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Diagnosing developmental dyscalculia by teachers of early childhood education in Polish schools

Abstract

The present article is devoted to the diagnostic competence of teachers of early childhood education in recognizing students' risk of specific learning difficulties in mathematics. Diagnostic tests carried out applying the method of a diagnostic survey and the technique of a survey, which was conducted among 112 Polish teachers. The analysis of the collected data shows that the teachers participating in the study are prepared to carry out educational activities aimed at recognizing students' risk of specific learning difficulties in mathematics in a satisfactory way.

Keywords: dyscalculia, teachers of early childhood education, diagnosing

Słowa kluczowe: dyskalkulia, nauczyciele wczesnej edukacji, diagnozowanie

Introduction

The scope of responsibilities of the modern teacher is expanding greatly, and consequently, the teacher is faced with completely different yet very important professional tasks. One of the priority educational tasks of early childhood education teacher is conducting diagnoses, which is particularly important at kindergartens, schools and educational institutions in Poland. In the pedagogical context, diagnosis means "research, assessment of selected aspects of a child-pupil's functioning, searching for sources of irregularities, determining the existing condition, and forecasting the impacts of the desired changes" (Skałbania, 2011, p. 22).

Definition of developmental dyscalculia

The British neuropsychologist B. Butteworth has been exploring specific mathematics learning difficulties for many years. The author estimates that "in the world's population, approximately 5–9 people out of 100 are affected by this disorders. This means that, statistically, in each class, there are one or two students with such problems" (Pitala, 2007, pp. 61–62).

In the specialist literature, as well as among educators and psychologists, specific difficulties associated with studying mathematics are more often referred to as developmental dyscalculia. As noted by U. Oszwa (2007), it may be due to the fact that "this term is a mental shortcut, a key-word resulting from its short linguistic form" (Oszwa, 2007, p. 38).

The term *dyscalculia* comes from the prefix *dis*-, the means the absence of something, the difficulty and the inability, and the verb *calculare*- (Latin) count, *calculate*. The word *developmental* indicates early difficulties, lasting from birth, rather than acquired later in life due to damage to the brain (Oszwa, 2007).

It is worth noting that the concept of developmental dyscalculia does not appear in the international lists of diseases and disorders. In the European classification of the World Health Organization (WHO) ICD-10, the difficulties in learning mathematics are listed under the name of the specific disorder of arithmetical skills (F81.2). In turn, in the classification of the American Psychiatric Association DSM-IV they are referred to as mathematics disorders (Pitala, 2007).

The first definition of developmental dyscalculia was formulated in 1974 by the Slovak neuropsychologist L. Košč (1982) from the Institute of Child Psychology and Pathophysiology in Bratislava. It reads as follows: "Developmental dyscalculia is a structural disorder of mathematic skills, having its source in the genetic or congenital abnormalities of those parts of the brain that constitute a direct anatomical and physiological foundation of mathematical skills according to age; it is a disorder occurring simultaneously without disturbance of general mental functions" (Košč, 1982, p. 23).

According to the classic definition of L. Košč and the current one proposed by the ICD-10 and DSM-IV it is assumed that the "developmental dyscalculia includes smaller or greater difficulties in mastering mathematics, with normal intellectual development of the child and appropriate teaching methods" (Oszwa, 2007, pp. 36–37).

Developmental dyscalculia is diagnosed when "the result of a standardized test to study mathematical skills is significantly lower than expected based on age and intelligence of the child (at least two standard deviations)" (Oszwa, 2007, p. 36).

Specific difficulties in learning mathematics are sometimes treated as a side effect of developmental dyslexia. However, as U. Oszwa (2007) observes, if that

were the case, all children with dyslexia could not cope with mathematical tasks. Meanwhile, research shows that among students with dyslexia, there are also those with exceptional mathematical talents (approx. 10%) (Oszwa, 2007). The fact is, however, that the occurrence of pure developmental dyscalculia is quite rare. Much more often, disorders connected with mathematical skills co-occur with specific reading and writing difficulties (Pitala, 2007).

Causes and symptoms of specific arithmetic difficulties

Numerous studies, including those in the field of neurophysiology, show that "the basic mathematical skills such as addition, calculating, comparing and understanding quantities are biologically conditioned" (Bąbel, Srebro, 2008, p. 37). During infancy, children are able to make distinctions between 1-, 2- and 3-element sets, and to perform tasks related to addition and subtraction. This ability is called subtilizing, i.e. rapid judgment of numbers. It follows that the elementary mathematical skills develop independently of formal education, as opposed to reading, which must be learned.

This fact proves that developmental dyscalculia has a biological basis and is the result of disorders of the brain areas that constitute the anatomical and physiological basis of arithmetic skills. Irregularities in the mathematical areas of the central nervous system are the most common consequences of micro-injuries in the prenatal period, during birth or in early childhood (Bąbel, Srebro, 2008).

Developmental dyscalculia can also be largely determined genetically. According to a study of the incidence of specific disorders of arithmetic skills in relation to an individual's close relationship, "the likelihood of dyscalculia among dyscalculic siblings is 5 to 10 times higher than in unrelated persons" (Bąbel, Srebro, 2008, p. 38). However, the exact mechanism of inheriting dyscalculic disorders has not yet been fully understood.

Very often, the causes of difficulties in learning mathematics are connected with attention-deficit disorder as well as impaired short-term memory, i.e. the reduction of its capacity, the reduction of the time of storing data, or both. However, in such cases, as noted by P. Bąbel and E. Srebro (2008), "difficulties in learning mathematics are accompanied by difficulties in learning other subjects" (Bąbel, Srebro, 2008, p. 38). Impaired memory and attention-deficit disorder are not specific to one area.

The immediate cause of the specific difficulties in learning mathematics, as presented in the study conducted by E. Gruszczyk-Kolczyńska (2008), is the "lack of adequate maturity to learn this subject under the class-lesson system" (Gruszczyk-Kolczyńska, 2008, p. 133).

According to E. Gruszczyk-Kolczyńska (2008) the most important indicators of maturity to learn mathematics at school include:

1. Child's counting, i.e. "arithmetic skills available to children very early before they start to reason at the level of concrete operations" (Gruszczyk-Kolczyńska, Urbańska, 1992, p. 285). This range of children's skills is developed mainly with the help of parents, guardians, teachers, and kindergarten teachers and early childhood education teachers. As a result, before starting school most children can:

— separate items they want to count and then count them in a certain way;

— distinguish between correct and incorrect counting;

— determine the result of addition and subtraction in the range of 10 using fingers or on working memory;

— determine in which of the sets to be compared there are more or fewer elements using two methods: counting objects and putting objects in pairs (usually the child prefers one of these methods) (Gruszczyk-Kolczyńska, 2008).

2. Operational reasoning at the concrete level. Its scope is defined by the following indicators:

— operational reasoning related to determining the stability of discrete amounts, i.e. the ability to understand the equipotency despite the observed changes in the composition of elements in the compared sets. Children performing operational reasoning understand that the two sets of 5 apples and 5 nuts are equal because they focus on the number of elements in each set and not on their quality characteristics, such as color, size, etc.

— operational organization of elements in a set, designating consistent series, i.e. the ability to recognize each ordered element as smaller than those are not ordered, and at the same time as the largest in a set of the already ordered elements;

— operational reasoning in determining the stability of weight, i.e. the ability to infer that the amount is the same even though the transformative changes suggest that there is now more or less of the mass;

— operational reasoning in determining the stability of length with the observed transformations;

— operational reasoning in establishing the constancy of the volume of liquid under transformations that change its appearance.

Operational reasoning at the concrete level, at least for the first two indicators, is essential for the child to understand the cardinal and ordinal aspects of the natural number, and to master basic arithmetic operations. It is worth noting that the first concrete operations, according to the theory of J. Piaget, appear in most children at the age of 7 (Gruszczyk-Kolczyńska, 2008).

3. The ability to function at the iconic and symbolic levels without resorting to the enactive level, that is, to practical action. Basically, the child "must understand the meaning of encoding and decoding information using contractual symbols (digits, actions, etc.) and diagrams (arrow graphs, trees and the like) and be capable of a smooth transition from one level of representation to another one" (Grzegorczyk, Sadłowska, Kmiecik, 2005, p. 116).

4. Emotional maturity, which is expressed by a positive attitude toward solving tasks without help. The child must be emotionally resilient enough to withstand the tensions that inevitably accompany exploring the secrets of mathematics in the conditions of the class-lesson system. The emotionally mature child behaves reasonably in overcoming intellectual obstacles. The child treats them as challenges that he/she wants to meet (Gruszczyk-Kolczyńska, 2008).

5. The ability to integrate perceptual-motor functions, which is expressed by the smooth and rapid execution of organizational activities, such as, for example, preparing school supplies, searching for a given page in the textbook, as well as reading the content of the task, or making simple drawings (Gruszczyk-Kolczyńska, 2008).

E. Gruszczyk-Kolczyńska (2008) notes that children who start learning mathematics too early to resort to defense mechanisms that effectively block the process of learning mathematics. These children become frustrated. They are discouraged, tense, and they avoid solving mathematical tasks, because they are afraid of being laughed at and of failing to perform. Apparent participation in math classes leads to a situation in which children stop gaining logical and arithmetical experience, and consequently their mental development slows down (Gruszczyk-Kolczyńska, 2008).

Starting school mathematical education with the appropriate level of the mental maturity to learn this subject is a prerequisite for minimizing children's failure to acquire the basic mathematical skills necessary to function effectively in everyday life. It follows that the responsibility for shaping and supporting mental activities important for learning mathematics rest largely early childhood education teachers.

Symptomatology of specific arithmetical skills disorders is extremely complex and, importantly, varies between individuals. This means that there is no single set of symptoms common to all people affected by this dysfunction.

Below is a list of alarming symptoms, which may indicate that the child may suffer from developmental dyscalculia.

At the stage of early childhood education

— pupil:
— fails to count objects;
— has difficulty counting verbally forward or backward, etc.;

— has difficulty assessing the size of the number (for example, it takes him/her a lot of time to decide whether 10 is more than 14 or less, or the pupil is not able to give the answer at all);

— cannot understand that some mathematical operations are reversible (i.e., the pupil may know that 3 + 5 = 8 but fail to understand that it is the same as 5 + 3 = 8);

— has difficulty understanding mathematical language (concepts: add, subtract, divide, multiply, symbols: +, x, <, >, =) necessary to perform operations on numbers;

— cannot estimate the result and give its approximate value without counting;

— has trouble with correct addition, subtraction, multiplication and division;

— has difficulty distinguishing numbers and digits, especially those containing zero;

— omits numbers or operations;

— misreads the numbers, for example, 12 is read as 21;

— fails to distinguish between digits of similar graphic image, for example, 6 and 9, 1 and 7;

— fails to provide mathematical products of multiplication tables;

— makes mistakes in writing numbers comprising digits, changes the order of digits in a given number;

— cannot cope with solving simple tasks;

— cannot match the mathematical operations necessary to solve a given task;

— cannot read the clock (which displays digits or uses hands);

— has problems with understanding the concept of time, i.e., an hour, and half an hour, or a quarter of an hour;

— does not know the order of months and days of the week;

— confuses units of measure of length (millimeter, centimeter, meter), weight (kilogram, half a kilogram, dekagram), volume (liter, half a liter);

— makes numerous mistakes in determining the direction, left-right sides and the location of objects in space;

— has problems with spatial orientation on a piece of paper (e.g., finds it difficult to find information in the top right corner);

— cannot draw arrows pointing in the right direction;

— poorly recognizes, names and draws simple geometric shapes, such as square, rectangle, circle, or triangle;

— has difficulty reading the information provided, for example, in a drawing or on a graph;

— cannot use simple mathematical instruments (ruler, set square) (Oszwa, 2008).

In the later stages of schooling, other problems appear connected with fractions, decimals, percentages, squares, cubes, roots, or orientation in a coordinate system, etc.

Paying attention to these worrying signs allows for early detection of serious difficulties in learning mathematics and subjecting the child to supportive, corrective and compensatory activities.

Forms of developmental dyscalculia

Developmental dyscalculia, or specific difficulties in learning mathematics, is not a homogeneous disorder. This means that there are at least several subtypes of this condition.

The most common and best-known classification of dyscalculic disorders was developed by L. Košč. The Slovak researcher detailed the six varieties of developmental dyscalculia, namely:

— Verbal dyscalculia,
— Practogonistic dyscalculia,
— Lexical dyscalculia,
— Graphical dyscalculia,
— Ideognostical dyscalculia,
— Operational dyscalculia (Kozłowska, 2009, p. 229).

Their detailed description is presented in the table 1.

Another classification of developmental dyscalculia, which appears in source literature, distinguishes two different types of difficulties in learning mathematics:

— generalized dyscalculia,
— specific dyscalculia.

Generalized dyscalculia refers to problems covering a wide range of mathematical skills, and using numbers. These are significant difficulties in mathematical thinking.

Specific dyscalculia refers to difficulties that cover a narrow range of mathematical activities, e.g. the child can calculate easily but has problems solving text tasks. The deficits in mathematical thinking in specific dyscalculia are selective in nature and are less severe (Stryczniewicz, 2005, p. 8).

Thus, each type of dyscalculia is characterized by a slightly different set of disorders. However, classifications of dyscalculic disorders are largely made for theoretical purposes because, in practice, different types of mathematical problems intertwine.

At the end of this part of the paper, it is difficult not to notice that developmental dyscalculia and dyslexia are complex dysfunctions that change with

Table 1. Types of developmental dyscalculia, according to L. Košč (1982)

The basic types of developmental dyscalculia	
Verbal Dyscalculia	This form of dyscalculia refers to problems in expressing mathematical terms and dependencies, such as the names of numerals and digits, symbols of mathematical operations, and the order and number of mathematical objects.
Practogonistic Dyscalculia	Practogonistic dyscalculia is also referred to as executive dyscalculia. This type of dyscalculia manifests itself as difficulties in manipulating real or drawn objects (for example, cubes or sticks) mathematically. The child has problems ordering objects according to their size, or deciding which is thicker, thinner or whether they are of the same size.
Lexical Dyscalculia	Lexical dyscalculia refers to problems in reading mathematical symbols, i.e. numbers, digits, and symbols of mathematical operations (+, x, etc.), as well as recorded mathematical operations. The problems refer to difficulties in reading two-digit numbers (13 is read as 31) or graphically similar digits (6 is read as 9). Older children have problems with reading fractions, decimals or multidigital numbers.
Graphical Dyscalculia	Graphical dyscalculia refers to problems of writing mathematical symbols (and frequently co-occurs with dyslexia or dysgraphia). Usually, the child has problems in writing two- or three-digit numbers, separating single elements, for example, 1,284 is written as 1000 200 80 4, or makes up its own way or writing numbers. In some more serious cases, the child is unable to write numbers that are read to it or even copy them.
Ideognostical Dyscalculia	Ideognostical dyscalculia is sometimes referred to as conceptual-cognitive dyscalculia. It is the inability to understand mathematical concepts and relations, and to perform simple calculations from memory. The child knows that 8 = eight and that its graphic symbol is 8, but does not understand that 8 equals 9 – 1 or 2 × 4 or 16 : 2.
Operational Dyscalculia	Operational dyscalculia is also referred to as functional dyscalculia. It refers to problems in performing arithmetic operations. The child changes arithmetic operations within the four core operations, i.e., performs adding instead of multiplying, subtracting instead of dividing or, replacing is more complex tasks with simpler ones. The child prefers written calculations, which can easily be done from memory, or counting on fingers instead of solving the task in a written way or from memory.

Own elaboration based on L. Košč, *Psychologia i patopsychologia zdolności matematycznych*, WRiT, Warszawa 1982.

age depending on the tasks people are faced with in life. The key to minimizing the difficulty is early diagnosis and proper therapy.

Diagnosis of developmental dyscalculia

Problems caused by dyscalculia are not only school problems that end with the completion of education. On the contrary, a person suffering from dyscalculia who has not developed their own methods of functioning in a mathematical environment may be exposed to numerous humiliations, difficulties in finding a job or dealing with administrative matters, and even to conflicts with their family members. Therefore, early diagnosis of this type of disorder can help protect the child from problems in adulthood.

K. Kozłowska discusses concepts related to the issue of specific difficulties in learning mathematics, and also presents a diagnostic procedure that can be applied while examining children with this disorder. In her view, diagnosing developmental dyscalculia should be performed following the four steps discussed below:

1. Initial diagnosis of the child's school readiness for learning mathematics at the age of 6–7.
2. Evaluation of the student's mathematical competence at the age of 8–10, which includes, in particular:
   — the aspect of number,
   — coordination of the concept of number with counting.
3. Diagnosis of the risk of developmental dyscalculia in students at the age of 11–12 identifying:
   — numeracy skills,
   — classification skills,
   — the ability to measure length,
   — the concept of volume,
   — the concept of weight,
   — operational reasoning,
   — spatial orientation.
4. Diagnosis of developmental dyscalculia in students at the age of 13–16. Rating the disorder of the structure of mathematical ability (Kozłowska, 2009).

According to the author the most important tasks of the diagnosis include:

— determination of the level of children's mathematical reasoning skills, according to the theory of J. Piaget, in relation to the developmental age of the child;

— assessment of performance features that are involved in the mathematical activity of the child (Kozłowska, 2009).

Kozłowska's proposals deserve special attention because practical knowledge in the field of diagnosis and treatment of specific difficulties in learning mathematics is much required.

Some interesting research outcomes that may be of importance for the diagnosis of specific mathematics learning difficulties in children, regarding the relation between the ability to count and phonological processes, were presented by U. Oszwa (2006).

Firstly, it appears necessary to include experimental and clinical procedures to test phonological processes in the set of methods used in the diagnosis of dyscalculia. Secondly, the level of the development of phonological processes, especially phonological awareness and, in the early stages of education, also the phonological memory and the speed of accessing phonological representations, may determine not only the difficulty in reading but also subsequent problems with performing arithmetic operations. Thirdly, caution should be exercised when establishing the relationship between dyslexia and dyscalculia in the child based on the level of phonological processes, as with the stable level of these processes their participation in the formation of arithmetic difficulties can be independent of the level of reading, which in a given child may not differ from the norm. Fourthly, it is reasonable to use exercises increasing the automation of high-speed counting in the treating of dyscalculia. They can be helpful in supporting the development of arithmetic skills. Fifthly, in the process of diagnosis and treatment of arithmetic problems, it would be advisable to take into account the fact that the use of numbers requires an adequate level of development of many mental processes, not only linguistic but also visual-spatial, analytical and synthetic, reasoning and logical thinking (Oszwa, 2006).

The diagnosis of developmental dyscalculia is the result of an interdisciplinary and multi-purpose diagnostic procedure.

The first step in analyzing the level of children's mathematical knowledge and skills is screening. "It allows identifying children at risk of school failure, and, above all, to characterize their individual problems, to plan effective intervention for prevention of later difficulties in mathematical education" (Jastrząb, Błaszkowska, 2009, pp. 26–27). Particular responsibility for carrying out screening tests rests on teachers of early childhood education because early diagnosis facilitates effective assistance.

The teacher, who wants to conduct an indicative diagnosis of math skills in preschool children and students in grades I–III may take advantage of publicly available diagnostic tools, such as, for example, *Skala Gotowości Szkolnej* [School Readiness Scale]; A. Frydrychowicz E. Koźmińska A. Matuszewski, E. Zwie-

rzyński, *Diagnoza dzieci 6, 7-letnich rozpoczynających naukę* [Diagnosis of children aged 6 and 7 starting school]; E. Tryzno, *Skala Umiejętności Matematycznych* [Mathematical Skills Scale]; cf. Oszwa, 2007, pp. 25–26. There are also teachers who prepare their own tests evaluating the level of mathematical knowledge and skills of their students. The scope of these tests (tests) usually covers the basic aspects of children's mathematical activity, namely:

— knowledge of basic geometric shapes (circle, square, triangle, rectangle),

— body orientation,

knowledge of spatial relationships and language terms used to — describe them (above, below, left),

— ability to organize objects in an ascending and descending order,

— ability to compare objects according to physical characteristics (e.g., bigger, smaller),

— classification (sorting) of objects by species, color, shape, etc.,

— knowledge linguistic terms related to time (seasons, days of the week),

— mathematical dictionary, including names of arithmetic operations, cardinal and ordinal numbers in the range of up to 10,

— ability to convert, and

— ability to convert,

— sequential counting,

— performing simple actions on the natural numbers (Kłysewicz, 2012).

The diagnosis, if possible, should be expanded to assess the level of operational reasoning using specific tests proposed by E. Gruszczyk-Kolczyńska and E. Zielińska. This applies in particular to 7-year-old students, who, according to J. Piaget's theory, should perform their first concrete operations, which are necessary for the children to create the concept of numbers and develop counting skills while studying at school (Oszwa, 2012).

The diagnostic description prepared by the teacher should also include information about how the child functions using mathematical knowledge and skills while solving various tasks. Is based on the observation of the child in a situation where:

— the child solves the problem without assistance, sitting at a desk in a classroom,

— it solves tasks on the blackboard, and the peers are witnesses to its actions,

— it solves the problem in a peer group (Oszwa, 2012).

Teachers, as claimed by J. Jastrząb and I. Błaszkowska, "can observe and characterize the symptoms of learning difficulties in mathematics. They can highlight the situational context, the severity of these problems, their impact on the behavior of the student. They also describe the effects or the shortcom-

ings of the measures used to overcome the problem" (Jastrząb, Błaszkowska, 2009, p. 25).

However, the professional diagnosis of developmental dyscalculia is reserved for professionals, of whom there are not too many. This is due to insufficient interdisciplinary competences among people interested in the issue. One needs to display sufficient psychological and mathematical knowledge to freely use discriminatory criteria: what and when should be included in developmental dyscalculia and what should be excluded in order to select the cause of growing problems with mathematics (Jastrząb, Błaszkowska, 2009).

Professional diagnostic procedure for developmental dyscalculia or specific difficulties in learning mathematics is carried out in a psychological and pedagogical clinic by a team of specialists and includes:

1. The analysis of the following documentation:

— application of the parents/legal guardians, to conduct specialist examination,

— opinion of the early childhood education teacher or math teacher, which takes into account the type of problems occurring in assimilating mathematical content and the level of mathematical knowledge related to the curriculum,

— tests, workbooks and notebooks of mathematical education (for inspection),

— other documents (obtained from the parent/legal guardian, which are important from the point of view of the diagnosis).

2. Interview with the parents or legal guardians of the child for the medical and educational history of the child, as well as the course of the psychomotor development from the prenatal period until the current situation.

3. Psychological examination, that is — in the first place — the evaluation of the level of mental development of the child. The psychologist measures the child's IQ, which, according to the definition of developmental dyscalculia, should be within the norm. The psychological aspect also relates to determining the level of these mental processes that are involved in solving arithmetic tests. These processes include: visual perception, visual-spatial perception, language skills, memory and attention. The entire psychological description is complemented by a psychological evaluation of the emotional and motivational spheres of the child (emotional resilience, ability to deal with problem situations, appropriate reactions to failure, etc.).

A pedagogical study, i.e. the evaluation of the knowledge and mathematical skills of the child (Oszwa, 2007).

If required, a psychological and pedagogical clinic directs the child to take part in an additional examination.

After the completion of the multiphase diagnostic procedure, the parent or legal guardian receives a written opinion on the results of the child's tests along

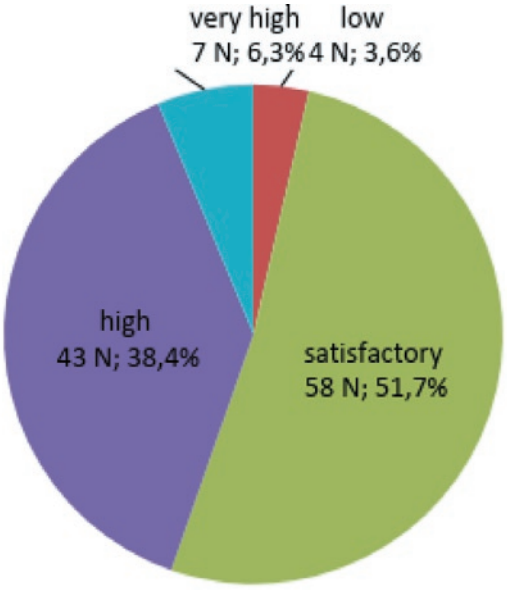

Fig. 1. Teachers' knowledge of terminology connected with specific learning difficulties in mathematics. N — number of teachers

with the recommendation of the appropriate forms of psychological and pedagogical assistance.

With regard to the difficulty in counting, U. Oszwa writes that "the diagnostic procedure is complicated because of the less known scientific process of reasoning and mathematical thinking and its characteristics, which cannot be easily translated into the mental functions that are its constituent elements" (Oszwa, 2007, p. 41).

Preparing early childhood education teachers to recognize children at risk of specific learning difficulties in mathematics — partial report on the author's own study. The main aim of my study was to answer the question of what is the state of preparation of early childhood education teachers to recognize and meet the developmental and educational needs of the students resulting from the specific difficulties in learning mathematics.

In the present paper, empirical studies are carried out using the survey conducted in the period of January to June 2013, with a group of 112 female early childhood education teachers have been presented. Preparing teachers of early childhood education for the diagnosis of dyscalculia was evaluated based on their self-assessment.

As is known, the teachers of early childhood education who make an attempt to recognized children with specific learning difficulties should have a high level of competence necessary for the effective implementation of this

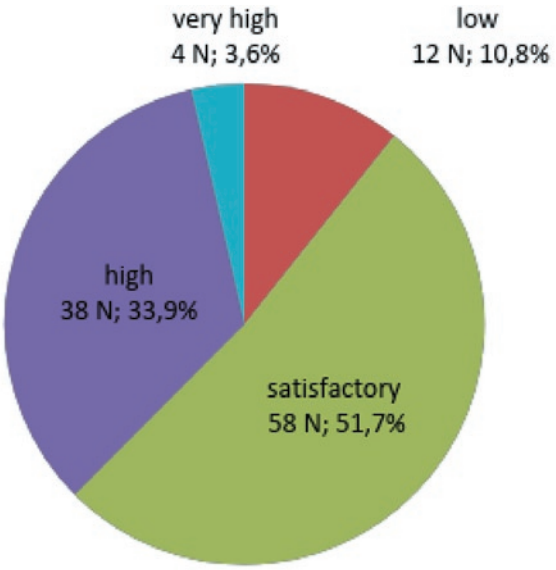

Fig. 2. Teachers' knowledge of the causes and pathomechanisms of specific difficulties in learning mathematics. N — number of teachers

task. The first, but not the only, component of competence is theoretical knowledge concerning specific issues. Therefore, the survey questionnaire completed by the teachers included the following question: "How do you assess the level of your theoretical knowledge necessary to diagnose the risk of specific learning difficulties of mathematics in the child?" The female teachers were asked to tick the correct number on the following scale: 1 — very low, 2 — low, 3 — satisfactory, 4 — high, 5 — very high.

Thus, based on the survey regarding the knowledge of terminology associated with specific learning difficulties in mathematics, the following diagram can be presented (Fig. 1).

The analysis of the data presented in Fig. 1 indicates that the largest group of surveyed teachers of early childhood education comprises those who rated their knowledge of the terminology associated with specific learning difficulties in mathematics as satisfactory (58 teachers, 51.7%). 43 teachers (38.4%) rated their level of knowledge in this area as high. Only 7 teachers (6.3%) declared that their knowledge of the terminology connected with dyscalculia is very high. 4 teachers of early childhood education (3.6%) acknowledged, however, that their knowledge of the concepts related to the phenomenon of specific learning difficulties in mathematics is low. At the same time, none of the respondents considered their knowledge of terminology regarding specific difficulties in learning mathematics as very low.

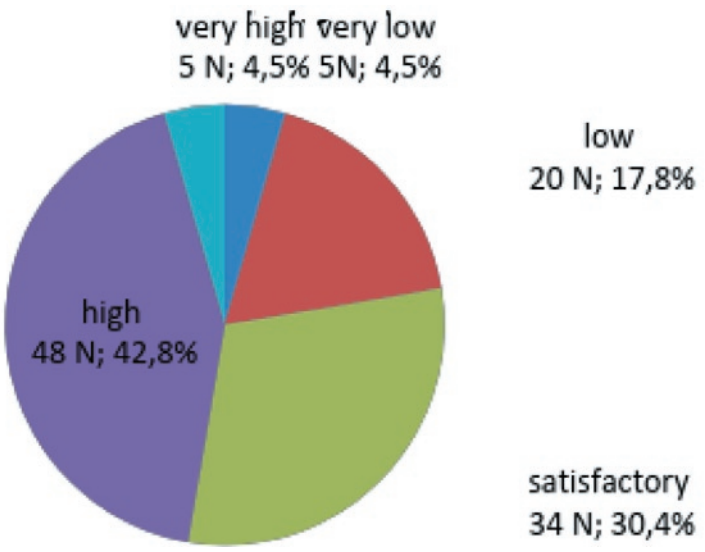

Fig. 3. Knowledge of the risk of symptoms of specific learning difficulties in mathematics among the teachers participating in the study. N — number of teachers

No less important than the knowledge of the basic terminology associated with specific learning difficulties is the knowledge of causes and the so-called pathomechanisms of dyscalculia. Therefore, early childhood education teachers surveyed were asked to rate their knowledge in this field. Their responses are presented in Fig. 2.

Considering the data presented in the Figure 2, it can be observed that 58 teachers of early childhood education (51.7%) declare that their knowledge of the causes and pathomechanisms of specific difficulties in learning mathematics is satisfactory. 38 respondents (33.9%) felt that their knowledge in this area is high, and 12 teachers of early childhood education (10.8%) regard the level of the knowledge as low. In contrast, substantial knowledge in this field is reported by only 4 teachers (3.6%) who participated in the study. Similarly, no a teacher of early childhood education reported a very low level of knowledge of terminology specific to learning difficulties in mathematics and the knowledge of the causes and pathomechanisms of these difficulties.

Effective implementation of the tasks related to the recognition of students' risk of specific learning difficulties in mathematics requires from the teachers of early education, a good knowledge of the symptoms characteristic of this type of disorder. Therefore, early childhood education teachers were asked to self-assess the knowledge of possible symptoms of any future specific difficulties in learning mathematics. The details are presented in Fig. 3.

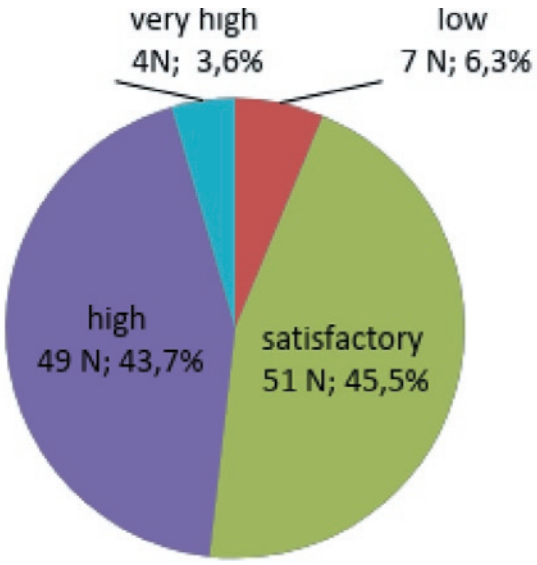

Fig. 4. Knowledge of the objectives, principles and stages of risk identification of specific learning difficulties in mathematics of the teachers participating in the study. N — number of teachers

After analyzing the results shown in Fig. 3 on the knowledge of the symptoms of any future specific learning difficulties in mathematics, we can conclude that 48 surveyed teachers of early childhood education (42.8%) acquired this knowledge to a high degree. 34 teachers (30.4%) assessed their knowledge as satisfactory, whereas 20 teachers (17.8%) admitted that their knowledge in this area is poor, and 5 (4.5%) very poor, and the same number of teacher — very high.

Early education teachers were also asked to rate their knowledge of the objectives, principles and stages of risk identification of specific learning difficulties in mathematics. The data related to this issue is presented in Fig. 4.

The analysis of the data presented in Fig. 4 shows that 51 teachers of early childhood education (45.5%) declared that they knew the objectives, principles and stages of risk identification of specific learning difficulties in mathematics in a satisfactory way. 49 teachers (43.7%) said that their knowledge in this area is significant, while 7 (6.3%) reported the level of their knowledge is low. Only 4 teachers (3.6%) identified their level of knowledge of the objectives, principles and specific steps to recognize the risk of difficulties in learning mathematics as very high, and 1 (0.9%) as very low.

Recognizing students' risk of specific learning difficulties in mathematics requires from the teachers of early education a good knowledge of the basic methods, techniques and tools that are proper and effective for the implemen-

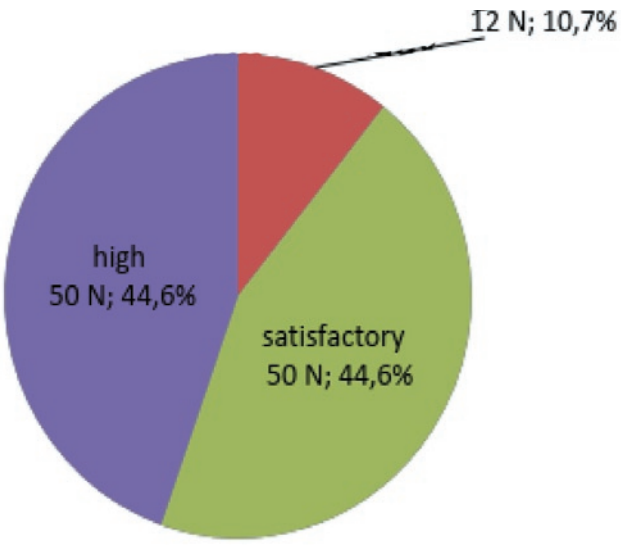

Fig. 5. Knowledge of methods/techniques and tools to recognize the risks of specific difficulties in learning mathematics of the teachers participating in the study. N — number of teachers

tation of this task at school. It is clear, in fact, that some of the methods/techniques and tools are reserved for professionals of the psychological and pedagogical clinics and centers. Therefore, the next task of the early education teachers was to determine their knowledge of methods/techniques and tools, with which the diagnosis of any difficulties in learning mathematics in children becomes possible (Fig. 5).

The results presented on Figure 5 are the basis for concluding that 50 teachers of early childhood education (44.6%) believe that their knowledge of methods techniques and tools aimed at the early diagnosis of the risk of specific difficulties in learning mathematics is satisfactory. The same number of respondents admitted that their knowledge in this field is significant. 12 teachers (10.7%) admitted that their knowledge of methods techniques and tools is low.

It is clear that a high level of theoretical knowledge of the effects of specific learning difficulties in mathematics of the teachers of early childhood education facilitates carrying out activities aimed at teaching children to recognize the risk of dyscalculia. It should be remembered, however, that the effective implementation of these tasks requires both theory and practice, i.e. some specific skills.

Conclusions

The analysis of the collected data shows that early childhood education teachers participating in the study are prepared to carry out educational activities aimed at recognizing students' risk of specific learning difficulties in mathematics in a satisfactory way. Of course, there are areas that should be improved, but generally speaking, the state of preparation of early education teachers to recognize students at risk of dyscalculia is so good that if we can look with optimism into the future. The teacher who is aware of the problem of specific learning difficulties in mathematics will not remain indifferent to the difficulties such children may have difficulty memorizing consecutive digits or multiplication tables. On the contrary, the teacher will assist the child, because he/she will be aware of the fact that a student needs to recognize the problem and requires stimulation of perceptual-motor functions, which are developing too slowly and disharmoniously.

We hope that there will be more teachers who understand the problem. The teachers who, as I. Czaja-Chudyba states, teach with passion, and adapt their practice to the conditions of a dynamically evolving world, keeping up with the changes and even predicting trends, accept their students making mistakes, and consequently, reorganize their ways of functioning at school (Czaja-Chudyba, 2013, pp. 7–20).

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