

Maths anxiety as a predictor of developmental dyscalculia

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Abstract In this paper, we address the issue of maths anxiety as a predictor of developmental dyscalculia. We present its diverse symptomatology in the emotional and somatic areas. In the presented research, we map the degree of experiencing maths anxiety due to gender differences; we also focus on the differences in its experiencing in students with learning disabilities and intact students. The aim of this paper is also to determine the representation of students within the established range of the degree of experiencing maths anxiety.

Key words: maths anxiety, mathematics, fear, anxiety, developmental dyscalculia

1. FEAR AND ANXIETY

Feelings of fear and anxiety are part of everyone's life. We can say that every child is afraid of something and for every age there is a characteristic fear of something specific. In an acceptable form, fear is a kind of driving force, but in an increased and persistent intensity it may already be accompanied by psychosomatic problems.

Based on the findings of Hall and Lindzey et al. (1997, p. 482) anxiety can be defined as "currently an unpleasant emotional state, which is characterized by feelings of danger". This finding is supplemented by Matějček (2011), Heretik and Heretik et al. (2007) on defining anxiety as a diffuse emotion that is more difficult to verbalize, is unconscious and more future-oriented. Říčan, Krejčířová et al. (1997) state that anxiety has no specific content compared to fear, on the contrary, fear is bound to specific subjects and situations. The authors consider them to be a common state of an organism and classify them among adaptive and normal developmental phenomena (Říčan and Krejčířová et al., 1997). According to Praško et al. (2006) anxiety is a natural response to danger or stress, and if it is disproportionately severe or lasts too long due to the evoking situation, it can cause problems for the individual. Anxiety can be seen as the preparation of the body for a possibly dangerous situation, where fear

is an immediate reaction of the organism at the moment when the danger appears (Praško et al., 2006). When evaluating cognitive processes in a child experiencing anxiety, it is very important to always take into account his/her developmental level (Vetró, Dombóvári, 2006). In early childhood, anxiety focuses primarily on the fear that comes from the environment. With increasing physical age, anxiety becomes more internal, more abstract, and reflects the development of cognitive abilities. Fear in a child can also develop on the basis of model learning and parental anxiety behaviour (Barlow, 1988; in: Vetró, Dombóvári, 2006). In determining the relationship between fear and anxiety, it was found that they are interdependent and anxiety usually arises from fear (Škorvagová, 2020). One of the external manifestations of anxiety is the child's fear of bad grades, the fear of certain subjects or the fear of the teacher (Matějček, 2011).

2. MATHS ANXIETY

Chinn (2020) and Rubinstein et al. (2018) state that anxiety about mathematics can be considered an international problem that affects the human population worldwide, not only students but also adults. In the 65 countries that participated in the International Student Assessment Program (PISA) in 2012, an average of 33% of 15-year-old students said they were anxious about solving math problems.

The first scientific article on maths anxiety was published in 1957 (Dreger and Aiken, 1957). In the specialized literature we can meet with several definitions of maths anxiety. Hembree (1990) provides a comprehensive description of maths anxiety, which is defined as a negative emotional response to mathematics that can impair the ability to solve mathematical problems. Rubinstein et al. (2018) perceive maths anxiety as a dynamic interplay of environmental (educational style, teacher attitudes, teaching strategies, social influences) and internal factors (i.e. neurocognitive and genetic predispositions, including brain disorders, heredity and tendency to experience anxiety). The dynamic interplay between these factors can prevent or accentuate the manifestations of maths anxiety. Due to the universal nature of maths anxiety, a systematic description of vulnerability factors is necessary. The information provided can

be of particular value in diagnostic assessment as well as in the design of interventions and intervention tools. Hembree (1990) adds that maths anxiety can manifest itself in various ways: emotionally (e.g. feeling of resentment, tension, worries, frustration or fear) or somatically (e.g. palpitations, gasping for breath, inadequate classroom behaviour, avoiding math problems). Skemp (1971, 1986) found that anxiety negatively affects the reflex activity of intelligence. The author states that even relying too much on memory or rote learning in mathematics can lead to anxiety and loss of self-esteem. A 2006 report by the British government schools inspectorate showed that little had changed in the teaching of mathematics in England in 35 years. The report also states that mathematics has become a seemingly endless series of algorithms for students, and not a coherent and interconnected set of knowledge (Ofsted, 2006). Hadfield and McNeil (1994) state that there are three causes of maths anxiety, which are environmental, intellectual, and personal. Environmental anxiety can include problems in the classroom, parental pressure and the perception of mathematics as a rigid set of rules. Intellectual anxiety can be caused, for example by a mismatch between the teacher's teaching style and the student's learning style. Personal causes of anxiety include, for example self-doubt, student passivity in a classroom or low self-esteem. Chinn (2020) also uses the above-mentioned "three-cause" construct to design a questionnaire aimed at assessing maths anxiety. Carey et al. (2017) found that more students with developmental dyscalculia met the criteria for maths anxiety than intact students, whereas the majority of students with maths anxiety achieving results corresponding to the standard level. Carey et al. (2017) note that the need for speed and accuracy of solving mathematical problems can reduce students' self-confidence, which is necessary in developing basic mathematical abilities and skills, such as the ability to estimate or the ability to solve given problems. These factors affect all students, intact and those who have been diagnosed with developmental dyscalculia.

Anxiety in mathematics can escalate into feelings of helplessness or decreased self-esteem, which can persist into adulthood (Chinn, 2020). Based on information from the Confederation of British Industry CBI (2006), it is assumed that maths anxiety may also contribute to the astonishing fact that around 50% of the UK adult population is unable to solve mathematical problems and problems beyond the level achieved in age 11 years.

3. DEVELOPMENTAL DYSCALCULIA

Students may fail mathematics not only because of anxiety that prevents them from performing optimally, but also because of a developmental learning disorder - developmental dyscalculia. In the specialized literature we can find several definitions. As. Košč (1974) is considered to a Slovak pioneer in developmental dyscalculia, we present his understanding of the condition. He characterizes it as a structural disorder of mathematical abilities, which is genetically or perinatally conditioned disruption of those parts of the brain that are related to adequate anatomical-physiological maturation of mathematical functions, but does not cause mental function disorder (Košč, 1985). The new 11th revision of the International Classification of Diseases (WHO, 2022) characterizes developmental dyscalculia as a disorder manifested by significant and persistent difficulties in learning academic skills, which may include reading, writing, or arithmetic. The individual's performance in the affected academic skill(s) is markedly below what would be expected for chronological age and general level of intellectual functioning, and results in significant impairment in the individual's academic or occupational functioning.

4. METHODOLOGY

4.1 Research objective and hypotheses

The primary objective is to determine the prevalence of anxiety about mathematics in the general population and the prevalence of the critical limit of anxiety. Another objective is to analyze the differences in the degree of experiencing maths anxiety between selected groups within the research sample (the first group of boys/girls, the second group of students with developmental learning disabilities /hereinafter DLD/ and intact students). According to the score criteria to find out in which of the 4 scales are the 4th grade students found (without maths anxiety, mild maths anxiety, higher rate of maths anxiety, high rate of maths anxiety).

Hypotheses:

H1: We assume a higher level of maths anxiety in girls than in boys.

H2: We assume a higher level of maths anxiety in students with DLD than in intact students.

H3: We assume that more than 4% of students will achieve a high rate of maths anxiety (score over 57 points).

4.2 Research sample

The research sample consisted of students from three classes of the fourth grade (9-10 years old) of two selected primary schools in the district of Nitra. The research group consisted of a deliberate group selection. Four primary schools were contacted, but only two of them agreed to the research in the fourth grade. The criterion for selecting the research sample was the classification into the grade. The research sample consisted of 51 students, of whom 24 were boys and 27 girls.

4.3 Research methods

Basic data on the experience of maths anxiety in fourth-grade students were obtained using a non-standardized questionnaire "How I feel about mathematics" (Chinn, 2016), which was adapted to our socio-cultural conditions. The author of the questionnaire is the English professor Chinn (2016), who is considered a pioneer and a world-renowned expert in the field of education and research of individuals with developmental dyscalculia. The questionnaire is part of the Chinn protocol for the investigation of mathematical difficulties and developmental dyscalculia (Chinn, 1991 in: Chinn, 2020, p. 9).

It consists of 20 questions related to mathematics. The questions are designed to best reflect the students' level of anxiety. It is advisable to enter the test individually, but it can also be administered in groups. Entering an individual questionnaire is a suitable tool in the diagnosis of developmental dyscalculia, along with a diagnostic interview about the perception and experience of mathematics in everyday life. Group administration is suitable for determining the range of anxiety of the whole class, whether due to teaching methods or student learning methods. The answers are designed in the form of scaling using the Likert scale from 1 to 4. Students have a choice of the following assessment points, where 1 = never, 2 = sometimes, 3 = often, 4 = always causes fear or anxiety. The concept of fear and anxiety is used in the questionnaire, as students at this age do not understand the term of anxiety. We evaluated the tests by statistical methods, where we created a table of the resulting values of the score from the entered questionnaire "How I feel about mathematics" from the obtained data. For data analysis, we used descriptive statistics, calculations of average values, percentage, standard

deviation, as well as calculations of the minimum and maximum score obtained.

4.4 Results

Firstly, we presented the questionnaire to 4th grade students from three classes of two selected primary schools in the Nitra district.

In the evaluation, we focused on comparing statistical data for 4th grade students. Our research is based on the scientific findings of Chinn (2016, 2020), who conducted research in the field of maths anxiety in students aged 11 to 16 in England. The author of the original questionnaire focused his research on the above-mentioned age group due to the GCSE testing, which is carried out during the transition to a higher level of education. As we focus in our dissertations on the diagnosis and reeducation of selected developmental learning disorders in primary education, we decided to adapt the questionnaire to the conditions of the 4th grade of primary schools. The average score was calculated for each group (hypothesis) separately. Out of 20 items of the original questionnaire, we gave students only 19. We omitted item 8: "... doing fraction questions", as this subject is not included in the maths curriculum of the fourth grade in Slovakia. The minimum score in the questionnaire is 19 points and the maximum score is 76 points. In accordance with the findings of Chinn (2020), we adjusted the original questionnaire to four intervals of experiencing maths anxiety, as follows: up to 19 points without experiencing anxiety, 20 to 38 points low rate of maths anxiety, 39 to 57 points higher rate of maths anxiety and 58 to 76 points high rate of experiencing anxiety in mathematics. Table 3 processes these statistical data as a percentage of all participating students. The recorded point score cannot be considered definitive, it is necessary to approach it in the context of several factors affecting the current state of the student.

H1: We assume a higher level of anxiety in girls than in boys.

We compared the total scores in a small group of boys and girls (Table 1), which we also calculated as a percentage due to the uneven number of the selected sample (24 boys and 27 girls). The boys received an average score of 28.3 points, which represents 37.24%. The girls gained an average of 34 points, which is 44.69%. The average score was 7.45% higher for girls than for boys. The standard deviation is statistically insignificant for both groups. It is 9.3 for boys and 9.7 for girls. Hypothesis H1 was confirmed; girls had higher points scores than boys, although the difference between the genders is not significant. Relatively few gender differences were noted in the Chinn survey (2020). However, Carey et al. (2019) in their research found not only a higher rate of anxiety in mathematics compared to boys, but also a generally higher rate of anxiety in girls, regardless of the current level of education. Both groups received a minimum score of 19 points. In the maximum score we can observe a 9-point difference, while the highest measured score was 51 points for boys and 60 points for girls.

Table 1: Average score of boys/girls

	average points	average %	standard deviation	min. point score	max. point score
boys (24)	28,3	37,24	9,3	19	51
girls (27)	34	44,69	9,7	19	60

H2: We assume a higher level of maths anxiety in students with DLD than in intact students.

Anxiety in mathematics can also be observed in students who achieve average results in mathematics (Carey et al., 2017).

Hypothesis H2 set by us was verified by comparing the obtained statistical data of the gross score and quantifying the percentage values in relation to the number of students within each group, as we have two unequally represented groups - students with DLD (5) and intact students (46), which is declared in Table 2. It is interesting that 4 students with DLD had a total score over 42 points (higher rate anxiety in mathematics) and one student had a score of 29 points (mild anxiety in mathematics). The average score for students with DLD corresponds to 44.3 points, which represents 58.2%. For intact students, the average score is 30.0 points, corresponding to 39.5%. Based on the above, we can state a significant difference in the average point and percentage values within the compared research groups. The values of standard deviations, the difference of which is up to 8 points, are also statistically significant. Intact students received a minimum score of 19 points and a maximum score of 60 points. The scores of students with DLD ranged from 29 to 45 points. Hypothesis H2 was confirmed. Our findings correspond with the research of Carey et al. (2017), who found that the criteria for maths anxiety were met to a greater extent by students with developmental dyscalculia than intact students.

Table 2: Average score of students with DLD/intact students

	average points	average %	standard deviation	min. point score	max. point score
students with DLD (5)	44,3	58,2	1,5	29	45
intact students (46)	30,0	39,5	9,5	19	60

H3: We assume that more than 4% of students will achieve a high rate of maths anxiety (score over 57 points).

Chinn (2020) states that the score of a high rate of maths anxiety reaches 2 to 6% of regular students. Students with a high rate of maths anxiety can often be anxious, which negatively affects their results. Based on the above, we determined the average percentage of students (4%) achieving a score above 57 points (the score corresponds to a high rate of maths anxiety). Table 3 points to interval score according to set criteria. We compiled these criteria on the basis of a 4-point scale belonging to the 19 questions of the questionnaire. Four students scored 19 points (7.8% of students), meaning they do not experience anxiety in mathematics. Mild anxiety in mathematics was recorded in 34 students, which is up to 66.7%. 12 students experience a higher rate of anxiety, which represents 22.5%. One student experiences a high rate of maths anxiety, which corresponds to 2% of the research sample. Hypothesis H3 was not confirmed, because we assumed that up to 4% of students will achieve a high rate of maths anxiety.

Table 3: Percentage of students experiencing maths anxiety

	anxiety score at intervals	number of students (51)	number of students in %
no anxiety	19	4	7,8 %
mild anxiety	38	34	66,7 %
higher rate of anxiety	57	12	23,5 %
high rate of anxiety	>57	1	2,0 %

5. DISCUSSION AND CONCLUSION

Maths anxiety is considered a widespread disorder that affects many people around the world (Rubinstein et al., 2018). In our research,

we focused on the issue of the rate of experiencing maths anxiety in students of 4th grade of primary schools in the district of Nitra. By comparison in a small research sample (51), we found that there are only slight differences between the gender groups, which are not statistically significant. Students diagnosed with a developmental learning disorder had a higher rate of experiencing maths anxiety compared to intact students. The high risk of experiencing maths anxiety in the research sample was not confirmed. High rate of anxiety in mathematics was found in only 2% of students in the research sample. Based on the information obtained, we can state that the issue of maths anxiety needs to be given increased attention, whether in diagnosis or subsequent intervention. From a practical point of view, intervention programmes should consider a comprehensive approach to the development of maths anxiety, which leads to the continuity of its manifestations, while it is also possible to use general methods of reducing the rate of anxiety. Awareness of the heterogeneity of the causes and symptoms of maths anxiety can help educators and psychologists to identify as soon and as accurately as possible students who have developed or are at risk of developing maths anxiety. Individual interventions should be based on the educational and behavioural needs of students, who need to be continuously monitored and re-evaluated. The scope of interventions should correspond with the therapeutic history of students and be based on the information obtained in monitoring the severity of their difficulties.

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