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Opportunities for recognising, assessing, and providing online support among elementary school students with dyscalculia

Options for recognising, surveying, and online support for dyscalculia in primary school students

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Mathematics is present throughout our lives. Already in infancy, children become acquainted with quantities and the differentiation of quantities (Starkey & Cooper, 1995; Huntley et al., 2000; Csépe et al., 2007, 2008). According to von Aster and Shalev (2007), the quantitative core system (cardinality) develops in infancy. An infant is capable of subitising, estimating, and comparing the quantities of a small number of items. After learning from their environment in early childhood, children perceive quantities and then understand the strategy needed for counting and are able to count verbally. They use different classifications to determine the quantities. Kindergarten prepares the knowledge needed for the application of the concept of numbers and lays the foundations for the concept of operations. As a continuation of knowledge acquisition of knowledge, in primary school the establishment of a unified and broad foundation takes place with a focus on the development and consolidation of the concept of numbers and operations. Number words representing quantities are associated with digits, therefore school children express them with symbols without the presence of quantities (von Aster & Shalev, 2007; Jármi, 2013, p. 50). This developmental process allows for the learning of written operation performance in the lower grades, while the internal number line (analogous quantity representation) develops in the child, which strengthens spatial thinking. In the initial stage of the lower school grades, active knowledge acquisition dominates, which is the first level of abstraction of mathematical activities. In the grades that follow, the constantly and spirally repeating, expanding nature of knowledge strengthens the fourth level of abstraction, i.e., the independent application of symbols.

Keywords: ability components, diagnostic system, dyscalculia, development

Dyscalculia in the diagnostic system of pedagogy and special education

The competence and ability components of mathematics do not develop at a pace similar to the majority for all children. There are cases where there is a developmental delay that can be addressed through tutoring within a school setting. There may be a difference in the child's motivation, attitude towards mathematics, and level of frustration. In many cases, these factors are due to personality or environmental effects, or possibly caused be neurocognitive abnormalities (e.g.: amygdala function).

In the case of mathematical learning disorders, individual development does not approach the developmental curve of most children, therefore remedial tutoring is not enough since these children need complex special education assistance and dyscalculia therapy. As a phenomenon, dyscalculia is the result of neurocognitive impairments (core system of numbers, arithmetic concept, short-term memory, working memory, attention, visuospatial abilities), as well as impaired basic numerical and arithmetic abilities, and non-numerical cognitive functions. It is therefore necessary to conduct a complex dyscalculia diagnosis which maps the neurocognitive deficiencies and base areas in order to determine the direction of development.

Based on the factors listed above, a definition of complex dyscalculia definition is given as the following:

> Dyscalculia is a difficulty with a wide spectrum of symptoms occurring in mathematical performance, which is not related to the general intelligence level, associated with mental dysfunctions, which is caused by a difference in the structures and functions of multiple processing circuits that can be specifically related to numbers, which, in the case of comorbidity, affects further neurological networks or functions as a result of an inherited and/or acquired injury. The form, size, and extent of the appearance of dyscalculia is greatly influenced by the environment but does not constitute a causal factor (e.g. personality, attitude, behaviour, frustration, family habits, educational methods). The presence of dyscalculia can change the social participation of a person and their environment, hence their quality of life depends on their own copying strategy and the opportunities provided by their environment (Farkasné Gönczi, 2008, 2011, 2018).

The mathematical learning disorder comorbid (combined) may be associated with other disorders, such as dyslexia, in which case there may be a grapheme and phoneme classification disorder, or ADHD, in which execution functions are impaired. In this case, a complex image of symptoms is mapped through a complex differential diagnostic procedure. In this case, the diagnostic goal is injury-specific isolation and then the definition of a direction of development.

The table below provides information on the types of test procedures used in the case of math learning difficulty and math learning disorder and the diagnostic focus. This is supplemented by Table 2, which summarizes the symptoms that appeared during the studies.

Table 1
The special pedagogical focus of the mathematical learning disability (MLD) clusters according to the definitions based on the work of Kaufmann and von Aster (2012) and Farkasné Gönczi (2017, 2018)

Definition	Background	Diagnostic focus	Dyscalculia diagnostic focus
Mathematical learning/ performance difficulty	Personality or environmental impact, which in some cases provides a neurocognitive background (e.g. amygdala function)	Motivation, attitude, frustration, environmental barriers and support	Complex pedagogical diagnosis (discovering deficiency and base areas, defining the development direction)
Mathematical learning/ performance disability (MLD) - counting difficulty DYSCALCULIA (DysC)	Neurocognitive background: numbers core system and related neurocognitive injuries (arithmetic concept, RTM, WM, attention, visualspatial ability). (table 3 of dissertation)	Basic numeric and arithmetic abilities, non numeric cognitive functions	Complex dyscalculia diagnosis (mapping of neurocognitive deficiency and base areas, defining the development direction)
Mathematical learning/ performance disability (MLD-CD) DYSCALCULIA (DysC-CD) - with comorbid difficulties	Neurocognitive background: Dyslexia comorbidity (grapheme and phoneme classification), ADHD comorbidity (executing functions)	Arithmetic, language, attention, executive cognitive functions	Complex differential diagnosis (injury-specific separation according to complex symptom characteristics, then determination of a development direction)

Based on the breakdown of the concept of mathematical learning disorders shown in Table 1 and the definition of the diagnostic focus of dyscalculia,

> the primary goal of complex dyscalculia diagnostics is to develop and successfully implement the therapeutic activity taking into account the autonomy of the individual being examined or, in the absence thereof, exploring the complex personal and environmental profile required for the individual development of coping strategies applicable to everyday life, ensuring permanent control of processes with regard to counting, numerical ability, mathematical attitude, etc. (Farkasné Gönczi, 2019, p. 53)

In order to achieve the above diagnostic goal of complex dyscalculia, the first task of answering the question, "Who?" is to get a symptomatic child or student into the special education care system in time. Professionals working in the field of public education are the primary signalling system, which requires

the creation of a well-structured and usable list of symptoms for kindergarten teachers, educators, and teachers. To recognise the symptoms, it is essential to know the complex skill and ability profile of mathematical competence (see Table 2), the absence of several elements of which indicates the possible presence of dyscalculia.

The complex skill and ability profile of mathematical competence presented in Table 2 on the following page shows what other ability and skill components children need to have in order to activate different mathematical skills. For example, in the case of solving a textual task, it is not enough to have the ability to count or perform operations: text reading pace, text comprehension, highlighting, mathematical data interpretation, strategy selection, spatial-visual sketchpad necessary for operation performance, procedural system operation, result interpretation, working memory, and text forming skills are also required.

Table 2

Complex skill and ability profile of mathematical competence with the related numerical processing and other systems (table drawn up based on Fábián et al., 2008, p. 14; Dékány, 2009; Csonkáné Polgárdi & Dékány, 2013; Jármi, 2013, Polgárdi, 2015; Farkasné Gönczi, 2018)

Skills	Numerical processing systems	Other psychological systems	Other knowledge	Thinking skills	Communication skills		Knowledge acquisition skills		Learning skills
					linguistic	visual	task solving	problem solving	
counting in ascending and descending order	verbal system, list presentation, central executive, mathematical core system (ANS, OTS, analogue quantity representation	tactile-motor-spatial system, procedural system	the principle of one-to-one correspondence, cardinality	systematisation	knowledge of number words, relational vocabulary			problem sensitivity	attention
counting			compensation strategy, principle of clear assignment, continuous calculation	combinatoriality	comprehension, text analysis, language development	partial-whole perception	reaction time	problem representation	verbal working memory, phonological loop
global quantity recognition	spatial-visual sketchpad, verbal system		fine motor skills	interconnection of representations, intermodality, association		test scheme			
quantitative deduction quantity constancy	central enforcement system		principle of invariance	deductive reasoning		spatial awareness, spatial relations		originality, creativity	memory extent, associative memory, meaningful memory

Skills	Numerical processing systems	Other psychological systems	Other knowledge	Thinking skills	Communication skills		Knowledge acquisition skills		Learning skills
					linguistic	visual	task solving	problem solving	
quantitative relations	approximate quantity system, list representation	spatial-visual system			language development, knowledge of relational symbols				verbal working memory, phonological loop
numeric-digit matching	verbal system, visual Arabic numeral format, abstract discrete representation, list representation	spatial-visual sketchpad, connection of representations	seriality, semantic knowledge, semantic coding, the principle of clear assignment			visuomotor coordination			
place value concept	verbal system, approximate quantity system, abstract discrete representation	spatial visual sketchpad	semantic transcoding seriality	grouping, quantity constancy, abstraction					
number memory	central enforcement system		compensation strategy	inverse thinking		spatial visual sketchpad			verbal working memory, phonological loop
estimation, measurement				inductive reasoning		representation, presentation, length estimation	problem solving		task management

Skills	Numerical processing systems	Other psychological systems	Other knowledge	Thinking skills	Communication skills		Knowledge acquisition skills		Learning skills
					linguistic	**visual**	**task solving**	**problem solving**	
basic operations	verbal system, visual Arabic numeral format, central executive, object tracking system, approximate quantity system, abstract discrete semantic system	spatial-visual sketchpad, procedural system	tactile-motor-spatial system, representation of multivariate numbers	analysis-synthesis, abstraction, analogies, algorithmic thinking, arithmetic conceptual knowledge, seriality	other language functions				working memory
unit conversion				quantitative deduction		task solving speed		metacognition	
solving textual tasks				reasoning, proof	reading speed				
comprehensive skills				speed of thinking	language development		operation performance speed		learning speed
motives, attitudes									

In the case of mathematical learning disorders, the components summarised in Table 2 are missing or do not match the additional abilities and skills. Based on the analysis of the gaps, Desoete (2006, quoting Krajcsi, 2010, p. 100; Farkasné Gönczi, 2019, p. 87) typifies the series of symptoms for the appearance of dyscalculia into four groups:

1. *semantic memory deficit*: confusion in the recalling of numerical facts. Incorrect or slow mental and written counting. Poor working memory performance is common in various tasks.
2. *procedural deficit*: a disorder in the planning and execution of complex arithmetic operations, suggesting a poor understanding of the concepts behind them.
3. *spatial-visual deficit:* disturbance of spatial-visual perception and memory, frequent reflection of digits and confusion in their placement, problematic arrangement of the elements of number sequences, difficult solution of spatial and possibly geometric problems.
4. *numeracy deficit:* confusion of transcoding between modalities (e.g.: semantic coding), confusion of number production and numbering.

Desoete's breakdown into four categories can appear in a complex manner during elementary school mathematical activities. For example, according to Table 2, up to all four areas may be affected in ascending order during a counting task.

From the point of view of screening for dyscalculia, the complex skill and ability profile of the mathematical competence listed in Table 2 provides a basis for the development of the list of symptoms:

- number concept: counting in ascending and descending order
  - swapping or omitting numbers from the number sequence
  - direction or rule confusion
  - uneven rhythm, stagnant, slowing pace
  - uncertain analogue quantity representation
- counting: knowledge required for counting
  - lack of application of the stable ordering principle, i.e., the invariance principle
  - lack of application of the clear assignment principle
  - lack of application of the principle of cardinality
  - abstraction from qualitative properties or spatial arrangement is incomplete
  - partial-whole relationship is uncertain
  - formulation and execution of "crossing ten" equations is inaccurate
  - global quantity recognition is uncertain
- quantitative deduction, quantity constancy, quantitative relations
  - global quantity recognition, incomplete or is developing
  - quantity constancy is not recognised or is developing
  - misinterprets the quantitative relation
  - confusion in the interpretation or identification of symbols related to a relation

  - misinterpretation of the spatial arrangement of a relation
  - confusion in the use of relation-related symbols
- numeric-digit matching
  - incorrect transcoding between numeric and digit
  - incorrect writing of digits in the square grid
  - incorrect numeric writing
  - incorrect number writing, even mirror writing
- place value concept
  - regular mixing of place value and sign-value notation
  - interpretation of place value undeveloped
  - lack of attention to place value during mathematical activity
- number memory
  - acoustic error in pronouncing numerals
  - numerical order incomplete
- operation performance
  - difficulty in moving between the four levels of abstraction (action, display, drawing, symbol) during the performance of the operation, often only solving the task by acting it out
  - device use or finger use for low numbers
  - difficulty in writing down or reading the operation
  - difficult recognition or appropriate application of analogies
  - errors in seriality
  - incorrect or very slow understanding or execution of the operation performance method
  - incorrect operation performance due to spatial orientation or laterality error
  - lack of transparency in the relationships arising during the operation performance
  - incorrect application of approximate calculation (estimation)
- measurement conversion
  - difficulty in determining approximate quantity
  - measurement conversion is extremely slow or not practicable
  - difficult interpretation and application of relationships
- textual task
  - incomplete mathematical interpretation of the text, emphasis on the point and the necessary data
  - incapability of translating the text into the language of mathematics
  - incapability of finding the right operation for the mathematical problem formulated in the text, incorrect strategy selection
  - incapability for formulating the answer

The complex appearance of the symptoms of several detectable indications listed here may be a sign among kindergarten teachers (number concept, counting with low numbers) and among elementary school teachers. Post-recognition screening can also be performed by teaching professionals, for

which the Dyscalculine survey sheets developed by Ottilia Szabó for five different numbers are suitable. In the following, the diagnostic examination is performed by experts in special education in a professional team, using the Dyscalculia Pedagogical Examination (DPV) examination tool developed by the Dyscalculia Research Group for different age groups.

Focal points to support students with dyscalculia

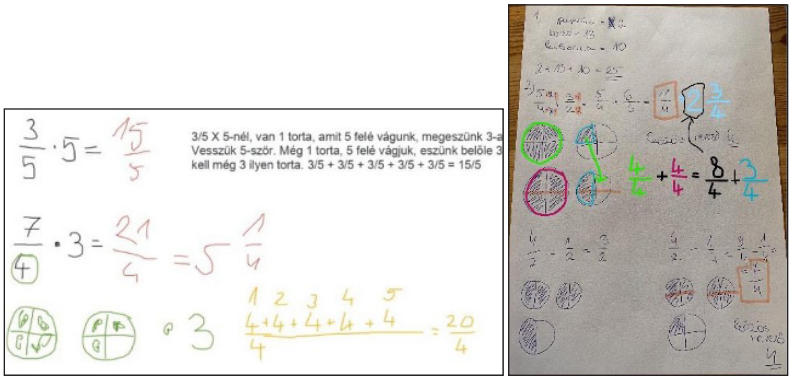
The presence of dyscalculia in mathematical performance can already be safely recognised in the lower grades of elementary school. In accordance with Mesterházi (2004), the primary goal of post-recognition development work is to determine and individually apply the results, time, and tools of the development process in accordance with the identified individual abilities and gaps in order to eliminate the negative learning spiral. Schlegel (2007) describes the negative learning spiral as *Teufelkreis*, which can be transformed into a positive learning spiral by the special education teacher in collaboration with the educator. The professionals need to work with all three pillars of this spiral for the achievement of success. These pillars include the child's personality, performance, and environment. Development alone is not enough if it is not supported by personality development and the creation of a collaborative atmosphere in the environment that is consistent with a holistic approach to special education therapeutic work.

It is necessary to motivate the student and create a safe environment during the therapeutic and integrated cooperation. For children, contextual work can be applied during therapy, by placing them in a motivating story for them, so mathematical challenges are endowed with situational interpretation. To this end, in addition to the usual school methods, the two individual and project method options detailed below are considered good practices.

Cooperation with individual work in an online space

Online individual or small group development work can be integrated well into the digital curriculum. In the case of the present practice, after acquaintance, we agreed on the different activities and the communication channels assigned therein. During our joint online work, we wrote the tasks on a Jamborad interface where we had the opportunity to create, explain, interpret, and correct simultaneously. I sent short videos to the student to interpret and analyse certain topics. After interpretation, the student completed the homework in classic paper-pencil form and photographed it, which I corrected with an image editing drawing program. I strengthened the practice by allocating a small number of regular tasks and different online games surrounding the topic. In addition to regularity, it was important to think in a small number of tasks, as in the case of dyscalculia therapy it is essential to get to know the thinking strategy, the method and means of performing the operation, breaking it down into small elements, mastering these step-by-step, strengthening the abstraction at a lower level, and then building upon this.

Images 1 and 2
Correction of the homework with an image editor, joint work performed on Jamboard



Project work in an online space

Beyond the usual framework of the school, the online project method and story-embedded development can be applied, which I continued as an ancillary activity to the research described in the doctoral dissertation prepared in 2018. For the primary school children participating in the research, I compiled a project consisting of individual and group tasks. In a participatory manner, the participants could choose a topic from a questionnaire with easy-to-understand communication[1], which, based on the votes, became the restaurant. In order to develop a partner and support role, the protagonist of the story is Mogyi, who opens a restaurant and asks for help from the children involved in the project.

I built the project on my own website, for which it was possible to upload the contents to a Drive interface and create joint projects there.

Image 3
Image of the project website.

[2] Easy-to-understand communication: Easy-to-understand communication is the display of important information content elements in the common language, or the development of independent information content in a simple and clear form that aides the correct understanding of the information. The reworking/elaboration of the information with easy-to-understand communication is aided by the adequate use of images and illustrations in compliance with the content and formal rules of adaptation. Available on the Easy-to-understand communication – easy-to-understand life website: http://konnyenertheto.gonczirita.hu/ismeret/fogalom/ (05.03.2021)

The participants did not know each other at the start of the joint task, and after they started the project, they could only contact each other or me online. The online project method included structured, overlapping tasks, which are presented in detail in Table 3.

Table 3
Application elements of the online project method in the topic of the Mogyi restaurant advertising campaign (pursuant to Farkasné Gönczi, 2018, p. 184)

Project method process	Topic	Targeted skills areas	Task
Preparation	Restaurant placement	spatial orientation, laterality, connection insight	Map drawing based on ppt story.
Topic selection	Planning an advertising campaign for Mogyi's restaurant	decision	Based on the maps made by the participants, an advertising campaign must be created according to the ppt notice made in Mogyi's name. The task is to independently explore the advertising campaign forms, and to determine the location of the campaign based on the information.
Planning	Team workflows	cooperation, planning, sequencing	The groups created based on the campaign's intended location choose their own advertising company name. They develop their work form and get acquainted with the online form of presentations. They divide the tasks among themselves. The decisions are recorded online and a plan is made.
Execution	Restaurant menu and poster designs	estimation	Teams gather information about restaurant prices and poster ads. Based on the information, they create their own menu and ad poster.
Restaurant opening	Presentation of menus and posters	presentation	The works created by the advertising company teams are posted on the online presentation interface.
Crisis communication	participants in decision-making	chart reading, sequence creation, opinion formation, decision-making, reasoning, transcoding, performing basic operations	As a result of the campaigns the restaurant is booming. A chart arrives at the advertising companies advising that the worst performing product will be removed from the menu. Teams need to learn how to read the chart, for which a description with easy-to-understand communication is available on the online interface. It is their job to make the decision regarding the recalling of the product. Part of the task was to perform tasks involving basic operations and transcoding (Farkasné Gönczi, 2014, p. 27)

Children's party	testing fun tasks for the event	more or less, quantity constancy, digit-numeric image matching, quantitative decision in the case of numerals and digits	According to the story, Mogyi's restaurant undertakes to organise a children's party. The games need to be tested, a step done by the participants.
Farewell	writing a farewell letter to Mogyi	wording, summary	The closing element of the project, where the children process the completion of the joint work.

In order to maintain motivation for remaining in the project, I developed a multi-channel support strategy found below.

- Providing story-based tasks that can be interpreted by children.
- Involving children in the story, i.e., in addition to solving the task, incorporating their decision into the project, shaping the story together.
- Creating individual and virtual teamwork.
- Immediate display of finished products in the Products menu, increasing the motivation associated with own featuring.
- Immediate feedback on responses to tasks and questionnaires.
- Diverse presentation format: description, image, PowerPoint projection, video, audio material.
- Provision of a variety of task solving situations. (Farkasné Gönczi, 2018, p. 185).

In parallel with the application of the project method, the participating children performed mathematical skills development tasks on the topic of everyday restaurant-related topics. Based on the evaluated submitted responses, we received a more accurate picture of the mathematical performance of the individual and their lack of knowledge and ability. Based on the responses received, the project method was also suitable for process detection at individual level with targeted tasks. The tasks and workbook developed from the project are currently available on the protected page, http://www.dyscalculiaport.gonczirita.hu/dyscalculiaportmese/.

Summary

The first actors in the recognition of dyscalculia are the parent and the teacher, who observe more from the list of symptoms in the article than the given child. As the exploration progresses, the educator clarifies the complex symptoms from a pedagogical point of view by performing a screening procedure, after which the child is directed to the territorially competent expert examination. Here, in cooperation with a team of specialists, the special education teacher assesses the changes in the structure of mathematical abilities and skills, then

makes therapeutic aspect and support proposals adapted to the findings. In the first half of this article, in addition to the definition of dyscalculia, the complex structure of the mathematical ability and skill structure is shown together with the list of symptoms adapted to it, the combined presence of several elements of which indicates the presence of dyscalculia. The second half of the article features two online good practices that can be applied when working with children with dyscalculia. In addition to the series of discussions, short videos and online games which can be applied during the course of online therapy and integrated education, by using the project method in an online context, the educator can imagine himself or herself in a situation that corresponds with interests of the children beyond that offered by the therapeutic framework. It is likewise possible to make decisions and shape the story while developing motivation and the ability to cooperate in an indirect way.

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