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EFFICIENCY OF NILD EDUCATIONAL THERAPY IN THE DEVELOPMENT OF MATHEMATICAL THINKING

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Abstract
Starting from the viewpoint according to which mathematical thinking is developed in close relation with the cognitive development of a child, the purpose of this study is to pinpoint the efficiency of NILD Educational Therapy regarding mathematical thinking development of primary school children with learning difficulties. The 13 participants of this study were aged between 6 and 11, pupils of which 6 were girls and 7 boys. Each subject was tested individually in two stages, twice, 30 – 35 minutes each, in a time span of 7 months between the pretest and posttest. After the pretest phase, 6 pupils were chosen for the experimental group and 7 pupils for the control group. The subjects of the experimental group followed an individualized program of the NILD Educational Therapy, based on each pupil's individual need, during a period of 5 months. After the processing of acquired data, the study showed that the pupils who followed the NILD Educational Therapy program, experienced a substantial increase in their mathematical performance, compared to those in the control group. In addition, the results of the study indicate that the subjects participating in the program scored higher in the posttest, both in the raw scores and the cognitive performance tests, and also in mathematics. On the other hand, subjects of the control group, scored higher in the posttest in the raw scores only, but not in standard or mathematics scores. There was an exception though, regarding the linguistic test, in which the control group subjects scored significantly higher in the posttest phase.
Key words: *mathematical thinking development, NILD Educational Therapy.*

Humans are distinguished from other creatures by thinking. They possess the specific capacity of processing information in order to gain knowledge, form principles, develop the skills and cognitive abilities they need to solve the problems they face in their everyday life. Although, it's a capacity that generally characterizes humans, thinking doesn't work the same way for everyone. People think in a different manner. Even more, the same person thinks differently in different situations. Each person develops their own personal way of thinking, an individual method of approaching and solving a problem.

According to Andrei Cosmovici (1996), thinking is a sequence of operations that leads to revealing important aspects of reality and to solving certain problems. We can distinguish between two categories of thought operations: general operations, present in every act of reflection, and specific operations related to a certain category of topics, with a specific field of research.

Utilizing the thought operations - analysis and synthesis, comparison, abstraction - generalization, concretism or exemplification - leads to the creation of notions, judgments and reasoning, which are the forms of reflective thinking. Notions (*concepts*) reflect the essential and general attributes of a class of objects. Judgments are links between different notions, and reasoning expresses the relationships between judgments.

Mathematical activities force the pupils into becoming more aware of their own thinking, into knowing "what they do" and "why are they doing it", into expressing themselves using a correct and precise language.

Mathematics can develop a series of abilities: individual and active thinking, making analogies, analyzing a problem, breaking up a math task into a simpler one, etc. Studying mathematics will result in the development of certain skills and capacities needed for mathematical activities, and later in life these will become useful in human practical activities.

The order of solving an exercise, a task, makes thinking accustomed to good discipline and it can become a personality trait. Working with tasks creates the most favorable ground for developing the creative capacity of a pupils' mind, if they have certain independence in solving tasks based on their personal experience (Mutzabaugh, 2012).

Any objectual action must be accompanied by verbal explanations of the sequence of steps followed to the resolution, this having the role of assimilation. Any new assimilation must be based on the renewing (*updating*) of existing knowledge. Mathematical activities have an exceptional role in the child's intellectual development, in logical thinking development, namely in a consistent, clear and accurate thinking.

Before learning natural numbers, children must establish immediate contact with a series of objects, discover their characteristic properties, find relations between them, and perform various operations that will result in new sets of objects with new properties.

The conducted mathematical activities have the foundation on the following psycho-pedagogical and methodological competences: development of aesthesis and perception through direct actions with the objects, recognition and naming of attributes: shape, color, size and position in the surrounding space, formation of sorting skills, arranging in series, classification by common traits, formation of overall assessment by pairing and the formation of language and mathematical representations.

The NILD Educational Therapy (National Institute of Learning Disabilities) implies the usage of special techniques that lead to better performance in the domains of writing, reading and mathematical thinking. In this respect, the therapy's objectives are: to develop

different neuro-cognitive functions, which are included in the writing-reading and mathematical thinking activities, and to build up socio-emotional skills.

The NILD Educational Therapy's characteristics are:

- The therapy's intervention must be well targeted;
- The transfer of the learned skills to everyday life situations is planned durig the therapy;
- Basic academic skills are integrated with the higher cognitive processes;
- Cognitive strategies are developed by analyzing concrete issues;
- Learning efficiency is increased by self-regulation.

In order for the therapy to be a success, it is necessary to make a precise diagnosis, since deficits influence learning. In this way the areas of perception and thinking that are functioning inefficiently are targeted, and these deficient abilities are stimulated.

Every pupil is a unique entity, thus needs a personal motivation, and deficient areas are particular for one pupil to another. Therefore, individualized treatment provides safety to these children.

According to Vygotsky's concept, the "zone of proximal development" (apud, Mutzabaugh, 2012) development doesn't begin from the level of the child, but from a higher level. It is essential to identify what problems a child can solve with assistance. The language used throughout the therapy is interactive with guided questions, so the intervention becomes active.

The NILD Educational Therapy (National Institute of Learning Disabilities) offers a large scale of techniques that can be utilized during the therapy of learning disabilities like: dyslexia, dyscalculia, dysgrammatism (*agrammatism*); can also be utilized in different cognitive function impairments, memory deficiency, language and thinking disorders. The NILD Educational Therapy is founded on the latest research in neuropsychology and psycholinguistics.

The twenty seven techniques used in NILD Educational Therapy are grouped in two major categories (apud, Mutzabaugh, 2012): central techniques: puts emphasis on writing-reading and mathematical calculations, and complementary techniques: develops cognitive functions such as: attention, memory, visuospatial orientation, language, understanding, thinking, etc.

In the NILD Educational Therapy central techniques are emphasized more, but are accompanied with some of the complementary techniques, depending on the diagnosed deficiency of the child.

This present study is an applied research having the purpose of calling attention to the NILD Educational Therapy's effectiveness in the development of mathematical thinking in primary school pupils who are struggling with learning difficulties.

In this study 13 subjects participated, from a school in Oradea, all primary school children from grade 0 to 4, aged between 6 and 11. Six of the subjects were girls and seven were boys. The children were selected according to the recommendation of their teacher as follows: 2 pupils from prep grade (grade 0), 1 from 1st grade, 1 from 2nd grade, 3 from 3rd grade, and 6 from 4th grade. For the experimental group 6 pupils were chosen randomly (1 from prep grade, 1 from 1st grade, 1 from 2nd grade, 1 from 3rd grade, and 2 from 4th grade), and the other 7 formed the control group.

For the evaluation of mathematical thinking the following tools were utilized: Raven's Colored Progressive Matrices, Parallel version (2003), which contains 36 items divided in three subgroups: A, AB and B. The initial test was first published in 1947, was revised several times, and finally in 1962 the Parallel version was created. The authors of the test are J. Raven, J C Raven and J H Court. In 2003 the test was adapted to the Romanian population by the Romanian Psychological Testing Services.

Also, the following subtests from the NEPSY battery (2007) were utilized: Tower, Arrows, Route Finding, Memory for Faces, Comprehension of Instructions, Sentence Repetition and Visual Attention. NEPSY is a complex instrument, created for the evaluation of the neuropsychological development of primary and secondary school children. The term NEPSY is an acronym derived from the word neuropsychology (NE from *neuro* and PSY from *psychology*). The NEPSY battery is comprised of different neuropsychological subtests that can be used in various combinations, depending on the child's need and the examiner's goal. A large number of subtests were included in this battery, designed to evaluate neuropsychological development in five areas of performance: (a) Attention and Executive Functioning, (b) Language, (c) Sensorimotor Functions, (d) Visuospatial Processing and (e) Memory and Learning. This validated and standardized neuropsychological tool was specially created for children between 3 and 12 years of age. The authors are Marit Korkmann, Ursula Kirk and Sally Kemp.

Another worksheet for mathematical performance was utilized, created specifically for the education level of children, based on the national curriculum for mathematical studies (Appendix). The worksheet contained mathematical exercises that are generally covered in the first years of study. The worksheet included 30 mathematical exercises grouped in the following manner: addition without changing place value, addition with changing place value,

base ten operations, subtraction without regrouping, subtraction with regrouping, multiplication, division, order of operations and other mathematical exercises. Each question that is answered correctly values one point, so the maximum point that one can reach is 30.

The research was implemented in several stages in a total absence of disturbing stimuli. Thus, in the first stage each subject was tested twice, individually, every phase lasting 30-35 minutes.

During the Raven's Colored Progressive Matrices, Parallel version test, subjects were asked to choose the right answer for the following question "a piece was cut from this rug, find which one is the missing piece that fills in the gap?" The child had to choose from the 6 given answers for each question. The results were registered in the Raven's Colored Progressive Matrices, Parallel version Personal File.

During the NEPSY Tower subtest the subjects were asked to move three colored beads on three pegs to match a goal position, taking into account the number of possible moves. The child was also limited by time and by being obliged to conform to certain rules. In the Arrows subtest the child looks at an array of arrows arranged around a target, and has to choose the two arrows that will hit right in the target's center. During the Route Finding subtest subjects are shown a house on a sketch of a map and are solicited to find that certain house on a more complex map. In the Memory for Faces subtest subjects are given instructions to look at a picture and memorize each face as it is presented. Right after the picture is shown children are asked to identify the faces from a new set of three pictures, one of them was shown previously and 2 are distractors. In the Comprehension of Instructions subtest the subject points out different items, taking into account its color, its location and its relation to the other items, acting by the verbal instructions received. During the Sentence Repetition subtest the subject repeats sentences of increasing length and difficulty. During the Visual Attention subtest subjects are asked to visually examine an image and mark the target item as soon and as accurately as they possibly can. Two items are given to every child, of which one is chosen randomly, the other one is of a more complex structure. The results of the NEPSY battery were registered in the NEPSY Personal File.

At the Mathematical performance test the subjects were each given a worksheet. During the test the pupils had the task to solve the math exercises on the handout, which were determined by the class they are attending.

After the first evaluation the subjects that were part of the experimental group were selected. They took part in a NILD Educational Therapy program tailored to every child's personal need. Only subjects with normal intelligence but with difficulties in mathematical

understanding were accepted in the study. The therapeutic sessions took place as follows: 2 pupils attended twice a week, 60 minutes each, at 21 and respectively 26 therapeutic sessions in 5 months, and 4 pupils participated weekly for 60 minutes, between 11 and 12 therapeutic sessions in 5 months.

After the completion of the NILD Educational Therapy program, all subjects were reexamined with the same mathematical exercises, in the same conditions and using the same procedures as in the initial testing, with a difference of 7 months in time (November 2013 – June 2014). The data was processed statistically.

Following the group-based comparison in the pretest phase, based on the results of the statistical analysis, which can be seen in Table 1, it is noted that there is a significant difference in the experimental group in the pretest phase in terms of Visual Attention (p=0.04), level of Comprehension of Instructions (p=0.05), level of Arrows (p=0.01), level of Sentence Repetition (p=0.05), addition total (p=0.04), subtraction total (p=0.02), addition with changing place value (p = 0.02), base ten operations (p=0.03), subtraction with regrouping (p=0,01), subtraction from tens (p=0,01), because in these cases p <.05.

Table 1. Experimental group based comparison in the pretest phase

Variable	**z**	**p**	**Average rank**
Visual Attention score	-2,04	0,04	Exp. group = 4
			Cont. group = 8
Comprehension of Instructions score	-1,89	0,05	Exp. group = 4
			Cont. group = 8
Level of Arrows	-2,38	0,01	Exp. group = 4
			Cont. group = 9
Level of Sentence Repetition	-1,78	0,05	Exp. group = 4
			Cont. group = 8
Addition total	-2,03	0,04	Exp. group = 4
			Cont. group = 9
Subtraction total	-2,20	0,02	Exp. group = 4
			Cont. group = 9
Addition with changing place value	-2,35	0,02	Exp. group = 4
			Cont. group = 9
Addition - Base ten operations	-2,13	0,03	Exp. group = 4
			Cont. group = 8
Subtraction with regrouping	-2,40	0,01	Exp. group = 4
			Cont. group = 9
Subtraction from tens	- 2,45	0,01	Exp. group = 4
			Cont. group = 9

As it is revealed in the table above, the subjects of the experimental group had lower performance on the above-mentioned items than the subjects of the control group.

Following the group-based comparison in the posttest phase the results are reveling the fact that there is no considerable difference between the two groups, because p>.05. But if we accept that there can be a possibility of 5% error, than there is a difference between the experimental and control group at the Subtraction from tens item.

Table 2. Experimental group based comparison in the posttest phase

Variable	**z**	**p**	**Average rank**
Visual Attention score	-0,48	0,62	Exp. group = 7
			Cont. group = 6
Comprehension of Instructions level	-1,36	0,17	Exp. group = 5
			Cont. group = 8
Level of Arrows	-0,64	0,51	Exp. group = 6
			Cont. group = 7
Level of Sentence Repetition	-0,79	0,42	Exp. group = 6
			Cont. group = 7
Addition total	-0,07	0,94	Exp. group = 6
			Cont. group = 7
Subtraction total	-1,59	0,11	Exp. group = 6
			Cont. group = 7
Addition with changing place value	-0,54	0,58	Exp. group = 6
			Cont. group = 7
Addition - Base ten operations	-0,47	0,63	Exp. group = 6
			Cont. group = 7
Subtraction with regrouping	-0,82	0,41	Exp. group = 6
			Cont. group = 7
Subtraction from tens	**- 1,93**	**0,05**	Exp. group **= 4**
			Cont. group **= 8**

In Table 1 in the pretest phase we can see that there is a significant difference between the subjects of the experimental group and that of the control group. This was the main reason for selecting those particular pupils for the experimental group. Following the intervention through the NILD Educational Therapy program, in the posttest phase, as we can see it in Table 2 we can't notice the significant difference between the two groups anymore, although this is less true for the mathematical test: at the Subtraction from tens where the threshold is equal to 0.05. Based on the results, we can say that there is a considerable difference in the performance of mathematical thinking of primary school children that participated in the NILD Educational Therapy program. Thus, students who have undergone the NILD Educational Therapy program have significantly higher performance than those in the control group.

Following the comparison based on the testing time of the experimental group according to the results of the statistical analysis, which can be seen in Table 3, it is found that there is a significant difference based on the testing time of the experimental group regarding

the total Raven score (p=0,02), I.Q. score (p=0,02), intelligence level (p=0,5), Tower score (p=0,04), Tower level (p=0,05), Sentence Repetition score (p=0,02), Sentence Repetition level (p=0,02), Arrows score (p=0,04), Addition total (p=0,04), Subtraction total (p=0,02), mathematical total (p=0,02), Addition - Base ten operations (p=0,04), Subtraction with regrouping (p=0,03), and Subtraction from tens (p=0,03), since in these cases p is less than or equal to .05.

Tabelul 3. Comparison based on testing time of the experimental group

Variable	**z**	**p**	**Rank average**	
Raven score total	-2,20	0,02	Negative (N=0)	0
			Positive (N=0)	3
			Equal (N=6)	
I.Q. score	-2,20	0,02	Negative (N=0)	0
			Positive (N=6)	3
			Equal (N=0)	
I.Q. level	-1,89	0,05	Negative (N=0)	0
			Positive (N=4)	3
			Equal (N=2)	
Tower score	-2,03	0,04	Negative (N=0)	0
			Positive (N=5)	3
			Equal (N=1)	
Tower level	-1,89	0,05	Negative (N=1)	1
			Positive (N=5)	3
			Equal (N=0)	
Sentence Repetition score	-2,,23	0,02	Negative (N=0)	0
			Positive (N=6)	3
			Equal (N=0)	
Sentence Repetition level	-2,22	0,02	Negative (N=0)	0
			Positive (N=6)	3
			Equal (N=0)	
Arrows score	-2,02	0,04	Negative (N=0)	0
			Positive (N=5)	3
			Equal (N=1)	
Addition total	-2,04	0,04	Negative (N=0)	0
			Positive (N=5)	3
			Equal (N=1)	
Subtraction total	-2,20	0,02	Negative (N=0)	0
			Positive (N=6)	3
			Equal (N=0)	
mathematical total	-2,20	0,02	Negative (N=0)	0
			Positive (N=6)	3
			Equal (N=0)	
Addition - Base ten operations	-2,04	0,04	Negative (N=0)	0
			Positive (N=5)	3
			Equal (N=1)	
Subtraction with regrouping	-2,07	0,03	Negative (N=0)	0
			Positive (N=5)	3

			Equal (N=1)	
Subtraction from tens	-2,12	0,03	Negative (N=0)	0
			Positive (N=5)	3
			Equal (N=1)	

As it is stated in the above Table the experimental group subjects have a lower performance in the pretest phase, compared to the posttest at the following items: Raven score total, I.Q. score, intelligence level, Tower score, Tower level, Sentence Repetition score, Sentence Repetition level, Arrows score, Addition total, Subtraction total, mathematical total, Addition - Base ten operations, Subtraction with regrouping, and Subtraction from tens.

Following the comparison based on the testing time of the control group the results reveal that there is a significant difference based on the testing time of the control group regarding: Raven score total (p=0,04), Tower score (p=0,04), Sentence Repetition score (p=0,04), Comprehension of Instructions score (p=0,03), Comprehension of Instructions level (p=0,04).

Tabelul 4. Comparison based on testing time of the control group

Variable	**z**	**p**	**Rank average**	
Raven score total	-2,04	0,04	Negative (N=0)	0
			Positive (N=5)	3
			Equal (N=2)	
Tower score	-2,04	0,04	Negative (N=1)	2
			Positive (N=6)	4
			Equal (N=0)	
Sentence Repetition score	-2,03	0,04	Negative (N=0)	0
			Positive (N=5)	3
			Equal (N=2)	
Comprehension of Instructions score	-2,13	0,03	Negative (N=1)	1
			Positive (N=6)	4
			Equal (N=0)	
Comprehension of Instructions level	-2,05	0,04	Negative (N=1)	2
			Positive (N=6)	4
			Equal (N=0)	

As it is stated in the above Table the control group subjects have a lower performance in the pretest phase, and higher performance in the posttest phase at the following items: Raven score total, Tower score, Sentence Repetition score, Comprehension of Instructions score, Comprehension of Instructions level.

In Table 3 we can see the fact that the experimental group subjects performed significantly higher in the posttest phase equally at raw scores and standard levels or scores, but also at the following mathematical tests: Addition total, Subtraction total, mathematical

total, Addition - Base ten operations, Subtraction with regrouping, and Subtraction from tens. At the same time, the control group subjects performed significantly higher in the posttest stage only at the raw scores of the psychological tests but not at the standard scores, as a result of the long time between the pretest phase and the posttest phase (7 months). The only exception was the linguistic test, the Comprehension of Instructions, which wasn't targeted during the NILD Educational Therapy program. Furthermore, there is no significant difference based on the testing time of the control group regarding the mathematical tests. According to the results we can affirm that there is a considerable difference regarding the development level of cognitive functions such as: fine motor skills, spatial orientation, memory and visual attention in the pretest and posttest phase in subjects who participated in the NILD Educational Therapy program.

This present study serves to prove that the pupils who participated in the NILD Educational Therapy program performed higher in mathematical tests compared to those who didn't take part in the program.

This program is meant to support children with learning difficulties, children who experience frustration and/or different forms of failure in their personal or school lives. This was the reason behind selecting the children with lower performances after the first testing.

At the end of the study, it was noted that of the pupils who did not participate in the intervention program, only 3 pupils (out of 7) obtained higher scores on mathematical tests compared to the previous testing, but of the children who participated in the NILD Educational Therapy program 6 students (out of 6) had better results on mathematical tests.

At the same time, it has been shown that students who have undergone this therapy achieved a higher development of cognitive functions at the end of the intervention compared to their initial assessment.

Pupils who participated in the NILD Educational Therapy program achieved better results in the posttest phase both at the raw scores of cognitive tests and at standard level tests. Consequently, the intelligence level, the logical thinking level, the aural memory and the spatial orientation skills have increased. Students in the control group achieved better results only at the raw scores of the psychological tests, without any change in the standard level test results. One exception was the linguistic tests at which both the raw score and the standard score has increased.

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