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Examining the mathematical thinking of disadvantaged students

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Abstract

Research shows that the level of mathematical knowledge of disadvantage students is significantly lower than their non-disadvantage peers. At the same time, experience shows that disadvantage children can perform mathematical operations quickly and correctly that is not necessarily acquired at school. The aim of the research presented in the paper is to provide a comprehensive picture of the level of development of the problem-solving skills of disadvantage students participating in the study and their ability to apply the acquired mathematical skills. A set of tasks was compiled to measure their skills. The results of the survey contribute to a better understanding of the learning difficulties, shortcomings, and problems of disadvantage students in acquiring mathematical knowledge.

Keywords: disadvantage students; problem-solving thinking; mathematical knowledge level;

1. Introduction

The concept of disadvantage is multidimensional and difficult to define in an exact way. Kozma Tamás (1975) introduced the concept of school disadvantage into the pedagogical consciousness, approaching it from the point of view of further education and school failure. Currently, school education identifies as disadvantaged those students whose social, economic and cultural circumstances place them at a disadvantage compared to the majority in terms of educational progress (Fejes & Józsa, 2005; Venter & Márton, 2009). According to this approach to disadvantage, it is possible to reduce social inequalities through pedagogical work in schools (Mogyorósi, 2009).

Disadvantage is an area of focus for education policy decisions, actions and work. All educational institutions aim to help disadvantaged students to catch up. Many researchers are looking at how catch-up programmes can help reduce disadvantage. Others approach disadvantage from the perspective of factors stemming from family background. Two dimensions are distinguished, material disadvantage, such as low income, low education, poor

cultural provision and inadequate housing, and emotional disadvantage, such as the absence of a family or intact family, family socialisation and parental deviance (Várnagy & Várnagy, 2000).

Liskó (1997) refers to belonging to the disadvantage ethnic minority as a criterion of disadvantage in itself. Low school attendance and high drop-out rates among the disadvantage ethnic minority are among the problems that characterize disadvantage students. The vast majority leave the school system without secondary education, and only a small percentage go on to tertiary education (CE, 2018).

Teaching disadvantaged students requires special methods and pedagogical expertise. Teachers face difficulties in developing and maintaining disadvantage children's motivation to learn. It is challenging to build and develop basic skills such as literacy and numeracy. Many experiments are still being carried out on how to motivate disadvantage children to go to school, to learn and to teach them the basic skills – literacy and numeracy– -they need in order to be able to succeed in the labour market and to meet society's expectations.

In our study, we use the term disadvantaged to refer to students of disadvantage ethnicity. We set out to show whether disadvantage students at Tonciu Primary School have the mathematical knowledge that is essential for further education.

1.1. Disadvantaged students at school

The effective schooling of problematic children, i.e. children who start from a disadvantaged family background and have difficulties in fitting in, requires a teacher with specialised knowledge. Despite this, most schools with a majority of disadvantage students suffer from a shortage of teachers, which in many cases can be filled by substituting other teachers. This may also be a reason why disadvantaged students are not able to acquire enough knowledge in certain subjects (Dobrică & Jderu, 2005; Horváth, 2015).

The lifestyle, way of thinking and beliefs of people belonging to the disadvantage national minority are specific to their traditions. Therefore, schools and teachers should expect to encounter a different way of thinking and a different set of values than they are used to. Often it is not easy for them to understand each other, as the inner workings of the disadvantage student group are not well known.

The extent to which these students are able to compensate for their initial educational disadvantage depends on a variety of factors. On the one hand, it depends on their talent and

ambition, and on the other hand, it also depends on the quality of education in the school. The reasons for disadvantage children's failure at school are mainly due to their socialisation deficits and socio-cultural disadvantage. In many cases, poverty and poor housing conditions mean that they do not live in adequate sanitary conditions, school children are neglected, carriers of infections and diseases. The conditions for learning at home are not in place, and there is a lack of learning tools at school (textbooks, teaching materials). Many of them arrive at school with a language handicap, lacking the vocabulary needed to learn in the language of instruction (Vasile et al., 2020; Vincze & Hajnalka, 2011; Horváth, 2015).

They live with the extended family, where the child plays a central role. Parents are not in regular contact with teachers, but if a child is harmed at school, the whole family will come to their defence and demand redress. Cooperation between schools and parents is more difficult than average, and teachers and school management have a very important role to play in developing appropriate forms of contact (Surdu, 2010). In general, school performance and knowledge are not necessarily important for the family. They consider that it is enough if the child learns to read and write. In traditional large families, crafts are inherited, the child learns them. Because they are not sufficiently motivated to learn by their parents' expectations, their motivation to learn is below average. The effectiveness of teaching and learning is fundamentally influenced by the teacher's ability to connect with students, to establish, maintain and develop their motivation to learn (CE, 2019).

1.2. Teaching mathematics in primary education

The quality of mathematics education has declined in recent years. There is no definite answer, but it is worth noting that education has undergone a major transformation since 1993 (Mathematics baccalaureate exam questions). Students' cognitive abilities, such as attention, memory, but especially thinking, which is closely linked to problem solving and learning, have changed. Today's standards are more lenient than they were 20-25 years ago, so it is noticeable that students enter secondary schools and universities with different levels of mathematical background. They lack a clear understanding of basic concepts that are essential if they are to continue learning.It is possible to determine which of the marks obtained in the national assessments (grades 2, 4, 6, 8, 12) indicate a deficiency in the students' ability to use the mathematical tools they have learned in an appropriate form.

Learning mathematics teaches disciplined yet flexible thinking and problem solving. It requires and develops clear, logical thinking. Creativity, deductive and inductive thinking, abstraction

and the ability to use analogies play an important role in the process of learning mathematics (Szívósné Tóth, 2009). Teaching and learning are made more difficult by the fact that many people feel that it is distant from their personality and therefore prefer to distance themselves from it. If we do not start teaching them abstract science, but start from the mathematical aspects of practice, we can be more successful in teaching it.

For learners, examples from everyday practice can lead the way to the acquisition of practical skills and marketable knowledge. "A school (and a teacher) fulfils its vocation if it prepares the students, through its curriculum, to meet the challenges that can be translated into successful employment, further education and harmonious social integration at the level of individual life." (Szívósné Tóth, 2009)

An essential element of education is the curriculum. The main elements of the disadvantage secondary school mathematics curriculum are presented below. In 5th grade, students are introduced to sets of natural numbers, which they have to identify in different contexts; they perform calculations using arithmetic operations and their properties; they are introduced to the concept and properties of divisibility. They then learn the concepts of ordinary and decimal fractions, using different graphical representations to help them perform operations. They gain an insight into the world of geometry: they learn about the elements of geometry and units of measurement.

6th grade starts with the concept of a set: performing operations on sets such as union, intersection, difference. This is followed by the factorisation, which plays an important role in determining the least common multiple and the greatest common divisor. They are introduced to sets of integers and operations with integers. Next comes the set of rational numbers, with which students should be able to solve operations in the same way. They get a taste of how to solve the equations. At the same time, they learn about angles in geometry (measure of angles, congruent angles, complementary and subordinate angles, angle bisectors), parallel and perpendicular lines and the meaning of a circle. The next important part of the geometry is the interpretation, construction and classification of triangles, as well as the illustration of the notable lines (contour, bisector, circle inside a triangle, circle around a triangle) and the congruence criteria of triangles.

Sudents are introduced to sets of real numbers and perform operations on them at the beginning of 7th grade. The introduction to square roots also takes place at this stage, and students should be able to square and draw radicals – the factorisation learned in the previous class will help

with this. They learn how to solve linear first-degree equations and systems of equations on a set of real numbers. On the geometry side, they are introduced to the concept and properties of convex quadrilaterals, specific paralelograms such as squares, rectangles, rhombuses, trapezoids. This is followed by the district and area calculation. They revive and complete their knowledge of the circle. It is important to extend their knowledge of triangles, such as the conditions for similar triangles (Thales' theorem and the inverse theorem) and metric relations in right triangles.

8th grade starts with number intervals and their representation on the number axis. This chapter also includes the solution of first-degree inequalities on the set of real numbers. The introduction of abbreviated calculation formulae helps to factorise expressions. This is followed by an introduction to solving the second-degree equation. This is followed by functions, which form a large part of the 8th grade mathematics curriculum. The elements of spatial geometry are introduced in parallel with those mentioned above. The interpretation and introduction to the properties of geometric solids (cone, truncated cone, tetrahedron, cube, cone, truncated cone, circular cylinder) are part of the curriculum.

Mathematics education, developing skills, is more than just learning concepts. Through a well-chosen or established teaching-learning-assessment process, the learner will be able to apply the concepts learned and use them in tasks. When planning and implementing learning activities, it is important to take into account the learning difficulties of the learners, their level of development: the depth and complexity of the content is related to the cognitive development of the learners.

2. Description of the research

The aim of our study was to explore the problem-solving abilities of disadvantage students in the primary phase of primary education when presented with a task in a context that is familiar to them. Within problem solving, we measured the level of development of mathematical skills. The survey took place at Tonciu Primary School. The sample consisted of disadvantage children in grades 5-8. 52 students (5th grade - 23 students, 6th grade - 7 students, 7th grade - 12 students, 8th grade - 10 students) participated in the survey in the second semester of the 2018/2019 school year.

Tonciu is a municipality in Mureș County with 63.76% of its population of disadvantage ethnicity and an even higher proportion of disadvantage children in school. The parents of the students are mainly involved in animal husbandry, and this is the main topic of conversation

for the children at school. During the break, they talk to each other about how many or what kind of animals their parents keep at home, or if sheep and dogs appear on the hillside, they start telling stories about the daily journey the shepherd makes with the animals.

We set up a series of tasks to measure knowledge. The problems required algebraic knowledge and were designed to match the level of knowledge that the students were expected to have. The hypothesis is that by placing mathematical problems in a context that is familiar rather than alien to them, they will find it easier to solve them. The survey was carried out in two rounds. In the first round, the students were given a familiar maths task from their class syllabus. Then, after a week, they had to solve the same set of problems, but in the form of a word problem. The solutions obtained were graded on a scale of 1 to 10. To assess and grade the students' knowledge, five groups were established based on the scores achieved, taking into account the disadvantage grading system: proficient (90%-100%), good (75%-90%), intermediate (60%-75%), satisfactory (45%-60%), unsatisfactory (0-45%).

2.1. Presentation of the sample task

Below you will find a problem and its solution from the test:

Exercise 1 The traditional mathematical task required in the curriculum

Calculate the following:

$$40 \cdot \left[1 - \left(\frac{50}{100} + \frac{2}{5}\right)\right] =$$

Exercise 2 A traditional mathematical problem in a familiar context

Solve the following task:

Every day, Johnny's father takes 40 sheep out to the meadow to graze: 50% of the sheep belong to Uncle Tom, 2/5 of the sheep belong to Uncle Joe, and the rest belong to Uncle Bob. Calculate how many sheep Uncle Bob has!

Solution:

Exercise 1

$$40 \cdot \left[1 - \left(\frac{50}{100} + \frac{2}{5}\right)\right] = 40 \cdot \left[1 - \left(\frac{50}{100} + \frac{40}{100}\right)\right]$$
$$= 40 \cdot \left(1 - \frac{90}{100}\right) = 40 \cdot \left(1 - \frac{90}{100}\right)$$
$$= 40 \cdot \left(\frac{100}{100} - \frac{90}{100}\right) = 40 \cdot \frac{10}{100} = \frac{400}{100} = 4$$

Exercise 2

Number of Uncle Tom's sheep: $40 \cdot \frac{50}{100} = 40 \cdot 12 = 40 \cdot \frac{1}{2} = \frac{40}{2} = 20\ sheep$

Number of Uncle Joe's sheep: $40 \cdot \frac{2}{5} = \frac{80}{5} = 16\ sheep$

Number of Uncle Bob's sheep: $40 - (20 + 16) = 40 - 36 = 4\ sheep$

Answer: Uncle Bob has 4 sheep.

3. Results and discussion

3.1. The problem-solving skills of 5th grade students

The results of the 5th grade students are not surprising. The algebraic skills needed to solve the problems were poor, and the class averages were very low ($average_{traditional} = 5.50$, $average_{word\ problem} = 4.00$). When the students did start to solve the word problem, they did not succeed at all. They were more able to start solving the traditional, textbook-based problem set, and even if they could not solve it correctly, they all got primary partial results.

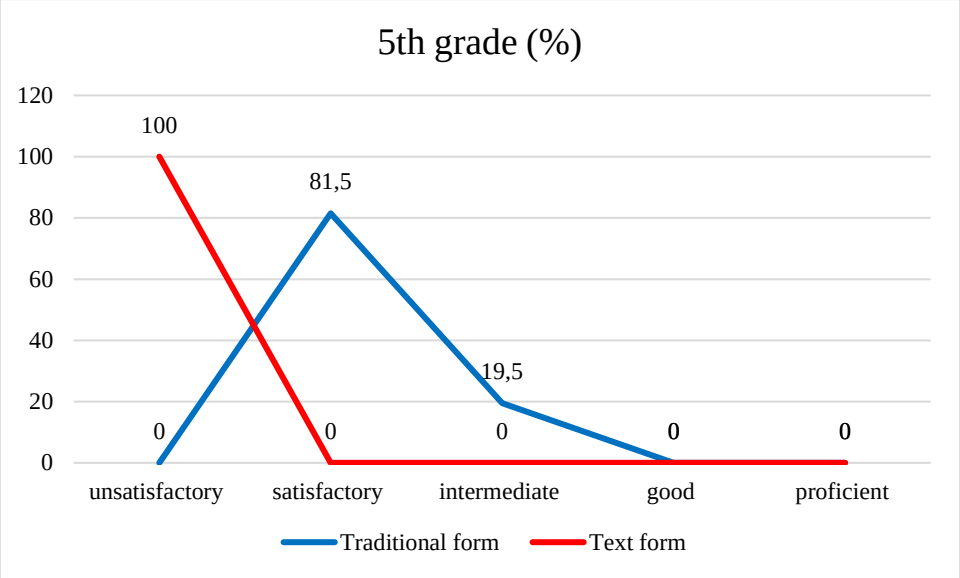

Fig. 1. Distribution of 5th grade students by grade level (%)

Looking at the results grouped by scores (Fig. 1), it can be seen that the students were not able to interpret the word problems at all, and for none of the tasks did they achieve at least a satisfactory rating. 81.5% of them were able to start solving the problems in a mathematical context appropriate to their prior knowledge and about 19.5% were able to solve them partially. The results also show that students not only enter compulsory primary education with a lack of basic mathematical knowledge, but also have significant difficulties in text comprehension. They were unlikely to have been able to interpret the text they had read correctly and extract the relevant information that led to the solution.

3.2. The problem-solving skills of 6th grade students

The results of the 6th grade students were better than those of the 5th grade students. When looking at the type of task for which they scored higher, it can be seen that they were significantly better at solving a problem in text form than in traditional form ($average_{traditional}$ = 5.43, $average_{word\ problem}$ = 7.43).

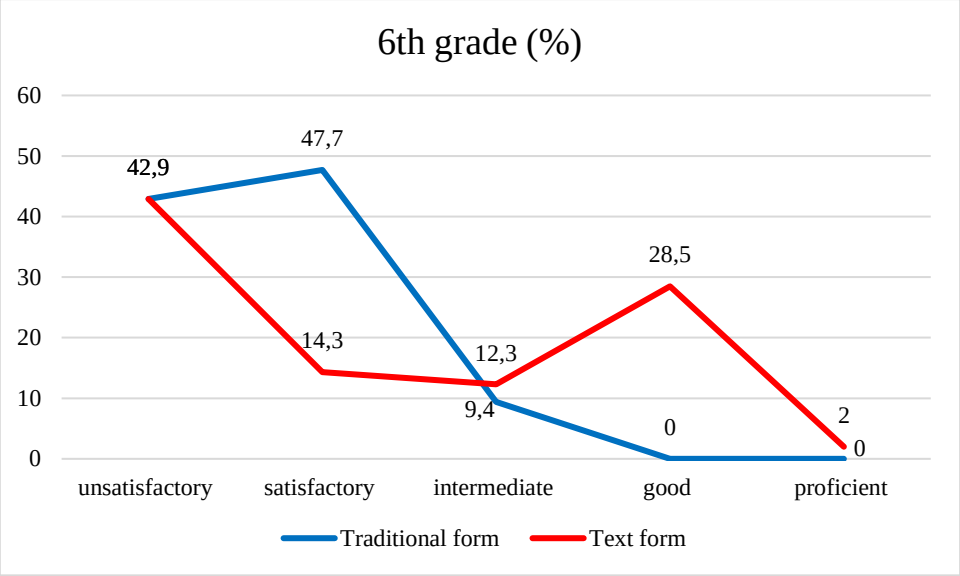

Fig. 2. Distribution of 6th grade students by grade level (%)

If we look at the results obtained by the students when solving the two types of tasks, we can see (Fig. 2) that while 47.7% of the students obtained satisfactory and only 12.3% medium ratings for the traditional task, the ratings obtained for the word problem were much better. In the satisfactory range, only 14.3% performed similarly on both types of task. A significant proportion of them (28.5%) were almost able to complete the word problem and 2% were able to complete it completely. However, it can also be observed that almost half of the students (42.9%) tried to solve the task, yet could not achieve a partial result in any of the tasks. Almost half of 6th grade students do not have the skills needed to succeed in mathematics.

3.3. The problem-solving skills of 7th grade students

The results of the 7th graders are similar, they were able to perform at the same level as their 6th grade counterparts. They did significantly better on word problems than on traditional tasks ($average_{traditional} = 5.67$, $average_{word\ problem} = 7.00$).

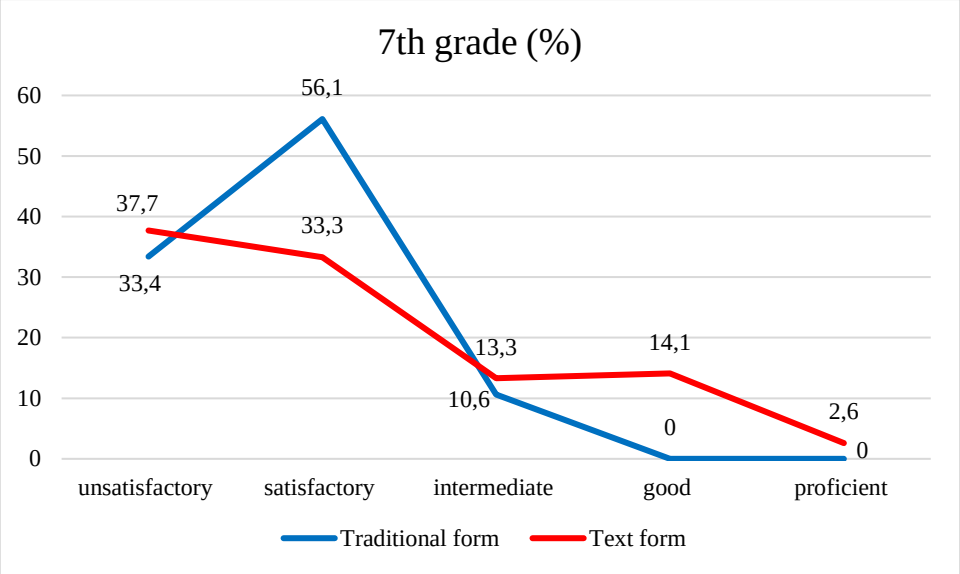

Fig. 3. Distribution of 7th grade students by grade level (%)

One third of the students did not reach the minimum level in solving the tasks (Fig. 3). While two thirds of students (56.1% satisfactory, 10.6% intermediate) were able to calculate some sub-scores in the traditional tasks, this proportion is much higher in the text tasks. The difference between the solution rates of traditional tasks vs. word problems in the sufficiency field supports our hypothesis that students can achieve better results in tasks placed in a text-based environment. As in the previous class, there was a very small group of students (2.6%) who could solve the problem correctly.

3.4. The problem-solving skills of 8th grade students

8th grade students have the highest averages. They did less well on the traditional task ($average_{traditional} = 5.75$), but were clearly better on the word problem ($average_{word\ problem} = 8.20$). They could retrieve the information they needed to solve a task in a familiar context and interpret it in order to solve the task successfully.

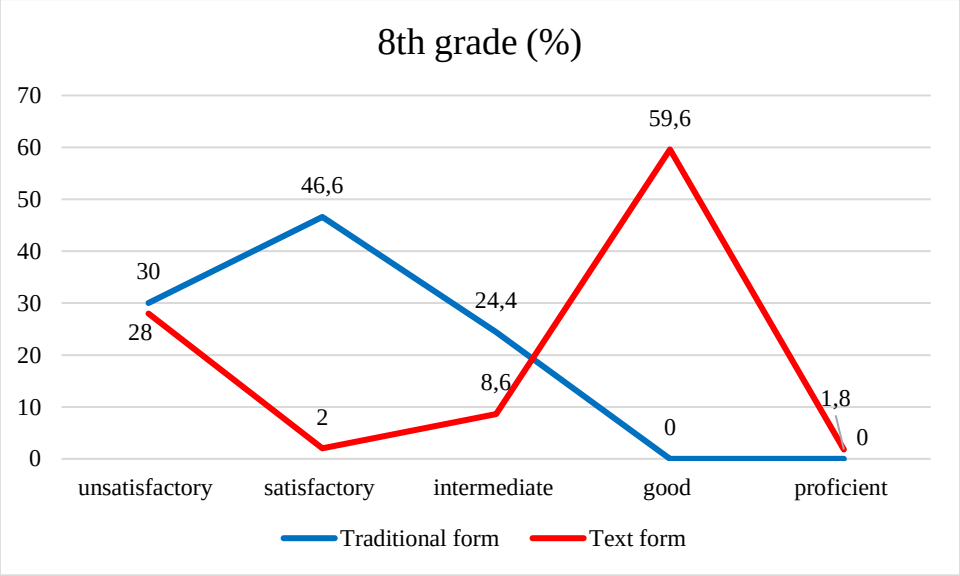

Fig. 4. Distribution of 8th grade students by grade level (%)

Fig. 4 also shows that students performed better on the word problem. As in the smaller classes, nearly a third of them did not achieve at least a satisfactory level. However, 70% of the students in the satisfactory and intermediate range, based on the scores obtained for the traditional tasks, are in the medium, good and excellent range in the case of the word problems. These results not only confirm that a third of students are not able to catch up or do not have the mathematical and literacy skills needed to pass the 8th grade proficiency test, but also that a larger proportion of them have the basic skills needed to complete the tasks.

4. Conclusions

In our survey for the 2019 school year, we aimed to measure disadvantage children's overall level of mathematical literacy. As some of the students in the experiment have learning difficulties, we set up two types of tests. One type contained exercises in the form that one would find in traditional mathematics textbooks, exercise books and collections of texts. In the second type of test, the same tasks were formulated in a textual form that was assumed to be close to the mathematical use of the tasks in the students' everyday life. The test was designed to test whether they had acquired the basic mathematical skills that were included in the curriculum requirements for their age group.

The results for students in grade 5 show the gaps that exist when students move from primary education to the early stages of secondary school. The results for students in grades 6 to 8 indicate the proportion of students who drop out because they do not have the basic mathematical and literacy skills needed to progress to the next stage of school. The proportion

of disadvantage students performing at an unsatisfactory level in each grade shows the extent of the drop-out rate among them.

The proportion of disadvantage children performing between satisfactory and proficient levels suggests that the process of abstract thinking is taking place. When solving tasks in a familiar context, students are able to answer questions for which the necessary information is available in the text. They can follow direct instructions to interpret and recognise problem situations, identify information in the text and apply routine procedures to solve problems. They can perform the steps that are obvious from the context of the task.

Ethical statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by Sapientia University.

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