THE DIAGNOSIS OF MATHEMATICAL DIFFICULTIES BY USING NUMERICAL TABLE

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Abstract

The main object of this paper is to inform interested professionals and the general public about a simple test that can be used to identify children from 2nd – 7th grades of primary schools(in Czech environment children ages about 7 -12 years old) with marked difficulties in mathematics. For this group of children authors implemented a research which confirmed their assumption of using their relatively simple test Numerical Table. This test corresponds to the current modern diagnostic trends in the sense that it combines qualitative and quantitative approaches in setting the test and its evaluation. These aspects are manifested by the fact that the investigator can flexibly apply the test setting during the investigation according to the detected level of mathematical thinking of a pupil. It means that a special education teacher or psychologist directly reflects selected sequence and solution strategies of individual probands and accordingly increases the difficulty setting. Within at the same time natural and necessary dialogue Investigator - Investigated logically more qualitative diagnostic findings emerge. Working with the test takes only a few minutes, which is also its other benefit. The authors compared the results obtained in this test using the Pearson correlation coefficient. The investigation was completed with the survey of children age period in which the test measures math skills most sensitively.

Keywords: diagnostics of dyscalculia; Numerical Table; difficulties in mathematics; dyscalculia; pupil

1 INTRODUCTION - THEORETICAL BASIS

International Classification of Diseases defines dyscalculia as follows: "This disorder involves specific disability of counting skills that cannot be explained by mental retardation or improper way of teaching. The disorder is related to numeracy (addition, subtraction, multiplication and division) rather than the more abstract skills such as algebra, subtraction, multiplication and division "(Blažková, 2009, p. 14).

Many authors, however, point to the fact that "no clearly defined phenomenon of dyscalculia exists". Each child has their own set of difficulties with understanding, error types, causes, etc.. (Simon, 2006, p. 159). This opinion is agreed by Zelinková (2009), who considers that there is no single compact mathematical ability. When solving mathematical tasks there is a wide variety of factors. These problems can be roughly grouped into four main categories: processing of numbers, memory for numbers, mathematical skills and mathematical thinking (Vágnerová, 2009).

Smits (2013) defines more areas. He talks about the mathematical abilities as a complex combination of skills: reading and writing of numbers, understanding of numbers, counting, ability to orientate on the number line, understanding of a specific mathematical language, coping with mathematical processes, memory for facts and symbols, logical thinking, ability to translate the wording of word problems into mathematical operations, ability to convert units and ability of visual-spatial orientation.

Novák (2000) appoints the following basic areas which the child in coping with elementary mathematical tasks should pass. It is classification (categorization, classification) of understanding of equivalence (equality), then it is preservation (at spatial changes the number of elements does not change), seriation (sorting by different criteria), reversibility (understanding of reversibility of mathematical operations) and its ability to count (including understanding that the last number indicates the number of elements).

Currently, there are many classifications of mathematical problems within dyscalculia (Košč, Geary,

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Blažková, Smits, Černá),but the truth is that these difficulties are exhibited by virtually all children with the disorder or reduced level of the acquisition of mathematical skills, so not only by children diagnosed with specific learning disabilities. This fact correlates with the concept of multifactor causes of mathematical problems which combines many causes, both endogenous and exogenous, which ultimately result in a symptomatic individual image of the disorder (Vitásková, 2005).

The most frequently reported categories of dyscalculia include verbal, practognostic, lexical, graphic, operational and ideognostic (Novák, 2000). The terminology of mathematical problems is unfortunately not yet accurately determined in the Czech environment, the boundaries of the specific difficulties are also often overlap. Except dyscalculic categories "there is" also a large number of other categories nondiscalculic - calculastenia, secondary calculastenia, secondary calculastenia neurotic, pseudo calculastenia, hypocalculia, oligocalculia, pseudodyscalculia ...

The authors of this contribution consider the amount of these categories to be unnecessary. Many of the problems that occur within these, to some extent artificial categories, are logically manifested to a much greater extent in language more exposed subjects. It means dyslexic, graphic or lexical dyscalculia in teaching of the Czech language. It is therefore not necessary to overwhelm a particular child by diagnoses (labeling), but rather diagnosticly label and identify areas where the observed problems occur most markedly.

The actual diagnosis of these problems should respect not only the above facts, but also make greater use of a combination of quantitative and qualitative edumetric verbal approach. Simon (2006) appoints five conditions to be met by appropriate diagnostic method, with the last point considered to be less important:

• It must be able to reveal the thinking processes of the child;
• It must be able to flexibly access to the anticipated strengths and weaknesses of the child;
• It should provide information how to start the treatment of the examined child;
• It should not act as an usual test;
• It should allow their standardization;

Establishing the clear diagnostic criteria for dyscalculia or other disorders associated with mathematical skills is difficult. Efforts to determine the specific taxonomy in this case in the Czech Republic appeared at the beginning of the 1990s, but at the same time also the criticism of the inclusion among categories intensified. Currently in the Czech Republic the opinion persists that the delay of the allocation of a diagnosis is not a manifestation of ignorance, but a responsible accession to the issue (Zelinková, 2009).

It should be noted that the situation in this area was not improved by increasing the number of tests used for diagnosing mathematical difficulties. These tests are in most cases impractical for too long and complicated evaluation.

2 METHODOLOGY OF THE SURVEY

In the context of these findings there was therefore created by the initiative of Svoboda and Červinková a simple screening test Numerical Table, which should to some extent eliminate previous mentioned deficiencies.

The beginnings of the use of numerical tables can date back to the 1980s. At that time, the author of this paper used this tool for primary school children in Military sanatorium for children in Vidnava for an animation in the teaching of mathematics in 2nd-6th grades of an primary school in this sanatorium. For the successful solution of this task, it was necessary to involve basic mathematical operations (addition and subtraction), visual-spatial skills and the ability to re-combinate the numbers by a given key. An indispensable part of many strategies for a successful solution was also creativity and the ability to simplify the task logically. At that time, however, it was not a standardized test, the author, on the basis of gained experience, suggested to a student at the Faculty of UP in 2011, to implement this standardization and validation of "diagnostic skills" of the test as a part of her thesis. This occurred in 2013. The survey results, which were subsequently implemented by Červinková, confirmed the assumption of both investigators regarding the utility of Numerical Table as a diagnostic tool for mathematical difficulties. This was also the reason for the publication of the details of the investigation.

2.1 Setting of the test task

Probands received a predrawn Numerical Table of four columns and four rows (without arrows shown in Fig.

1). The task was:

"Add to this table any numbers such that their sum in columns and rows was always 10" The investigator added this verbal instruction with pointing respective directions shown in Figure 1 (task no. 1). If the child is successful, the task was made more difficult by the instructions: "Try it so that the numbers in rows and columns do not repeat." (task no.2). After successfully solving this task it was followed by the last instruction: "Try to do it so that the sum of 10 was in diagonals, while the same numbers anywhere in the rows, columns and diagonals were not repeated" (task no. 3). The child was shown what the columns, rows and diagonals are. This word we, if appropriate, replaced by the word cross.

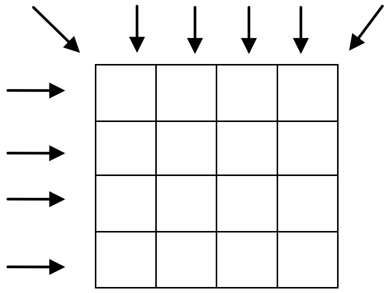


Fig. 1: Numerical Table with the directions of requiered sums

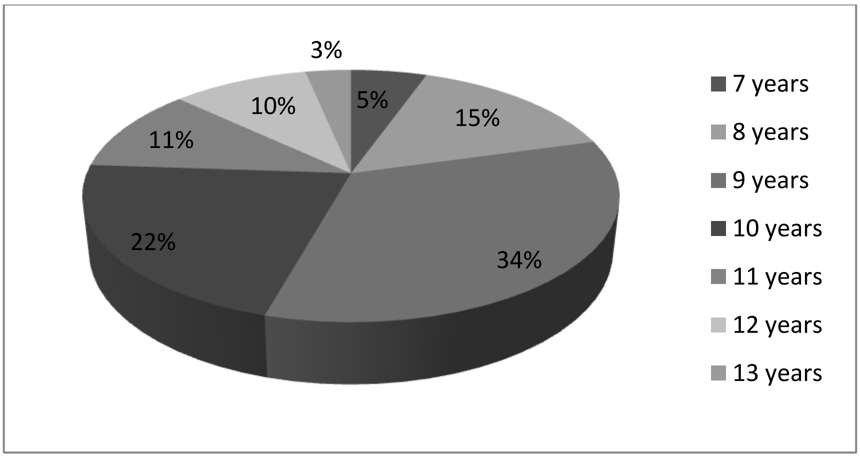
In December 2011 Červinková performed a pre-research with the test Numerical Table in an primary school, on the basis of which was mainly found:

• Children need different levels of verbal support in solving the test Numerical Table;
• It is necessary to show to the child exactly where the column, row and diagonal are;
• It is necessary to follow the exact wording and sequence of instructions given to solve the task;
• There is no need to measure time;
• Testing must be carried out individually;

The actual research was carried out subsequently in two stages. In the first stage were tested pupils of 2nd – 7th grades on the first selected primary school X in February 2012 (This was a common primary school in the city with approximately 13,000 inhabitants in the Olomouc region.). A month later, the second stage of testing at this school was completed and the author performed the testing on other selected school Y (This school was located in the city of fifteen thousand inhabitants in the Central Bohemian Region). In the second stage pupils from 3rd and 4th grades were tested. It was a deliberate choice of schools, the author of the research chose primary schools, where she had previous contacts with their headmasters, and after obtaining the consent of parents the investigation was allowed without any major problems.

In the first stage a total of 52 pupils (including 21 boys and 31 girls) was tested , in the second stage a total of 58 children (21 boys and 37 girls) was tested. Overall in the research 92 children, including 34 boys and 58 girls, participated. The structure of tested children due to their age (in relation to the grade they attended at the time of testing) states the following graph no. 1.

Graph no. 1: Age structure of children monitored at the first stage of the research



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The authors, on logical analysis of data and experience gained , set off for additional data age group of 9-10 year old children, which corresponds approximately to the children who attend 3rd or 4th grade of a primary school. Pupils from 2nd grade needed help of a considerable degree to solve Numerical Tables , while pupils attending fifth grade already solved this task more or less alone. Based on the observation of the performance of children and logical analysis of data, it seemed that Numerical Table will be most useful in 3rd and 4th grade of a primary school.

The main task was to verify testing ability of Numerical Table. In case of verification above mentioned assumption regarding the greatest efficiency of Numerical Table, the intention of the authors was to further define the time period (age of children tested) in which the method provides the most accurate results. The authors developed the following additional criteria for the evaluation of test results of tested children:

Rating A - pupil is unable to solve the task independently at all, they need a strong help, for example with a one row and one column, and so on.

Rating B - pupil is unable to solve independently the task, needs help, for example with practical description of what they are asked for, but help is not as strong as in the evaluation of A.

Rating C - pupil is able to solve the task independently according the first instruction (see Fig. 2).

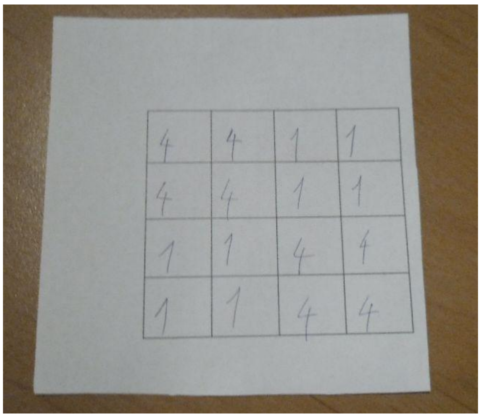

Fig. 2: Numerical Table, the variant of succesful solution of the first task

Rating D - pupil solved independently and successfully first additional task (see Fig. 3): "Add into this table any numbers such that their sum in rows and columns was ten, but that the same numbers are not repeated in rows or columns. "

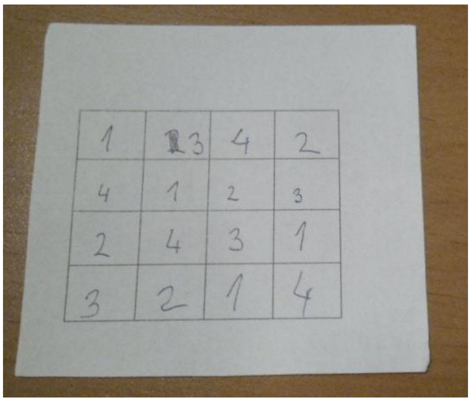

Fig. 3: Numerical Table, a variant of the successful solution of 3rd additional task

Rating E - pupil solved independently and successfully also the second additional task (see Fig. 4): "Add into this table any numbers such that their sum in rows, columns and both diagonals was ten, but the same numbers do not repeat in rows or in columns or in diagonals. "

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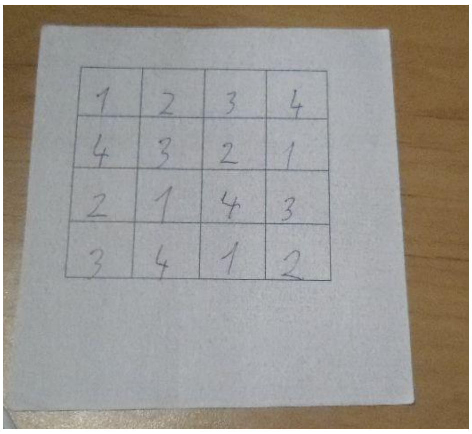


Fig. 4: Numerical Table, a variant of the successful solution of 3rd additional task

In some borderline cases the pupil performance was evaluated with an intermediate step, ie. rated A-B, B-C, C-D, D-E.

The results obtained from the evaluation of Numerical Tables authors also compared among the pupils from 3rd and 4th grades with the quarterly written test of mathematics using Pearson coefficient of correlation. Authors attributed certain values to the ratings obtained using Numerical Table (see Tab. no. 1):

Tab no. 1: The operalisation of avaluating graphems

A	1
A – B	1,5
B	2
B – C	2,5
C	3
C – D	3,5
D	4
D - E	4,5
E	5

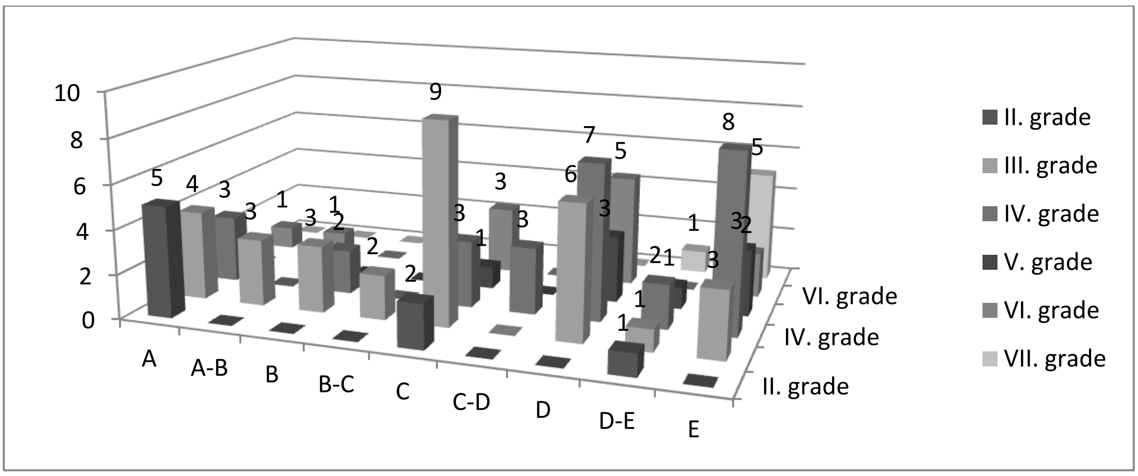
The results of the Pearson coefficients were further verified by test criterion that is 5% statistical significance. Hypothesis was formulated:

$H_{1\ (a)}$: Numerical Table test results will be among monitored children compared with their acquired points in the quarterly writtent test of mathematics in significant correlation.

3 RESULTS OF THE RESEARCH

Evaluation by Numerical Table is shown in the following graph no. 2 and graph no. 3:

Graph. no. 2 Profiles of the results from 2nd – 7th grades (1st and 2nd stage of the research)



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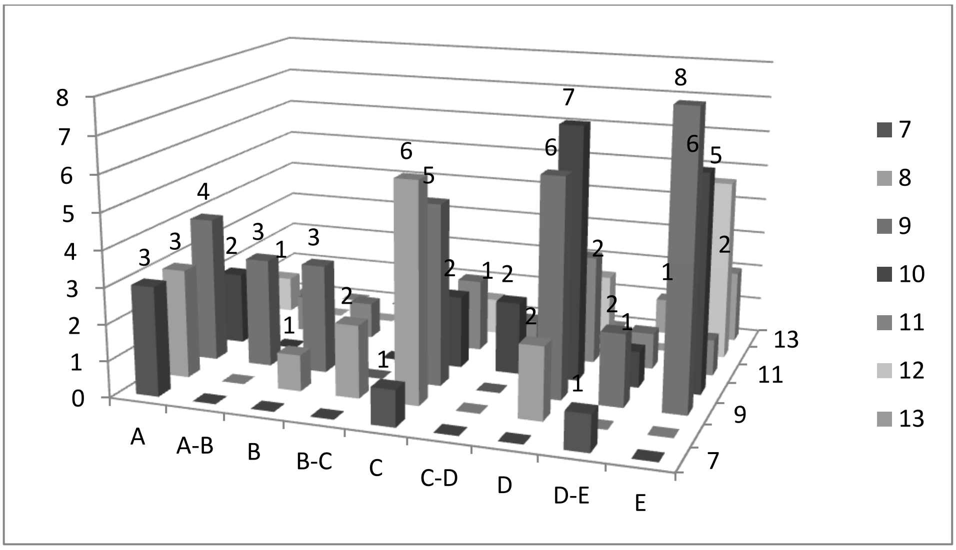
Graph no. 3: Summary representation of the evaluation results of Numerical Table in terms of the age of children from 1st and 2nd stages



From the graphs no. 2 and no. 3 we can observe that the pupils from 2nd grade acquire lower rating, ie. approaching more ratings A and vice versa pupils from 7th grade gained the highest rating, ie. approaching more ratings E. For pupils of third and fourth grades the Numerical Table evaluation results were most variable.

The results obtained by relating using the Pearson correlation coefficient were recorded in the following table (see Tab.no. 2):

Tab no.2: Basic values for the counting of Pearson correlation coefficient

Grade	III.	IV.	III. + IV.
number of children	31	27	58
Pearson (r_p)	0,669	0,569	0,532
Test criterion t	4,856	3,461	4,713
Critical value f f= n-2	2,045	2,060	2,003
5 % statistical signifikance level t > f	YES	YES	YES

Pearson correlation coefficient came out in the third grade children (n = 31) 0.669. Test criterion t amounted to 4.856 , which value is higher than the critical value f (2.045).

Pearson correlation coefficient came in fourth grade children (n = 27) 0.569. Test criterion amounted to 3.461, which is higher value than the critical value f (2.060).

The correlations obtained on the basis of Pearson correlation coefficient showed summarized in the third and fourth grades (n = 58) value of 0.532. Test criterion amounted to 4.713, which is higher value than the critical value f (2.003). All these values show moderate (significant) dependency between the points gained in the quarterly written test in mathematics and Numerical Table evaluation.

4 THE CONCLUSIONS OF THE RESEARCH

Hypothesis $H_{1\ (}\ a_{)}$: "The Numerical Table test results among the investigated children compared with their points gained in the quarterly written test in mathematics will be in significant correlation" was confirmed. Test criteria in all cases were higher than a critical value; correlation is statistically significant.

The results of the research can be drawn:

• Numerical Table reflects the level of mathematics in relation to chronological age and grade the pupil attends;
• The higher the grade, the higher the degree of autonomy and the higher evaluation using Numerical Table;
• Using Numerical Table for the diagnosis is best for pupils from 3rd and 4th grades;
• Using Numerical Tablefor diagnosis is most appropriate for pupils of the age of 9 years;

If in a school or counseling practice Numerical Table proved to be a diagnostic tool, that could be used for screening of children with mathematical problems, it would mean a simplification of often very complicated diagnosis of mathematical difficulties. The authors believe that Numerical Table has, in comparison with the tests available to diagnostics, for example dyscalculia (eg. Adding test T - 146, Numerical test T – 44, Numerical triangle T - 74, dyscalculia T- 248...) an advantage of a relatively large degree of variability and flexibility. An obvious advantage is the fact that the children goes through the solution of the task and can rely on the assistance of the examinator that during counting reflects their ability level. This method of examination is not mentally demanding and stressful for the child. Various options of solution strategies that enable to identify better the ways of thinking among investigated children are also very valuable.

Numerical Table still cannot be considered the only universal tool that will help to diagnose unmistakably such a complex thing, which a mathematical failure is. The limits can be found in a relatively narrow age range of children where the measuring is most sensitive. A smaller number of investigated children (although this sample showed statistically significant findings) is also still a limiting factor, which does not yet allow far-reaching conclusions.

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