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LEARNERS' ACHIEVEMENTS IN MATHEMATICAL INFORMATION PROCESSING AT PRIMARY SCHOOL

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Abstract

The following article provides an analysis of the skills that enable a primary school learner to process mathematical information. The author studies students' performance on particular tasks from the mathematics tests developing for primary school learners, presented in the regional research (2014-2016), and from the TIMSS international research test (2011, 2015). The author describes the two categories of information processing skills – subject-related (mathematics specific) and interdisciplinary learning skills – and illustrates them with corresponding quiz items, designed to test one's ability to handle information. The author also singles out the two groups of challenges: students may lack, on the one hand, subject skills, on the other hand, universal learning skills. The results of the research reveal the difficulties related to mathematical education and show that when the learner has to process mathematical information, he/she demonstrates sufficient awareness of how to apply mathematical information in order to accomplish various tasks. Therefore, the increase of informational literacy should be considered as one of the learning outcomes of the primary education.

Keywords: Information processing, learning process, learning skill, TIMSS research, mathematics, monitoring.

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1. Introduction

Nowadays the term information can be interpreted in a few different ways. The main ones would be, as follows: a set of valuable data in an object under consideration; coded knowledge; "the semantics of signals, symbolic messages, numbers, notes, images" (Gubarev, 2011, p.11); schematic models (tables, schemes, diagrams, and others). The student develops the ability to handle information both in the learning environment and in daily situations.

According to the Russian approach to primary education, information processing stands for the number of the learner's achievements in a particular subject as well as the fourth grader's overall performance at school. In the first case, the Federal State Educational Standard of Primary General Education (FSES PGE) considers such universal learning skills as "the application of various methods of search…, collection, comprehension, analysis, compilation, transmission, and interpretation of information in compliance with communicative and cognitive purposes…" (Ministerstvo obrazovanija i nauki Rossiyskoy Federatsii, 2015, p.9) to be the teaching priorities. Such skills let one regard informational literacy as "an integral feature" (after Vinogradova) of learner's functional literacy in the primary school.

2. Research Questions

How can the TIMSS international research tests and results of regional research be taken into account in the development of the learning tasks connected with information processing.

3. Purpose of the Study

This study was designed to analyse learners' ability to handle information in the Russian primary schools. Thereupon, I distinguish between two categories of information processing skills (subject and interdisciplinary learning skills) and describe the peculiarities of the development of some subject and universal learning skills, which demonstrate the child's ability to handle mathematical information.

The objectives of the study were, as follows: to illustrate how primary school learners' informational skills manifest themselves in course of writing monitoring papers, to single out the main challenges and their possible causes, and suggest ways of their prevention and elimination.

4. Research Methods

This study is based on the Data Analysis type of tasks accomplished by Russian learners in the frames of the international TIMSS (TIMSS – Trends in Mathematics and Science Study) test in 2011 and 2015 (Rezul'taty mezhdunarodnogo issledovanija TIMSS, 4 klass, 2015), as well as the Information Processing type of tasks that were included in the regional monitoring and assessment tests (*Primernaja osnovnaja obrazovatel'naja programma nachal'nogo obshhego obrazovanija,* 2015). The tasks for the regional monitoring were designed by Kuznetsova, Krasnyanskaya, and Rydze in the Centre for Educational Quality Assessment (Kovaleva, Director), the Federal State Budgetary Scientific Institution (FSBSI) Institute for Strategy of Education Development of the Russian Academy of Education, and

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Moscow Education Quality Centre (Soldatov, Director), the Academy of Public Administration in Moscow Oblast. I analysed the subject and interdisciplinary content of the TIMSS test (Foy, 2013; Martin, Mullis, 2009; Mullis et al., 2016; Mullis, Martin, Goh, Cotter, 2016; Mullis et al., 2015) and the Sample Main Syllabus (*Primernaja osnovnaja obrazovatel'naja programma nachal'nogo obshhego obrazovanija,* 2015). I systematised the skills of interest and analysed them in different papers (tests).

5. Findings

As the study of the specifically chosen type of mathematics tasks, Information Processing, shows, among the main subject skills one may list (*Primernaja osnovnaja obrazovatel'naja programma nachal'nogo obshhego obrazovanija,* 2015) the ability to comprehend and complete tables as well as read diagrams. Moreover, the student has an opportunity to learn to "comprehend simple mathematical expressions, including linking words ('…and…', 'if…, then…', 'it is true/ false that…', 'each', 'every', 'all', 'some', 'not'); to make, take down, and follow an instruction (a simple algorithm) or a search plan; to recognize the same information in different forms (tables or diagrams); to design simple research, collect and present information obtained in tables and diagrams…" (*Primernaja osnovnaja obrazovatel'naja programma nachal'nogo obshhego obrazovanija,* 2015, p. 50). I suggest restricting the student's educational environment to mathematics, in particular, to quantitative and spatial data, as well as different kinds of dependence, algorithms, and statements (true/false) that are provided in the wording of an assignment set to the learners or represented in a graphical model (tables, schemes, diagrams, and others).

5.1. Processing Information. Subject Skills

The present group includes subject-related skills and competences that learners develop since the first grade. The majority of students, finishing primary school, can easily "read" a table or a diagram, select necessary data, and fill in table cells. According to the results of both regional and international studies, more than 80% of children cope with this task. Subject Skill – Reading and Finishing a Table

Sara – green Barbara – yellow Tom – blue Christine – green Ron – brown
Juan – red Tina – red Bill – brown Mary – green Emma – red Don – blue
John – blue Sally – yellow Paul red Linda – blue Jeff – yellow

Mrs. Jones then asked the students to make a table showing these results.
Fill in the missing numbers in the table.

Table 01. The assignment for students.

Color	Number of Students Who Like the Color
Blue	4
Brown	
Green	3
Red	4
Yellow	

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Answer: brown – 2, yellow – 3.

Results. 94.1% of Russian students found the right answer in 2015 (84.3% in 2011).

Commentary. The students' brilliant performance proves that they understand the principles of table organisation, know how to select necessary information, and are able to lay out and control their accomplishment of the task. Information selection and work planning manifest themselves when the student successively picks out every answer "brown", sums all of them up, and inserts the number into the corresponding cell; after that, she follows the same procedure with the answer "yellow". Self-control manifests itself in the student's focusing on a particular stage of the task accomplishment (*I'm counting all brown-s*) and a certain colour within one stage. The additional research, conducted in the experimental environment, in particular, in the Gymnasium in Troitsk, Moscow, demonstrated that few children made a mistake when they counted the answers (for example, they wrote "2" instead of "3" in the "brown" row). When the teacher asked them, "How can you check whether you have made a mistake?", without any effort the children always gave self-tips, which could let one check the answer in this type of tasks. The suggested recommendations were, for instance, "I will go backwards – I will look at the number in the "brown" row and recount the children that gave this answer"; "I will count how many children answered the question (there are 16 of them) and how may answers I put down in the table (4+2+3+4+3=16)".

Subject skill – Interpreting Data (Facts, Information)

Task 2. (Regional Monitoring 2014/2015, 2015/2016)

Read the text and fill in the missing numbers in the Table 02.

Pete, Dean, and Alex are taking part in a competition, consisting of two parts - a 60 metres race and a long jump. It takes Pete 10 seconds to run the distance, Dean's result is 1 second worse, and Alex is 1 second slower than Dean. Alex stages a jump of 310 cm, Pete's result is 295 cm. Dean's result is 10 cm better than Alex's.

Table 02. Table with Competition Results.

Participant	**Race, 60 m (s)**	**Long Jumps (cm)**
Pete	*	*
Dean	***	**
Alex	***	*

Table 03. Answer:

Participant	**Race, 60 m (s)**	**Long Jumps (cm)**
Pete	10	295
Dean	11	320
Alex	12	310

Results. The task was accomplished by more than 30 thousand fourth graders at the end of the 2014/2015 academic year and more than 3.2 thousand fifth graders at the beginning of the 2015/2016

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academic year. 32% of fourth graders and 24% of fifth graders completed one column or one row correctly (and got 1 point). 49% of fourth graders and the same number of fifth graders completed both columns correctly.

Commentary. In order to finish the task correctly, one was supposed to translate some information form the text into the table without any change. These cells are marked above with *. In order to fill in another cell, one was expected to perform a simple mathematical operation, in which third and fourth graders hardly ever make a mistake (the cell is marked with **). Nevertheless, in order to fill in the cells marked with *** one had to interpret the context dependent words "worse" and "slower". The sentence "Dean's result is 1 second worse", here meaning that it takes Dean 1 second more to finish the race, was understood not by all of the students. Most learners associate "worse" with "less", but when one deals with speed values while discussing the same distance, the dependence between speed and time is reversed. Thus, the primary school students could get the right answer if they possessed necessary subject skills – if they could fill in the table, knew the "…more/ better…" relation and understood the dependence between movement values. Evidently, the students were also expected to do the task up to the end and check their answers in the cells.

Subject skill – Making and Verifying Statements for Particular Sets of Data

Task 3. (Regional Monitoring 2015/2016)

Mike wrote numbers 3, 9, 27, 54 on the chalkboard and said, "All these numbers are odd, and every other number is three times greater than the previous one." What number do you need to write instead of 54 for his statement to be true?

Answer: _____ The right answer is "81".

Results. The task was offered to fifth graders (approximately, 8 thousand people) at the beginning of the 2015/2016 academic year; 72% gave the right answer.

Commentary. The task tested the learners' skill in processing mathematical expressions. The content of the mathematical expression – the difference between odd and even numbers and multiplication where one factor exceeds the limits of the table – had been taught in the third grade. At the beginning of the fifth grade, this knowledge was still active and relevant for further learning. In order to get the right answer, the students were supposed to distinguish between odd and even numbers and to perform multiplications; furthermore, they were to analyse all the numbers suggested in the task and determine the next number. Even though students do not typically make mistakes in information selection when the data are provided explicitly, about 30% of fifth graders failed the task. What were the challenges they faced? The children gave various wrong answers, such as: 27 (contradicts the condition "every other number is three times greater than the previous one"), 162 (contradicts the condition "instead of 54" and the statement that all numbers were odd), 57 (instead of multiplying the last number by three, the learners added 3 to it). The answers illustrate the challenges the students meet while working with the wording of the task (they have to determine the algorithm, take into account that it is number 54 that is to be replaced, and apply the same algorithm to check the answer), while focusing on the task (it is evident when the children correctly pick out 54 to replace it, but insert a new number according to a different rule), and while checking whether the answer satisfies all task conditions. Meanwhile, for instance, after getting the answer "57", a learner that is able to check his answer will test whether the sequence "3, 9, 27, 57" conforms to the problem situation and will see that the answer "57" is wrong.

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I also suggest paying attention to a generally accepted fact that fourth graders find it difficult to process (comprehend, present, and interpret) informational texts, nevertheless, it is the predominant text type in mathematics and daily life. They are more difficult to handle than literary texts. Both Russian and foreign scholars address this challenge in their papers (Kurovskaya, 2016; Kuznetsova, 2016; Little et al., 2007 ; Zuckerman, Kovaleva, Kuznetsova, 2013; Rydze, Pozdneva, 2014). As it is noted in one of them, "most problematic were the questions addressed to the basic reading skill of retrieving explicitly stated information and making straightforward inferences" (Zuckerman, Kovaleva, Kuznetsova, 2013, p. 127).

Therefore, the learner's ability to handle mathematics information depends on such skills as reading information, represented in a graphical model (for instance, in a table), and filling it in; interpreting data (facts, information); making and checking statements for particular objects, data, as well as drawing a conclusion. While completing a task individually, apart from subject skills, the learner also demonstrates universal learning skills, such as analysis, focusing on the task, planning, and control of the process and the overall outcome.

5.2. Information Processing. Interdisciplinary Learning Skills

One may conclude that a learner is equipped to process information, when she possesses certain subject skills and when she is able to foreground the information necessary to solve the problem, to justify her solution, to focus exclusively on the suggested situation and question without trying to replace it with a simpler one, etc. I will now regard some of these skills and describe them in regard to the researches under consideration.

Interdisciplinary Learning Skill – Processing Information Provided in Different Forms

Task 4. (TIMSS-2011, 2015)

In 2008, Peter paid the following amounts in the first six months for his telephone bill.

Table 04. Student's assignment.

Month	January	February	March	April	May	June
Cost (zeds)	65	20	60	40	60	45

In 2009, Peter paid the following amounts in the first six months for his telephone bill.

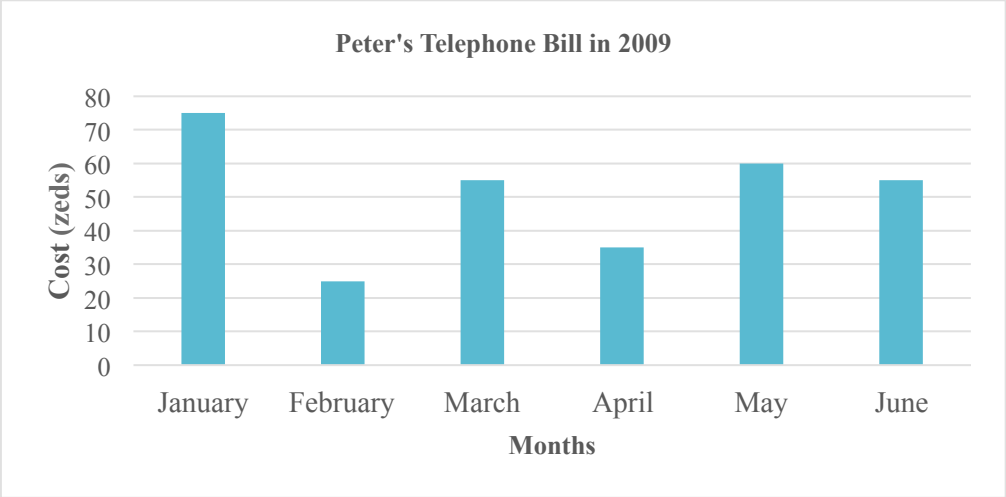

Figure 01. Peter's Telephone Bill in 2009.

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In some months, Peter paid less for his telephone bill in 2009 than in 2008.

In which months?

Answer: _____. The right answer: "Peter paid less in 2009 than in 2008 in March and April" or "In March and April.")

Results. In 2015, 58% of Russian learners got the right answer, in 2011, 64.8%.

Commentary. One may single out two main factors that contributed to the accomplishment of the task. Fist, the learner was supposed to read the table and the diagram, second, to compare the information from both. Such tasks are rare in mathematics course books at primary school. As a result, the percentage of right answers is rather low. This type of task is of importance as nowadays more and more often children have to receive information from various sources and draw parallels between different sets of data. For instance, it might be information about the weather, heard from a radio weather forecast or inferred from personal observations (with the help of a thermometer); prediction of travel time, as calculated individually, with the help of one's parents or the internet; choice of a product (for example, an exercise book) while shopping in different places, and others (Baranova et al., 2011; Rydze, 2016).

5.3. Interdisciplinary Learning Skill – Drawing Conclusions Based on Personal Selection and Choice of Data

The following task was accomplished as a part of a complex quiz entitled *Exhibition Guide "Inventing a bicycle"*. Below I cite only a fragment of this work. The whole test consisted of a text, schemes, and illustrations. Learners were expected to analyse the suggested information and choose the right answer (answer a question) relying on the fragment below.

Task 5. (Regional Monitoring 2014/2015, 2015/ 2016)

Exhibition Details

The exhibition takes place from 14 September to 14 October in Moscow at Pavilion 230 of the Exhibition of Achievements of National Economy (VDNH).

Opening Hours: 10.00 am – 8.00 pm (box office open until 7 pm)

Exhibition Prices: Adult - 300 roubles, Pupil – 150 roubles, Pre-schooler – free.

Question 1. How long will the exhibition last?

1) 2 weeks 2) all summer

3) 1 year 4) 1 month (the right answer)

Question 2. How much money will a family of three people with two adults and a five-year-old child spend? (The right answer: "600 roubles.")

Results. 71% of the fourth graders gave the right answer to Question 1, 90% answered correctly Question 2. The test was written by more than 30 thousand in Moscow Oblast.

Commentary. In order to cope with the questions, the learner was expected to analyse the text of the complex test and select the necessary fragment herself. While completing the task, the fourth grader had to focus on and select only that information that was necessary and sufficient to provide the answer. The high performance rate in the second task (Question 2) can be justified by the fact that the learners faced a test item they had often completed in class before, and, as a result, could easily understand it (buying a ticket, taking into account the price and the age of the visitor) this time as well. The learner was supposed to demonstrate her ability to use her knowledge (to complete a task in addition) and formulate

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the outcome of the procedure (the child decides herself whether she wants to do the task orally or in writing) in the form of an answer.

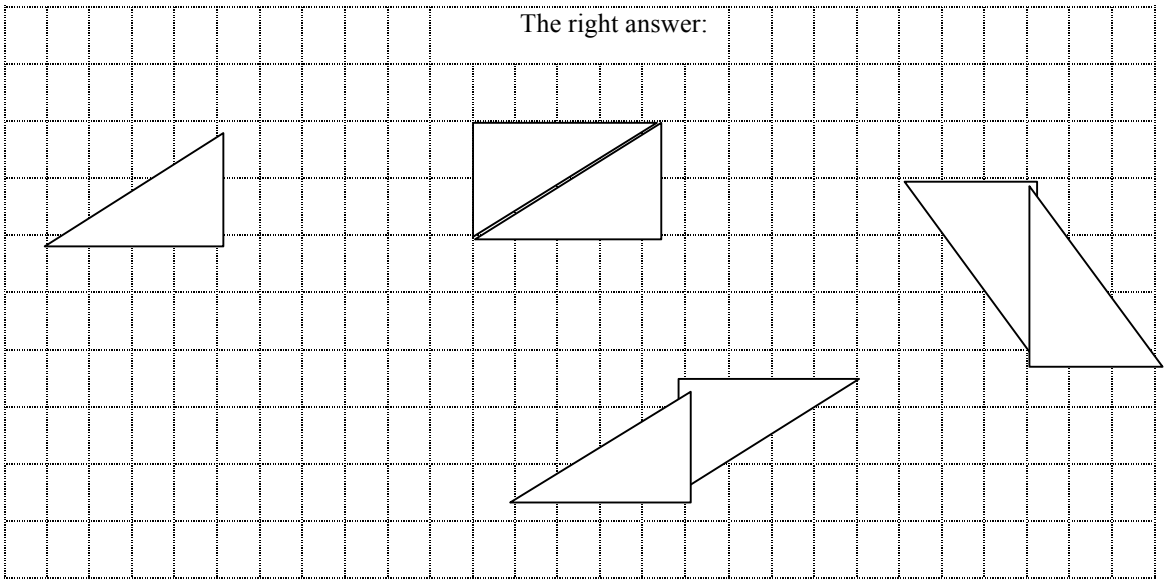
5.4. Interdisciplinary Learning Skill – Presenting the Outcome of one's Actions in a Set Format (Way)

Task 6. (Regional Monitoring 2015/2016)

Tonny said, "One can make two different quadrangles, if one takes two of such triangles." Was he right? Prove your answer with pictures.

Answer: _____.

The right answer: "Yes, he was" ("yes"). One of the following quadrangles should be depicted.



Results. The task was first offered to fifth graders (the task was accomplished by more than 1.6 thousand students) in October in the 2016/2017 academic year.

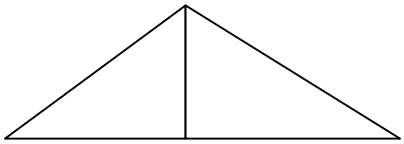
Any learner could get either 0, 1, or 2 points for the test item.

2 points were granted to the learners who gave the answer "Yes, he was", ("Yes") and drew two different quadrangles.

1 point was granted to the learners who gave the answer "Yes, he was", ("Yes"), and drew one quadrangle or two identical quadrangles.

0 points were granted in any other case (for example, the answer was right, however, a triangle was depicted instead of a quadrangle, like in *Figure 02*. below).

Figure 02. Assignment sample.



Note. If the initial size was not preserved, though the form of the figure corresponded to the right answer, the student was still granted a point.

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40.6% of the students coped with the task (received 1-2 points), whereas 15% did not start doing the task at all.

Commentary

The main challenge was to give the right answer not only in words but in images as well. The fourth grader is expected to be able to draw a quadrangle, constructed out of two triangles. Thus, she possesses the subject skills necessary to accomplish the task. By the end of primary school, the learner also possesses general universal communicative skills, therefore, she may formulate a statement, justify her answer, etc. (Little et al., 2007 ; Mullis et al., 2016). In this case, the students were expected to draw and justify their conclusion with the set – graphical – means. About 18% of the learners provided the right answer, though did not depict any quadrangles (and were granted 0 points). The papers, in which the learners stated that it was possible to construct such quadrangles (though did not show how) are of special interest. Supposedly, such learners just lacked experience in accomplishing similar tasks and readiness to respond to non-standard test items. I presume, if at primary school learners are encouraged to discuss different approaches to solution justification, to note down the process of accomplishing the task not only step by step (or with a mathematical expression), and to choose a suitable (or rational) way to solve a task and present the outcome; they will develop more skills in presenting mathematical information and proving that their answer is correct.

Discussion

The research results allow us to draw the following conclusions. Whether the learner will get the right answer or fail a subject task in information, processing relies heavily upon the inclusion of special topics and numerous types of tasks, related to tables, diagrams, and students' abilities to read and complete tables, diagrams, and schemes, in mathematics course books. The challenges the learner may face are both of subjective and objective nature. On the one hand, there can be an insufficient amount of tasks, drilling the ability to provide statements relying on a model or instruction (for instance, "When answering, use the model If…, then…"). On the other hand, children are used neither to using mathematical terms nor to formulating statements, because they are likely to think, "this is Maths, not Russian or Literature". When the learner faces test items of interdisciplinary character, where he/she has to handle mathematical information in contextual and practical situations; he/she gets the right answer only when the assignment type is familiar to him/her and does not require any personal approach to the solution or format.

6. Conclusion

The research has showed that students tend to lack the following universal learning skills – focusing on the task, generalizing data provided inconsistently or in different forms, planning and controlling the order and result of one's actions, presenting the outcome, and justifying it. At the same time, when students write final tests (on the primary school material), they demonstrate sufficient awareness of how to apply mathematical information in order to accomplish various tasks.

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One's ability to process mathematical data and solve subject and interdisciplinary learning tasks is of crucial importance for the increase of informational literacy as an outcome of the primary school education.

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