THEMATIC ARTICLES
ARTYKUŁY TEMATYCZNE

EETP Vol. 18, 2023, No. 1(68)
e-ISSN 2353-7787
DOI: 10.35765/eetp.2023.1868.02

Submitted: 07.11.2022
Accepted: 02.01.2023

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Language of Mathematics Handbooks in the First Grade as the Context for Building Educational Mental Pathways of Students and Their Teachers

Język podręczników do matematyki w klasie pierwszej jako kontekst budowania mentalnych ścieżek edukacyjnych uczniów i ich nauczycieli

KEYWORDS

early childhood mathematics education, mathematics handbook language, mathematics culture, student, teacher

ABSTRACT

A handbook is a part of the teaching and mathematical culture. As an important part of the mental experience of students and their teachers, it can be an interesting subject of research. It can be assumed that the language of a handbook is a carrier of specific meanings created by its users. It is important for first-grade students and their teachers to indicate the cognitive paths constructed by the language of the suggested handbooks. The analyses undertaken in the text made it possible to identify some significant categories of the language of instructions and questions contained in the mathematical tasks included in handbooks. They are the cognitive context for the creation of mathematical cultural meanings by first-grade students and their teachers. They define what mathematics education is, what it means to understand what mathematics learning is, or who I am in mathematics lessons. The interpretative methodological approach allowed for in-depth analyses, and the document analysis method proved to be fruitful. The results showed that handbooks may hinder the development of mathematical knowledge in children. The language of handbooks reveals the potential for harmful influences by creating beliefs that are inconsistent with current scientific knowledge about learning mathematics in the early grades.

SŁOWA KLUCZE

wczesnoszkolna edukacja matematyczna, język podręcznika matematyki, kultura matematyczna, uczeń, nauczyciel

ABSTRAKT

Podręcznik jest elementem kultury dydaktycznej oraz matematycznej. Jako ważna część mentalnych doświadczeń uczniów i ich nauczycieli stanowić może interesujący przedmiot badań. Można przyjąć, że język podręcznika jest nośnikiem określonych znaczeń tworzonych przez jego użytkowników. Istotne dla uczniów klasy pierwszej oraz ich nauczycieli jest wskazanie poznawczych ścieżek konstruowanych przez język proponowanych podręczników. Podjęte w tekście analizy pozwoliły wskazać pewne znaczące kategorie języka poleceń i pytań zawartych w podręcznikowych zadaniach matematycznych. Są one kontekstem poznawczym dla tworzenia przez uczniów klasy pierwszej i ich nauczycieli matematycznych znaczeń kulturowych. Definiują one, czym jest edukacja matematyczna, co to znaczy rozumieć, czym jest uczenie się matematyki czy też kim ja jestem na lekcjach matematyki. Interpretatywne podejście metodologiczne pozwoliło na pogłębione analizy, a zastosowana metoda analizy dokumentów okazała się owocna badawczo. Wyniki pokazały niepokojący potencjał ograniczania rozwoju wiedzy matematycznej. Język podręczników ujawnia możliwość szkodliwych oddziaływań przez tworzenie przekonań niezgodnych z aktualną wiedzą naukową o poznawaniu matematyki w klasach początkowych.

The meaning of a handbook in early childhood education

In Poland, research on textbooks has a long tradition, which is marked primarily by the conventional nature of its theoretical and methodological perspective (Zalewska, 2009, p. 518). As a result of this approach, “in the research on a school textbook, most space has been devoted to the analysis of its didactic functions and the assessment of its factual correctness” (Zalewska, 2009, p. 519). The textbook can be seen as an element that mediates the communication between the teacher and the student, or as an element that “speaks” to the student. Its structure, suggested tasks, graphic design or the way in which instructions are formulated, create a kind of language through which the student gives meanings to knowledge, learning, but also to himself: his abilities, limitations and perspectives. Ewa Zalewska believes that in recent years there has been an expansion of the early childhood education textbook, as the textbook became a tool to which all teacher and pupil activities are subordinated (Zalewska, 2013, p.10). Anna Landau-Czajka writes that “textbooks for young children are a very important part of teaching. Even if the content directly conveyed by them has long fled from memory, their atmosphere and the message they carry still remains in one’s mind” (2002, p. 5). Thus, reading the meanings created by the atmosphere and language of a textbook can have a much deeper meaning than we assume.

Teachers who have just started working treat the textbook as a guide through the "thicket" of detailed mathematical content, which seems quite understandable. During their studies, they are still unsure of their didactic and mathematical knowledge (Czajkowska, 2012), so they create their own teaching experience also on the basis of the textbook content which determines, to a large extent, the mental paths of the teacher and students, directly shaping their understanding of the educational processes taking place in the classroom. The mathematics textbook in the first grade largely contributes to the most deeply inscribed meanings.

Textbook in mathematic culture

Defining the concept of mathematical culture is not straightforward, especially at the level of primary grades, which is often seen by professional mathematicians as proto-mathematical. In Poland, mathematical culture is most extensively dealt with by Małgorzata Makiewicz who studies its manifestations in photography. She emphasizes the nature of mathematical culture which is that of a process and certain continuum: "Mathematical culture is not formed in an algorithmic way on the 21st, 32nd or 47th lesson of mathematics. The process of its formation is related to everyday human interaction in the mathematical world" (Makiewicz, 2011, p. 21). According to Dorota Klus-Stańska, "culture has an everyday dimension; [...] it is expressed in everyday habitual behaviour, ordinariness, reflexively assigning meanings to the reality around us" (2010, p. 302), and its acquisition begins in early childhood (Kuřina, 1991, p. 30). Assuming that specific cultural patterns, i. e. behaviours and ways of thinking defined in a given community, are an element of culture, it is possible to assume that school didactic culture means a configuration of beliefs, values, norms and behavioural patterns related to the ways of knowledge creation that are accepted at school (Klus-Stańska, 2011, p. 30). It is thus formed by such elements as the actions of the teacher, the actions of students and the broadly understood learning environment, which includes the textbook. The textbook is a part of the mathematical culture and the teaching culture. The language of the textbook is a carrier of specific meanings created by its users: in this case, early childhood students and their teachers. I would therefore like to incorporate the textbook's message into the way in which mathematics is perceived and learned.

Methodology

Attempting to understand what primary school (grade 1) students and teachers think about teaching mathematics when working with a textbook will be based on qualitative and interpretative research. For despite their differences, they have "their own identity (or perhaps several identities)" (Flick, 2012, p. 12), but what is common to these methodological approaches is deciphering how people understand the reality and how they create it (Angrosino, 2010, s. 11). The aim of the research was to recognise the language of a first-grade mathematics textbook as a context for creating the mental pathways of its users. Within the aspect of qualitative recognition of meanings, the study was planned using the method of document analysis. Krzysztof Rubacha (2008, p. 157) perceives it as the method of data collection and he calls is "browsing through secondary sources". In this research method, one pays attention to the role that may be played by documents in creating and managing human actions (Rapley, 2013, p. 173). It is because, in qualitative research, "interactions and documents are seen as ways of constructing social processes in which people cooperate or compete with each other" (Flick, 2012, p. 13).

As Rapley (2013, p. 158) points out, documents are always analysed in a context. In the study reported here, the context was determined primarily by the following problem question: What mental pathways might be created by students and their teachers in relation to the language of the mathematics textbook in grade one?

Manifestations of the language of the textbooks studied were looked for in the content and form of instructions, text tasks, illustrations for instructions and tasks, and in the accompanying literary works for children, such as stories and rhymes.

All 1st-grade mathematics textbooks which are on the list of textbooks approved by the Ministry of Education and Science were analysed. In particular, they include:

1. M. Rożyńskai A. Szwejkowska-Kulpa, *Uczymy się z Bratkiem*, parts 1–2.
2. K. Bielenica, M. Bura, M. Kwil and B. Lankiewicz, *Elementarz odkrywców. Matematyka*, cz. 1–2.
3. J. Hanisz, *Szkolni przyjaciele. Matematyka*, parts 1–3.
4. J. Dymarska, J. Hanisz, M. Kołaczyńska and B. Nadarzyńska, *Nowi tropiciele*, parts 1–5.
5. M. Dobrowolska and A. Szulc, *Lokomotywa 1. Matematyka.*
6. B. Mazur, B. Sokołowska and K. Zagórska, *Gra w kolory*. parts 1–4.
7. J. Białobrzeska, *Ja, ty – my. Na tropach matematyki*, parts 1–2.
8. J. Faliszewska and G. Lech, *Ja i moja szkoła na nowo*, parts 1–5.
9. K. Mucha, A. Stalmach-Tkacz and J. Wosianek, *Oto ja. Podręcznik matematyczno-przyrodniczy*, parts 1–2.
10. M. Lorek, A. Ludwa (and B. Ochmańska – parts. 3–4), *My i nasz elementarz. Matematyka*, parts 1–4.
11. A. Głuszniewska, K. Prus-Wirzbicka, D. Stryjewska, K. Szczepkowska-Szczęśniak and M.Zatorska, *Szkolna trampolina*, parts 1–2.
12. K. Sawicka and E. Swoboda, *Wielka przygoda*, parts 1–4.

Each textbook was coded in such a way that the first digit indicated the number of the package, the second digit after the dot – the part number, and after the colon the number of the page is given.

Can the language of the textbook be harmful? – research results

The textbooks analysed are characterised by certain mental potentials that can be created by first-grade students and their teachers. I have selected only those aspects of the message that are related to the didactics of early childhood mathematics.

Language of limiting the cognitive context

Already in the 1980s, Jerzy Trzebiński wrote about the dominant teaching principles in which the aim is to achieve the best learning outcome. To this end, new concepts are formed in pupils by experiencing their limited, most "typical" exemplifications. This leads to the disadvantage of creating concepts that are not very flexible, and limited representations of school situations rather than specific areas of reality are formed in pupils' minds (Trzebiński, 1981, pp. 204–207).

The analysis of mathematics textbooks shows that first-graders experience cognitive limitation in several areas:

- the meaning of concepts: monotonous and repetitive contexts for learning about numbers, e. g. "Write the operations matching the drawings in your notebook. Calculate". Drawing: 10 flowers divided into 3 groups. First 5 in a row, next 3 in a row crossed out, and 2 more in a row crossed out. Under the drawing, the notation: "10 – 2 – 3 = " (7.4:19). Not only can 5 not be taken away at once, but the order of taking away (from the end) is also imposed, which has little to do with the actual act of taking away. In the geometrical field, such an important concept as the ruler is reduced to the instruction of conduct: "Draw a line of 5 cm in your notebook. 1. Put the ruler to the sheet of paper and hold it so that it does not move. 2. Then start drawing a line from the hash mark marked with 0. 3. Finish drawing at the hash mark marked with 5" (6.3: 57). Eleven of the textbooks surveyed suggest learning about numbers starting with the concept of 1. This seems implausible in view of the many studies indicating that already two-year-olds (and even much younger children) often understand how much one is and can even cope with addition and subtraction to two (Landerli Kaufmann, 2013, p. 77). In this context, instructions such as "In pairs, think of as many questions as possible with the answer being 1" (6.1: 75), are simply a waste of time;

- too low a number range: common practice of textbooks limiting the number range, but also the children's knowledge of arithmetic operations: "From the given numbers [1–20 – note A. K.], arrange as many operations (addition and subtraction) as possible, with the results. Write them in your notebook" (6.4: 84);
- limited cognitive contexts: presentation of numbers in identical contexts (mainly the cardinal and ordinal aspect). Definitely limited opportunity to explore other properties of numbers (evenness, divisibility and other relationships between them), and exercises like "Write consecutive numbers in your notebook and their verbal notation according to the formula. 0 zero, 1 one", which are repeated for months" (6.3: 35);
- the content of mathematical texts: these are structured in a similar way (data and question given in the shortest way possible). Tasks are crafted texts limited to short sentences with numbers significantly different from real-life mathematical texts, such as instruction manuals or product advertisement;
- the ability to show mathematical relationships in objects and drawings: colourful and richly illustrated textbooks show their users that detailed and colourful illustrations are necessary for learning mathematics. This limits the ability to imagine mathematical relationships because in textbooks such relationships are already ready. Students do not learn to notice the mathematical relationships between the characters in the story presented in the task and they often treat the picture as an illustration, seeing only a superficial view of the content of the task. Individually, there was a suggestion that mathematical reality is present all around and everyday objects, such as paperclips or buttons, are used to explore it (7.1: 5).

Language of imitation and repetitions – cognitive rituals

The contents and the way they are presented in the mathematical textbooks of first graders constitute a set of a kind of cognitive rituals shown in similar commands or questions. Their form varies, but the sense leads pupils to repeat activities following the suggestions of the textbook.

- Follow the pattern: "Here are instructions showing how to cut a square out of a rectangular piece of paper" (5.1: 52). Drawing with coloured circles in two colours. Underneath, example notation: 2+2= according to colours (8.2: 8). Mechanical writing according to the pattern supported by colours can distract the child from the meaning of addition, linking this activity only to suitably prepared objects (the colours mentally limit the ability to add 3+1, as a result of which they limit broader understanding of what number 4 is). Similarly imposed structure of the task and its solution; given formula with information: task, question, solution, answer. Then, the instruction to do the same with the pictures (8.2: 9). "Arrange similar questions" (5.1: 5).

- Restricting colloquial language: "Use supportive words", use appropriate phrases (5.1: 5); "Say what 'maths-kids' do. Use the words given in your statements" (8.1: 6).
- Activities with objects: "Talk about the tower shown on the right. Find the blocks it is made of in the illustration. You can build your own tower in the classroom" (12.1:87). Pupils can only build their own construction after they have seen the example, which becomes a model, limiting their original ideas. Then, they learn that the possibility to act according to personal ideas is not the most important thing to learn, but it is a kind of additive to make it more enjoyable for the child.

Language of trivialization and/or making contents fantastic

- Ridiculous and artificially prepared facts: infantile rhymes with numbers: "three old men to love" (3.1: 43). "Solve the tasks. Write the operations in your notebook. Calculate. Write the answer"; "Aliens came to Earth. One of them had to pay for parking his space vehicle. The ticket machine showed two ways to change a 10 PLN note into coins. Look at the coins and suggest how else you could change the note" (1.2: 82). For unknown reasons, the process of changing money is carried out by an alien and not by an ordinary person who needs coins for, e. g., a supermarket trolley. The authentic experience of paying in a shop, which is the basis for understanding the reality (in this respect, of course), is replaced by an improbable story about aliens. In another picture, a table is set with plates of different foods: 3 different vegetables, 3 pears, 3 eggs, etc. The instruction is: "Think of an addition based on the picture showing eggs and pears" (8.1: 75). The pupil may experience the artificiality of such addition, in which the sense of the operation is imposed and limited to reading the numbers accompanying the objects. In another example, the content of the task is incompatible with natural knowledge: "The spider had to carry 8 ants across the river. He has already moved 2 of them. How many ants are waiting to cross the river?" (6.4: 30). It is difficult to say how the spider (apart from the water spider) carries the ants across the river without eating them. Also, instructions that are not very meaningful from the child's perspective appear:

„Stand next to the chair and follow the instructions:
Stand in front of the chair; stand behind the chair;

Place your right leg on the chair;
Slide your left leg under the chair;
Hide behind the chair; look behind the chair" (3.1: 7).

- Low level of difficulty. Example task: "Play in pairs. One person shows the number 1, 2 or 3 on their fingers, and the other arranges as many crayons as the number of fingers shows" (1.1: 85).

Language of pictorial judgement of mathematic facts

In the textbooks analysed, the commands: "indicate less (more)", "determine how much…", refer only to drawings of various objects and the observed relationships are static in nature. Judgement about measurement facts (weight, capacity, size) is made only on the basis of the drawing (6.4: 47). Meanwhile, the development of operational thinking must be supported by action and observation of changes in the arrangements of objects, i. e. phenomena of a dynamic nature (Szemińska, 1981, p. 124).

- Practising the knowledge of the concepts and not constructing them: "Look at various clocks. What times do they show?" (6.4: 13).

Language of opening to independent cognitive search

Incidentally, there were suggestions to allow children to experience the fulfillment of their own ideas or opportunities to ask questions. However, even in these developmentally desirable cognitive situations, various limitations appeared: Here are some examples:

- free thoughts: an example task is: "Draw 29 dashes and 36 lines in your notebook in any way you like. You can invent your own way" (6.1: 27) No explanation is given to the child as to why exactly this number of lines. The child's personal way is at most accepted and treated as a possibility, not a necessity;
- question knowledge: suggesting the creation of questions by students most often occurs after the examples given earlier. Individually, there is an opportunity for mathematical modelling by inventing riddles for a picture (12.1: 85). However, the term "riddle" is identified with simple calculations that can be applied to describe the reality in the picture;
- justification and cognitive reflection: there are limited opportunities to make hypotheses like "guess", "try to figure it out yourself"; but also to justify: "say why this is the case", "why do you think so", etc. In many tasks, asking such questions would be an opportunity for children to become aware of mathematical relations. In one

task, a drawing (pattern) appears: alternately three red triangles and two green circles. The instruction only encourages the children to count: "Look at the figures and say if there are more triangles or circles" (12.1: 88). The question: "why do you think so?" could help the child to realize correlations like: every time there are more triangles than circles. Since the same thing is repeated, it is known that there are more triangles. Such knowledge is already a deepening of the relations in addition, which could be described formally: "The sum of a certain number of larger components is greater than the sum of the same number of smaller components";

- discovering regularities: incidental rule recognition; here: rules for writing down a number (5.1: 26), reversed order of instructions. Count the dashes first, and then identify the rules for writing down. Reversing the order could show the children that writing rules can make calculations easier;
- referring to children's personal knowledge – incidental suggestions such as: In the textbook there is a drawing of three juice bottles with glasses next to them. The command is cognitively interesting: "Tell me the amount of which juice is the largest and which is the smallest. Why do you think so?" (12.1: 90). In this case, however, this task is additionally marked as more difficult, requiring a deeper analysis of the content, i. e. it suggests that it is different from everyday school mathematics and not intended for all students.

Mathematical games (2.1: 26) are present in the textbooks in traces of one or two suggestions per semester. The game contains a strict description of the rules and the students have no room for any modifications. A single invitation to invent one's own board game: "In pairs, prepare a board game in which, according to the rules you invent, you will use tasks with geometric figure according to set rules. For example: if a pawn stands on a field with a square, it jumps further by 4 fields" (7.1: 12). However, the rules of the game are also imposed here.

Suggestions summarizing several topics are referred to in one textbook as "Think and solve" (2.1: 31), and they sometimes contain interesting suggestions. However, the "usual" topics contain mostly reproductive and unattractive commands and questions.

Students' and teachers' mental pathways created by the language of a mathematics textbook for first graders. Findings from the study

The message of mathematics textbooks for children in the first grades of primary school appears to carry the meanings that limit mathematical thinking, which is alarming. The ways of understanding what learning mathematics is and what mathematics itself is, which are conveyed through the language of the textbooks, make it possible to formulate some general beliefs that can arise in the minds of pupils and their teachers.

The language of mathematics textbooks may be the source of the conviction that the transmission of structured knowledge creates equally structured meanings in the student's mind. The knowledge of cognition does not support this, and Klus-Stańska (2010, p. 90) even argues that cognition should begin with a chaos of data that must be individually understood, which results from the personal construction of mathematical meanings.

Equally damaging and untrue may be the belief that children in the first grade like easy and childish mathematical tasks. It is disturbing to constantly suggest that children learn about even the closest and commonly available reality (for example, measurements) through pictures. Edyta Gruszczyk-Kolczyńska has been writing about the harmfulness of this belief for the development of mathematical thinking for years (Gruszczyk-Kolczyńska and Zielińska, 2009, p. 31 et seq.), referring to ready-to-complete worksheets and calling this phenomenon "paper mathematics".

Another disadvantageous belief for pupils may be the acceptance of the absence of manipulative experiences. The language of the textbooks examined creates a belief among teachers that the youngest students do not need to explore mathematical relations with the use of objects. It is now emphasized, however, that students need to manipulate and watch the changes they make in order to develop their mathematical knowledge (Boaler, 2015, p. 168 et seq.).

Also, the language of the textbooks creates the conviction that children must use mathematically correct language from the beginning, which will guarantee correct understanding of concepts and their use in the process of mathematical thinking. Klus-Stańska shows precisely such a picture of Polish didactics, in which pupils' personal knowledge is marginalised or even ignored. Instead, "public knowledge is to be multiplied, and the optimum outcome is 'the same knowledge in every mind'" (2019, p. 9).

From the very first days at school, the pupil begins to understand that learning mathematics requires external assistance and subordination of thinking to the teacher's expectations indicated by the textbook. Also, the absence of suggestions for experiencing errors indicates to pupils and teachers the need to avoid incorrect solutions, since such solutions can be cognitively damaging. This is a view challenged by researchers, who argue for the necessity of the emergence of incorrect ideas and student attempts to recognize correct knowledge (Heinze, 2005).

"Introducing" consecutive natural numbers in lessons suggests to teachers that mathematical concepts arise in cognitive isolation, which contradicts the assumption that numbers are constructed in the environment of other numbers. "Counting and simple calculations are acquired in a similar way to native speech. Analogous to the development of speech, children also have the ability to grasp regularities in the area of counting" (Filip and Rams, 2000, p. 26).

The lack of suggestions to work together on mathematical problems suggests to teachers that mathematical knowledge is created in isolation (individually), rather than being the product of a community. However, it is now considered that mathematics "is a social domain created and transmitted in various aspects; it is a common good, jointly created and mutually transmitted. The student, too, can and should invent, suggest, discover a lot in this area" (Filip and Rams, 2000, p. 26).

Ready-made tasks and examples of actions, and the lack of suggestions for problems in which the child would have to apply mathematics independently, creates the belief that mathematics does not describe everyday situations and has no application outside school. Learning ready-made formulas and patterns of behaviour closes the mind to learning. The research by JoBoaler and Pablo Zoido shows that a rigid mindset towards knowledge is cognitively damaging (especially for high-achieving girls). Interestingly, the researchers also suggest that a belief in one's own wisdom does not support development (Boaler, 2016, p. 7). Unfortunately, the language of mathematics textbooks builds the belief that repetition of content does no harm, even when the child already knows it.

In the context of the research presented here, the question arises whether a textbook constructed in this way is a help or a hindrance to students and their teachers in opening up to mathematical concepts and relations. The alarmingly high number of untrue or outdated beliefs that can be constructed by the language of mathematical textbooks raises the concern that they can harm students and teachers, paradoxically becoming a barrier to the development of mathematical knowledge and skills.

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