delis, Kaplan & Kramer, 2001), standardised in the Slovak conditions.

45–60 minutes interventions were carried out in 25 sessions twice a week. The sessions took place in the elementary school attended by the pupils, within an extracurricular time. Considering the programme pilot testing, the following was examined: (1) detailed processual aspects of the intervention with the emphasis on observation of pupils' behaviour when working with stimulus material; (2) interventions' influence on the dependent variables.

Research Results and Interpretation

Results of the input diagnostics by D-KEFS tests (Table 1) present the current level of the examined pupils' executive functioning. Results in the input tests of a person's executive functioning are perceived as indicators also of the current level of metacognitive abilities, which complies with Levin and Hanten (2005), who referred to executive functions as metacognitive and understood metacognitive abilities as an important component of a person's successful executive functioning. The pupils' performance in the indicators examined within the input diagnostics may be assessed as under-average in relation to the average performance according to the standardised norms.

[7] H. S. Levin & G. Hanten refer to executive functions as metacognitive, because they perceive metacognitive abilities as an important component of a person's successful executive functioning.

Table 1. Examined pupils' executive functioning level (D-KEFS)

D-KEFS test (Input measurements)	Test Emil	Test Vanda	Average performance according to the standardized norm
Trail Making Test, Condition 1, Visual Scanning	45	25	28–30
Trail Making Test, Condition 2, Number Sequencing	63	62	48–53
Trail Making Test, Condition3, Letter Sequencing	77	50	54–59
Trail Making Test, Condition 4, Letter – Number Switching	157	125	99–109
Trail Making Test, Condition 5, Motor Speed	55	80	46–54
Verbal Fluency Test, Subtest 1, Letter Fluency	8	14	18–19
Verbal Fluency Test, Subtest 2, Category Fluency	24	26	29–31
Verbal Fluency Test, Subtest 3, Category Switching	8	9	11
Design Fluency Test, Condition 1, Full Dots	8	7	7
Design Fluency Test, Condition 2, Empty Dots	7	7	7
Design Fluency Test, Condition 3, Switching dots	3	3	5
Colour-Word Interference Test, Subtest 1, Name colours	52	48	40–42
Colour-Word Interference Test, Subtest 2, Read words	47	43	33–34
Colour-Word Interference Test, Subtest 3, Inhibition	148	95	75–80
Colour-Word Interference Test, Subtest 4, Inhibition/ Switching	120	80	80–86
Tower Test – total resulting score	16	14	16

Source: Own processing
Legend:
– Under-average performance according to standardised norms
– Average performance according to standardised norms
– Above-average performance according to standardised norms

Similar results were produced by the observation procedure BRIEF represented by behavioural evaluation of the examined pupils' executive functioning assessed by their class teacher (Table 2). The results reflected the extent to which examined pupils were capable of effective self-regulation in the school setting conditions. In this case, the pupils' performances were mostly under-average compared with the norm for the given age category of pupils.

Table 2. Examined pupils' executive functioning level (BRIEF)

BRIEF (Input measurements)			
Scale/Index	T-scores Emil	T-scores Vanda	Average performance
Inhibition	60	49	50–65
Shifting Attention	60	81	
Emotional Control	45	73	
BRI	56	70	
Initiative	72	73	
Working Memory	83	61	
Planning and organizing	77	64	
Organization of Materials	86	46	
Monitoring	74	63	
MI	80	64	
GEC (BRI + MI)	73	68	

Source: Own processing
Legend:
– Under-average performance according to standardised norms
– Average performance according to standardised norms
– Above-average performance according to standardised norms

T-scores – linear transformations of the scale raw scores. T-scores give information about individuals' results in relation to the results of respondents in the standardised group.

BRI – Behaviour Regulation Index – represents the pupil's ability to shift attention, modulate emotions and behaviour through adequate inhibition.

MI – Metacognition Index – represents the pupil's ability to begin, plan, organise, and retain working memory.

GEC – Global Executive Composite – summarises all eight clinical scales of the BRIEF method (Gioia, Isquith, Guy & Kenworthy, 2011).

Selection from Pupils' Case Studies

Case Study Emil

Before intervention. Based on interviews and observations of the pupil, his self-confidence and motivation could be assessed as reduced. His family perceived Emil as a poorer pupil without a potential to complete, e.g., a university (source: an interview with the pupil).

During intervention: Emil was observed deficits in the processes of organising and prioritising – the inability to *identify key information and distinguish it from details of the text, create a title for the paragraph based on the content of the paragraph.* To eliminate the observed manifestations of reduced functionality of the monitored processes, the following was applied: a) intervention using the SMARTS stimulating units; b) strong verbal stimulation of the pupil to pay attention to solving tasks using the "think aloud" method.

After intervention. There was progress, manifest in the improved ability to identify key information in the text, distinguish it from details and create a graphic text to memorise the caption. As said Emil himself: "I used a strategy of my own named "picture" *(*his modification of the "Triple-Note-Tote, Double-Note-Tote") which I used at Homeland and Nature Study, and Natural Science. I always drew what I did not understand in order to understand it". The pupil was able to internalise the learnt strategies for organising and prioritising but still required intense leading and scaffolding by the administrator. His preparation for classes was failing mainly in the home setting.

Case Study Vanda

Before intervention. Vanda's writing was neat but with many spelling and grammar errors. Her reading was slow, lacking fluency, with many mistakes. Her speech was slow, calm and diffident. Her working pace could be considered slow. Vanda had difficulty presenting outcomes of her thinking both verbally and in writing.

During intervention. During sessions, an effort to solve assigned tasks was observed, but adversely affected by the pupil's low self-confidence (e.g., when asked why she frequently copied off of her school-mate, she answered: "Because I am not sure about the answer"). Observation during the stimulating units revealed the following significant difficulties of the pupil: reading with comprehension, the inability to identify key information in the text, difficulty to paraphrase sentences and categorise information. Also, difficulties with mastering concepts and vocabulary were observed, which can be considered the predictor of the ability to read with comprehension. The difficulty to decode individual words in the text affected working memory capacity. The pupil had problems retaining information in memory, which subsequently caused problems in the area of inferential thinking and, indirectly, problems arose with comprehension of the text. In result of the cascade of deficits, the pupil was not capable of metacognitive monitoring of her own text comprehension linked with connecting individual thoughts of the text. She had difficulties applying metacognitive strategies to check her own interpretations of the text's meaning. To eliminate the observed manifestations of reduced function-

ality of executive functioning processes (organising, prioritising), the following was applied: a) *intervention method* – stimulating units "Purposeful Highlighting", "Triple-Note-Tote/Double-Note-Tote"; b) *intervention by the administrator* – the administrator produced her own task solving examples and systematically applied metacognitive questions for the pupil to arrive at the correct solution of the task on her own.

After intervention. At the final stage of the stimulating sessions, significant progress in metacognitive and cognitive processes was observed in the pupil, this in the abilities: *reading with comprehension, paraphrasing sentences, identifying key information and distinguishing it from details in the text, creating titles for analysed paragraphs.*

Table 3. Summary outcomes of the intervention process

Stimulation phase (Outcomes)		**Intervention process outcomes**	
Metacognitive abilities	Observed problem	Emil	Vanda
Prioritizing, Organizing, Flexibility	Problem to read with comprehension		Progress
	Problem to paraphrase the text		Progress
	Problem to identify key information and details in the text	Progress	Progress
	Problem to create paragraphs and their titles	Progress	Progress

Source: Own processing.

Based on the outcomes obtained by observation and interviews, the impact of the intervention on the pupils' metacognitive abilities can be assessed as positive (Table 3). Following the termination of the intervention, the pupils' behavioural manifestations in the educational process were also evaluated by their class teachers. The author's assessment sheet consisted of 20 scaled items representing indicators of the pupil's metacognitive behaviour. Teachers assessed the level of manifest metacognitive behaviour before and after the intervention. Both examined pupils progressed in more than 15 items/indicators out of 20.

Discussion, Conclusions, and Recommendations

The pilot research has benefits and limitations. The benefit of the qualitative research design can be seen in the comprehensive evaluation of the pupil, his/her cognitive dispositions, experiencing, emotions; the possibility to observe detailed processual aspects of emerging metacognitive abilities. Moreover, the qualitative study is necessary in case of the new programme adapted to the conditions of the Slovak context. On the other hand, the small research sample (3 pairs of pupils; 1 pair analysed in the article) does not allow even approximating to generalisation of the outcomes. However, it should be emphasised that only understanding relations and connections within qualitative research can converge to future experimental testing of the intervention within a quantitative research design. The results of the input measurements and outcomes of the intervention phase may have been influenced by intervening variables (the school setting, pupil's current emotional situation, administrator's competencies, time of interventions, etc.). The original design of the quasi-experimental approach (pre-test – intervention – post-test) was not fully complied with due to the current epidemiological (COVID-19) situation. It would be good to examine the impact of the SMARTS Programme over a wider time frame. The research pilot-tested more of the stimulating units of the SMARTS curriculum, which could subsequently be formed into a set of stimulating units according to pupils' individual needs. The findings of our research suggest possibilities to implement SMARTS at two levels:

(1) *Stimulating programmes (domain-general)* – based on the SMARTS programme principles and strategies applied in the form of "tutoring" the whole class, a group or a pair of pupils, or individual tutoring;
(2) *Instruction programmes (domain-specific)* – SMARTS principles implemented in curricula of specific subjects (mostly Language, Mathematics, Natural Science, Homeland and Nature Study) and applied by teachers as part of instruction; e.g., outcomes of an experimentally tested domain-specific programme are analysed by Kovalčíková et al. (2021). The presented research results indicate the intervention's potential to effectively influence the ability to work with the (factual) text. The visible progress of the pupils was registered most of all in the pupils' motivation to learn new concepts and ideas, improved ability to read with comprehension, paraphrase the text, identify key words and information and details in the text, create paragraphs and their titles, categorise information obtained from the text, create a graphic text as an aid to memorise information. This

method of learning a text, e.g., from Natural Science and Homeland and Nature Study, reduces learning the word for word, influences retention of knowledge in long-term memory. The intervention process also indicated the administrator's competencies and experience as the key determinant of pupils' behaviour in the programme testing process. We assume that it is necessary to further examine and define the competencies the metacognitive stimulation administrators need to successfully implement the intervention. The pilot testing shows that knowing pupils' cognitive equipment, understanding the thinking and information processing process is necessary, as Susantini, Indana, and Isnawati (2018) stated. This equipment allows the administrator/teacher to work with the programme so that s/he can flexibly respond to a pupil's cognitive needs. Interventions of a similar type cannot be administered mechanically without understanding possible reasons for a pupil's failures when working with specific learning material. In this connection, the following questions can be formulated: How to motivate teachers to apply the principles of similar programmes to instruction? How can the stimulation of a pupil's metacognitive competencies and strategies be implemented into the teaching-learning process? The suggested questions may be a direction of further basic and applied research in cognitive pedagogy.

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