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LEVEL OF ACHIEVEMENT OF LEARNING OBJECTIVES IN NATURAL NUMBERS TEACHING IN THE 4TH GRADE OF PRIMARY SCHOOL

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Abstract. *This paper presents the results of the research on the level of achievement of course objectives in natural numbers teaching in the 4th grade of primary school using the taxonomic model designed for this research purposes. The taxonomic model consists of five levels: recognition, reproduction, comprehension, generalization and application, problem solving. It was aligned with Bloom's taxonomy in the cognitive domain, and also with the requirements related to the assessment of students' knowledge presented in the Primary School Mathematics curriculum. A descriptive method in its analytical and classification form was used, whereupon data were obtained on the degree of operationality and classification of learning objectives in terms of concretization, realization and possibility of verifying whether the objectives can be achieved. The survey was conducted on a sample of 315 students of the 4th grade. The obtained results indicate that as the level of complexity based on the taxonomic model increases, the level of achievement of learning objectives regarding natural numbers in the 4th grade of the primary school decreases. Moreover, in the case of two learning objectives, students achieved all levels of complexity, while in the case of three learning objectives students reached the level of comprehension. When it comes to the remaining four learning objectives, they reached the level of reproduction, that is, they acquired only the basic knowledge that each student is supposed to gain at the end of the learning process. The obtained results can contribute to changes in the approaches to teaching contents in the following way: changes and innovation to the mathematics curriculum, identification and formulation of learning goals, evaluation of the level of achievement of learning objectives, more efficient individualization of the learning process, identification of criteria and standards for assessing students' knowledge, acquiring a more permanent and better-quality knowledge, etc.*

Key words: *taxonomy, learning objectives, natural numbers, level of achievement of learning objectives*

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1. INTRODUCTION

Along with the development of the mathematics curriculum for the first four grades of primary school, learning objectives and outcomes are also designed with the intention of achieving them in the process of education. They are the starting point, but also the outcome of every education process that begins with a certain intent and ends with a verification of whether that intention has been achieved (Bognar & Matijević, 2002, 158). The educational goals determine the results that wish to be achieved with the overall educational work and represent the end of the education process and anticipate future results. In order for these goals to be feasible, they must be clear, specific, usable for those who work on their accomplishment and there has to be a way to verify whether the learning content was adopted. For that purpose, the goals, general and specific objectives, as well as course contents and outcomes of education, need to be a coherent whole that would, from a didactic and methodical point of view, constitute *a system of goals and objectives*, that is, such a process that will ensure the continuity, integrity and operability of the teaching process. Moreover, it is necessary to pay particular attention the regularity of setting a particular goal as a general and divisible whole and hierarchy.

On the other hand, in the process of acquiring knowledge, it is important that there is a hierarchical sequence that coincides with a hierarchically organized series of psychological processes, arranged in such a way that it starts from the simplest ones and moving onto those most complex psychological processes (memorize, understand, generalize, apply, analyse, synthesize, evaluate, etc.). Bearing that in mind, some authors classified the educational goals and objectives into hierarchically arranged levels, so that each one that follows contains the requirements of those preceding it in the series, which they called the *Taxonomy of Educational Objectives*. According to Krathwohl (2012), the Taxonomy of Educational Objectives is a scheme for classifying educational goals, objectives, and, most recently, standards. It provides an organizational structure that gives a commonly understood meaning to objectives classified in one of its categories, thereby enhancing communication“ (Krathwohl, 2002, 218).

The use of taxonomy in defining educational goals enables the following: more efficient and quality individualization of the learning process in terms of creating quality alternative learning models for all types of students, starting from those who fall behind their peers, to those who are the most creative and gifted; design of Criterion-referenced tests in order to measure student performance and the level they achieved against a set of course predetermined learning standards (Vučić, 1979, 27); definition of assessment criteria and standards in accordance with the set of learning objectives that include the description of knowledge, skills and attitudes that students should acquire at a certain level of education, etc. Their significance is also reflected in the fact that they help formulate such tasks and questions that will be hierarchically arranged into categories, whereby attention should be paid to the complexity of all categories, that is, level of complexity should be assessed based on its quality, thinking process and problem solving. If one starts from the lower levels of complexity (memorize, recognize, reproduce) and move onto the higher levels (comprehend, apply, solve problems, be creative), it is possible to compile a certain number of questions and tasks for any of the levels that would serve as indicators and measure student knowledge and behaviour which is characteristic of each level. The problem is how to determine a clear boundary between levels of complexity and abilities, that is, how to identify educational levels, for which there is no ideal methodology. This is corroborated by the fact that the researchers working on *TIMSS* study (conducted in more than 60 countries around the world) change the tasks and questions, that is, cognitive levels in every assessment cycle (Milanović-Nahod, 2005, 347; Mullis, Martin, & Foy, 2005, 6). Accordingly, there is a problem with the formulation of questions in tests that would serve as indicators and measure the proper cognitive level, which raises the question of the validity of tasks, that is, whether the tasks measure the level of complexity that they should measure (Milanović-Nahod, 2005, 349). How to design a model that will be suitable to track, assess and evaluate the achieved goals and objectives of each student is a question that still has not been precisely answered.

Given that contemporary teaching is based precisely on predefined educational goals, objectives and outcomes that should be reflected in achievement standards as expected learning outcomes defined by levels, the study and verification of the degree of accomplishment of goals and learning objectives by using the taxonomic model makes it justifiable to improve the education process.

2. Taxonomic Model and Operationalization of Objectives and Goals in Mathematics Teaching

One of the creators of the taxonomy of learning objectives is the American psychologist B. Bloom (Blum, 1981), whose taxonomy is based on the cognitive, affective and psychomotor domain. Given their interrelation, no modern theory of teaching and learning justifies Bloom’s division of teaching activities into the above domains, and therefore, taxonomy of the cognitive domain is mainly used in teaching practice. Many supporters of behavioural learning theories have insisted on the strict hierarchy of learning objectives which were proposed by the taxonomies of Tyler (1949), Mager (1997) and others. The taxonomy of Anderson and Krathwohl (Anderson, Krathwohl, et al., 2001) originated on the basis of Bloom’s taxonomy as *A Revision of Bloom's Taxonomy of Educational Objectives.* Moreover, Gagne’s taxonomy (Gagne, 1992) is also used in European countries in the area of testing and assessing students’ knowledge. One of the most used and disputed taxonomies since it was published is Bloom’s taxonomy in the cognitive domain. “While still widely used, Bloom’s taxonomy is gradually being supplemented – and may perhaps even supplanted one day – by new insights into the workings of human thought and learning made possible by advances in brain imaging and cognitive science. Still, it is likely, given its logical simplicity and utility, that Bloom’s taxonomy will continue to be widely used by educators” (The Glossary of Education Reform, 2014). This is supported by the fact that, among other things, the TIMSS research, “found support in the division of knowledge according to Bloom’s taxonomy” (Milanović-Nahod, 2005, 347).

The taxonomic model designed for this research purposes is on the one hand in line with Bloom’s taxonomy, and on the other hand, it is in line with the requirements related to the assessment of students’ knowledge presented in the Primary School Mathematics curriculum (Nastavni program za četvrti razred osnovnog obrazovanja i vaspitanja, 2006, 2008) in Serbia. It contains five main levels: *recognition, reproduction, comprehension, generalization and application, problem solving*. Sublevels were defined for each level which help more closely specify and define the contents of the educational objectives for each level. Knowledge at the level of recognition and reproduction is considered as *basic knowledge* and represents the minimum knowledge that each student must gain at the end of the learning process, that is, at the end of the school year. Analogous to Bloom's taxonomy of the cognitive domain, this taxonomy can also be divided into two groups. The *first group* includes lower levels of complexity (recognize, reproduce, perceive, memorize), while *the second group* includes higher levels (understand, apply, generalize, solve problems, intellectual skills) (Bogdanović & Malinović-Jovanović, 2009, 620).

Below is a schematic representation of the taxonomic model of learning goals and objectives.

Table 1 Taxonomic model of operationalization of learning objectives and goals

Group	Levels	Sublevels
1. Reproduction	1.00. Recognition	1.10. Knowledge of specific
		1.20. Knowledge of terminology
		1.30. Knowing the meaning of specific details
	2.00. Reproduction	2.10. Knowledge of rules of connection
		2.20. Knowledge of classification methods
		2.30. Knowledge of criteria and methodology
		2.40. Knowledge of the universals, principles and abstractions
2. Production	3.00. Comprehension	3.10. Translation
		3.20. Interpretation
	4.00. Operationality	4.10. Generalization
		4.20. Application
	5.00. Creative problem solving	5.10. Analysis
		5.20. Synthesis
		5.30. Evaluation

The operationalization of learning goals and objectives for each specific course is provided by educational objectives which predetermine what students need to know and be able to do at the end of each grade, in order to be able to say that the goals set were actually achieved. By defining the learning outcomes, so that each subsequent level implies the previous levels were already mastered (Dejić & Milinković, 2012, 98), the requirements set in the overall learning objective are concretized through prominent knowledge and skills, by level of achievement (Malinović-Jovanović & Stojanović, 2015, 358). In our case, operationalization was related to the design of: specific objectives and outcomes, as well as related learning content which refers to natural numbers which are studied in the 4^{th} grade of primary school and, based on that, evaluation of the level of complexity that students are expected to have after the learning content is processed.

The goals and specific objectives as well as basic requirements (learning outcomes) are given in the Mathematics curriculum for the 4^{th} grade of primary school (Nastavni program za četvrti razred osnovnog obrazovanja i vaspitanja, 2006, 2008). Given that the learning outcomes were not given by level of achievement, levels were aligned with the designed taxonomic model of operationalization of learning objectives and goals.

Accordingly, the level of achievement of learning objectives on natural numbers in the 4^{th} grade of primary school was determined in relation to the 4^{th} grade specific objectives and the taxonomic model designed for the purposes of this research which serves as an indicator of the level of achievement of these.

3. METHODOLOGICAL FRAMEWORK

The main goal of this research was to identify the level of achievement of learning objectives on teaching natural numbers in the 4th grade of primary school. Moreover, the level of achievement was verified in relation to the levels of complexity of the taxonomic model. In line with that, for each level of complexity, as well as for each learning objective, the achievement of the predetermined minimum criteria was verified, as well as the differences in the performance of students among the levels of complexity of the taxonomic model, and the highest level that students achieved for each learning objective. In accordance with the goal set, it was assumed that *with the increase in the quality of knowledge according to the taxonomic model of the operationalization of goals and learning objectives, the level of achievement of learning objectives on natural numbers in the 4th grade of primary school decreases.* Moreover, the following was assumed as well:

1. *The level of achievement of learning objectives on natural numbers in 4th grade of primary school is the highest in recognition level and the lowest in creative problem-solving level.*
2. *There is a statistically significant difference in the evaluation of the quality of knowledge against the taxonomic model of the operationalization of goals and learning objectives*
3. *The smallest difference in students' performance is between the neighbouring levels of the taxonomic model*
4. *Students are able to adopt basic knowledge in the reproduction level of the taxonomic model against all learning objectives on natural numbers in the 4th grade*
5. *With regards to certain learning objectives, students are unable to achieve certain levels of knowledge defined by the taxonomic model.*

The sample included primary school students from Pčinja County in Serbia, more precisely 3548 pupils of the 4th grade. The sample included the three following schools: five classes of 4th grade students from primary school "Radoje Domanović", six classes of 4th grade students from primary school "Vuk Karadžić", and three classes of 4th grade students from primary school "Jovan Jovanović Zmaj" from Vranje. A total of 315 students of the 4th grade was tested, which significantly exceeded the rate of 0.05, that is, 5%. Given that the research basis included learning objectives related to arithmetic which accounted for more than 70% of the total content studied in 4th grade during the whole school year, the survey was conducted in May and June. The research basis consisted of learning objectives on natural numbers given in the Curriculum for the 4th grade of primary school which, in order to further analyse and interpret the results of the research, we provide below. Students should be able to:

- 4.1 successfully master reading and writing of natural numbers in the decimal numeral system;
- 4.2 get familiar with the N set, that is N_0 set;
- 4.3 learn to assign points of a number line to a natural number;
- 4.4 understand the feasibility of operations in N set, that is N_0 set;
- 4.5 read and write elementary properties of arithmetic operations using letters; conduct commutative, associative, and distribution operations (without using these terms), as well as other properties of mathematical operations for easier and faster calculation;
- 4.6 notice the functional dependency on the examples of dependency between the results and components of the operation;

4.7 read, compile, and calculate the value of multiple operation expressions, as well as to know the variable on adequate examples;

4.8 know how to solve equations and inequalities in a form that students are familiar with in the set of natural numbers;

4.9 successfully solve (using expressions and equations) the tasks given in the textual form.

For the purposes of this research, we used the *descriptive method* in its analytical and classification form. The analysis resulted in data on taxonomic models, learning objectives and learning objectives, that is, on the degree of operationalization and classification of learning objectives in terms of concretization, realization and possibility of verifying whether the objectives can be achieved. The classification of learning objectives was performed through the design of the taxonomic model. The choice of techniques and instruments that were used was made in relation to the nature of the research-related issues and methods. As part of the descriptive method, *content analysis technique* and *testing* were used. *Content analysis technique* was used to provide data on the descriptions of levels of complexity in terms of quality that should provide the basis for making conclusions on student performance. It was also used to check the validity of the tasks and questions given in the tests.

For the purposes of this research, *criterion-referenced tests* were designed in order to measure student performance and the level of learning objectives they achieved. Five tests were designed: *recognition test (TP), reproduction test (TR), comprehension test (TS), operationality test (TO), and problem solvingtest (TRP).* The questions and tasks in the tests were designed according to the requirements of learning objectives and the taxonomic model. The number of questions in each test depended on the requirements of learning objectives. Since each test measured the same level of complexity, the tasks in the tests were not ranked by complexity, and each of them brought the same number of points as the requirements of the learning objective it related to. The tests included the following types of questions: alternate choice, multiple choice, fill in the blank, discovering relationships among given elements, short answers to a given question, and open-ended questions that required a more complex answer. Alternate and multiple-choice questions, fill in the blank questions, and discovering relationships among given elements were used in recognition tests. Fill in the blank questions were used in reproduction tests, but only in cases where students were supposed to, based on the information given in the question, make conclusions by filling in relevant statements. In all other tests, only open-ended questions were used and adapted to the level of complexity they needed to measure.

Table 2 shows the maximum number of points that can be achieved in each test in relation to the requirements of learning objectives.

Table 2 Number of points in tests in relation to the requirements of learning objectives

Unit objectives	Maximum number of points in tests for each learning objective						
	TP	TR	TS	TO	TRP	Total for learning objectives	
						# of tasks	Maximum points
4.1. Numbers	4	4	4	4	4	10	20
4.2. N set structure	2	2	2	2	2	6	10
4.3. Number line	1	1	1	1	1	5	5
4.4. Feasibility of operations	4	6	4	6	6	11	26
4.5. Properties of operations	8	8	8	8	8	16	40
4.6. Functional dependency	9	8	9	8	8	17	42
4.7. Numerical expressions	6	6	6	6	6	12	30
4.8. Equations and inequalities	8	7	8	7	7	14	37
4.9. Textual tasks	4	4	4	4	4	10	20
Total per category	46	46	46	46	46	101	230

Logical analysis examined the validity of the given questions and tasks, based on which it was established that the designed questions and tasks encompass all the requirements asked by the respective educational goals and objectives, and that they are in accordance with the levels of complexity they were supposed to measure and which were determined by the taxonomic model. When evaluating the level of achievement of learning objectives, among other things, the following evaluation components were taken into account: to what extent a student has adopted and understood the *knowledge* required by learning objectives; whether this knowledge is *applicable and functional*, that is, whether students are able to use the acquired knowledge in solving various tasks and adopting new mathematical knowledge; whether students are able to perform certain intellectual, practical and other operations relatively quickly, accurately, skilfully and to a certain degree of *proficiency*; whether they have developed certain useful habits: clear and concise writing skills, orderly and systematic work, responsibility and autonomy, etc.; contribution of mathematics teaching to the development of students' skills: intellectual (analysis, synthesis, application), mental (logical thinking, deduction, creative thinking), perceptive skills, etc.

The interpretation of results with regards to the type of test related to the percentage of solved tasks and questions, and the classification of the level of achievement of learning objectives is given in Table 3.

Table 3 Interpretation of test results with regards to the level of achievement of learning objectives

Level of achievement of objectives in %	Results description				
	TP	TR	TS	TO	TRP
0% - 20.0%	VLL of recognition	VLL of reproduction	VLL of comprehension	VLL of operationality	VLL of creative problem solving
20.1% - 40.0%	LL of recognition	LL of reproduction	LL of comprehension	LL of operationality	LL of creative problem solving
40.1% - 60.0%	AL of recognition	AL of reproduction	AL of comprehension	AL of operationality	AL of creative problem solving
60.1% - 80.0%	AAL of recognition	AAL of reproduction	AAL of comprehension	AAL of operationality	AAL of creative problem solving
80.1% - 100%	HL of recognition	HL of reproduction	HL of comprehension	HL of operationality	HL of creative problem solving

Legend: VLL – very low level, LL – low level, AL – average level, AAL – above average level, HL – high level

The basic knowledge achieved at *the level of reproduction*, that is, knowledge belonging to the first group of the taxonomic model was said to be the *minimum knowledge required to achieve learning objectives.* Without such knowledge, the adoption of new, more complex knowledge and skills and further evaluation within the second group of the taxonomic model cannot be successfully continued.

It was required to solve between 60.1% – 80.0% of tasks and questions within a certain knowledge level, that is, to reach *above average level* in order to be considered to have reached the *minimum level of achievement within that certain knowledge category*. This means that if students have achieved at least the above average level of complexity in a certain category of given learning objectives, it can be said that they are able to solve that task in that category. This is significant from the aspect of identifying the highest quality of knowledge that students can adopt in meeting learning objectives.

Evaluation was carried out based on the levels of the taxonomic model and it related to the *level of achievement of learning objectives in natural numbers teaching*. The highest number of learning objectives within one class allows for a quick, *immediate/direct* evaluation. Since this was a final evaluation, it was actually possible to reach even higher levels of knowledge within each learning objective than those required by it and contained in it. Namely, knowledge acquired at the beginning of a school year will be at a certain level, and that knowledge will be at a higher level at the end of the school year, since it will be integrated into the knowledge that follows.

Statistical package SPSS20 was used for statistical data processing. It included the calculation of percentages and arithmetic mean to indicate average values, as well the calculation of standard deviation as an indicator of variability. Moreover, the corresponding *t*-values were also calculated in order to identify the difference in the number of solved tasks and questions among the levels of the taxonomic model.

4. RESEARCH RESULTS

Identifying the level of achievement of learning objectives related to the content on natural numbers studied in the 4^{th} grade, against the levels within the taxonomic model was performed by observing the percentage of solved tasks on the tests for each type of knowledge, while the differences in students' performance regarding the categories of knowledge within the taxonomic model were identified based on the calculated *t*-values that have shown the difference in students' performance by indicating the differences in percentage of solved tasks that measure the level of achievement of each learning objective.

Table 4 shows the distribution of results for each level within the taxonomic model.

Table 4 Descriptive indicators and percentage of solved tasks against taxonomy level

Level of the taxonomy model	N	Miss.	Max.	Sum	Min	Max	Mean	SD	Sk	Ku	%
Recognition	310	5	14260	10769	6	46	34.74	8.57	-1.06	0.83	75.52
Reproduction	309	6	14214	9501	1	46	30.75	9.85	-0.64	0.06	66.84
Comprehension	301	14	13846	8141	0	46	27.05	11.45	-0.40	-0.58	58.80
Operationality	289	26	13294	6567	0	46	22.72	12.20	-0.04	-1.10	49.40
C. prob. solving	293	22	13478	5126	0	46	17.49	10.66	0.65	-0.51	38.03

Based on the values of arithmetic means and their corresponding standard deviations, we can see that standard deviation value indicates a large dispersion of results around the mean value for all levels, which means that the average value expressed through the arithmetic mean is not a valid indicator of the level of achievement of learning objectives, which is why, further on, the results will be expressed based on the percentage of tasks solved. The data in the table related to the distribution in form of skewness and kurtosis indicate that the distribution is negatively skewed (most of the values cluster toward the larger values) when it comes to all levels of complexity (Sk_p = -1.069; Sk_r = -0.645; Sk_s= -0.408; Sk_o = -0.048), except for the problem solving level where the distribution is positively skewed (Sk_{rp} = 0.65) and most of the values cluster around the smaller values. With regards to the level of recognition and reproduction, based on the tailedness, the distribution is platykurtic (Ku_p = 0.836; Ku_r = 0.066), which means that contrary to expectations the results were not clustered around the average values, while for all other levels the distribution was leptokurtic (Ku_s = -0.581; Ku_o = -1.109; Ku_{rp} = -0.512), which means that, as expected, the results were clustered around the average values, that is, there are more average values than larger or lower values.

Based on the percentage of tasks solved and by using the table with results interpretation (Table 3) as a performance criterion, we can see that the students achieved: *above average level* of recognition and reproduction – they solved 75.52%, that is, 66.84% of the tasks given; *average level* of the comprehension and operationality (58.80%; 49.40%), and *low level* of the creative problem solving (38.03%).

The results indicating the difference in students' performance by levels of taxonomic model are given in Table 5.

Table 5 Statistical significance of differences in percentages per taxonomic model level

Level of the taxonomy model	Recognition		Reproduction		Comprehension		Operationality		C. prob. solving	
	t	*p*	*t*	*p*	*t*	*p*	*t*	*p*	*t*	*p*
Recognition			2.391*	0.017	4.46**	0.000	6.822**	0.000	10.00**	0.000
Reproduction	-2.391*	0.017			2.057*	0.040	4.377**	0.000	7.374**	0.000
Comprehension	-4.46**	0.000	-2.057*	0.041			2.297*	0.022	5.169**	0.000
Operationality	-6.822**	0.000	-4.377**	0.000	-2.297*	0.022			2.778*	0.005
Cr. problem solving	-10.00**	0.000	-7.374*	0.000	5.169**	0.000	-2.778*	0.005		

** *The difference is significant at the p < .001*

* *The difference is significant at the p < .05*

The table shows us that there is a statistically significant difference in all the cases and it is highly significant at the level of 0.01 and 0.05. Furthermore, it is the highest between the recognition and problem solvingcategory ($t(292)$ = 10.000, p = 0.0001), while it is the lowest between the reproduction and comprehension category $t(300)$ = 2.057, p = 0.0406. All in all, we can see that the smallest difference is between the neighbouring categories at the significance level of 0.05. The highest difference is between the problem solvingcategory and all the other categories.

Moreover, the difference increases as the level of complexity increases, starting from recognition level and ending with creative problem-solving. Therefore, when it comes to the difference in student performance between the level of recognition and other levels, the smallest difference exists between recognition and reproduction ($t(308)$ = 2.391, p = 0.0174), while the biggest difference is observed between recognition and creative problem solving (*t(292)* = 10.000, *p* = 0.0001). The difference also increases between the reproduction and all other levels, where the difference between reproduction and comprehension is the smallest (*t(300)* = 2.057, *p* = 0.0406), while it is the largest between reproduction and creative problem solving *t(292)* = 7.374, *p* = 0.0001. The same applies for the comprehension level, since *t(288)* = 2.297, *p* = 0.0223 and *t(292)* = 5.169, *p* = 0.0001 in cases where difference existed between comprehension and operability, and comprehension and creative problem solving, respectively.

Based on these *t*-values, the first three assumptions have been confirmed, that is, we can conclude the following: *there is a statistically significant difference in evaluating the quality of knowledge against the taxonomic model levels; the level of achievement of learning objectives in teaching natural numbers is the highest in the level of recognition, and the lowest in the level of creative problem-solving; the difference is the smallest between the neighbouring taxonomic model levels.* Moreover, given that the greater the difference between the levels of the taxonomic model, the greater the *t*-value will be – we can accept the initial assumption that *as the quality of knowledge increases, students' success in solving tasks that measure the level of achievement of learning objectives related to natural numbers in the 4th grade decreases.* Furthermore, the percentage of tasks solved for each learning objective was also calculated. These results are shown in Table 6. In relation to these, we also calculated the corresponding *t*-values of differences between the percentages of students' performance in solving tasks based on all taxonomic model levels, which measure the level of achievement of each individual learning objective. This was done in order to find out which are the learning objectives related to the corresponding natural numbers content studied in the 4th grade which students can master and to what level of complexity quality-wise.

Table 6 Percentage of tasks solved per each learning objective

Level of the tax. model	Learning objectives								
	4.1.	4.2.	4.3.	4.4.	4.5.	4.6.	4.7.	4.8.	4.9.
Recognition	88.15	88.23	82.58	80.18	62.22	73.76	65.65	81.73	82.23
Reproduction	88.17	84.63	82.58	63.70	62.26	60.02	68.39	61.16	69.21
Comprehension	57.97	81.89	60.47	69.35	48.46	62.64	50.50	63.54	52.08
Operationality	59.00	80.12	58.02	65.51	55.61	48.83	39.22	44.34	27.16
Creative problem solving	34.04	82.94	34.26	71.50	34.68	18.77	25.82	36.62	30.37

The results indicate the following:

1. Regarding the learning objectives 4.1., 4.3., 4.6., 4.7., 4.8. and 4.9., the results obtained were expected to be such, because a statistically significant difference for these learning objectives did not exist only in one or two cases between neighbouring levels of complexity, while in all other cases it was very statistically significant at the level of 0.01 – it was the lowest among the neighbouring levels and increased with the increase in the difference between them in the following way:

- Regarding learning objectives 4.6, 4.7, 4.8 and 4.9 there was no statistically significant difference in only one case. Thus, with 4.6 and 4.8, there was no statistically significant difference between the reproduction and comprehension (*t(300)* = -0.812, *p* = 0.4174, and *t(300)* = -0.606, *p* = 0.5450), in case of 4.7 between the recognition and reproduction (*t(308)* = -0.724, *p* = 0.4696), and in case of 4.9 objective, between the operationality and problem solving(*t(288)* = -0.855, *p* = 0.3933).

– With regards to learning objectives 4.1 and 4.3, there was no statistically significant difference observed in two cases, between the recognition and reproduction, with $t(308) = -0.007$, $p = 0.9944$ for the learning objective 4.1, and $t(308) = -0.089$, $p = 0.9291$ for the learning objective 4.3, and between the comprehension and operationality ($t(288) = -0.253$, $p = 0.8004$; $t(288) = 0.607$, $p = 0.5443$ respectively).

2. In the case of learning objectives 4.2, 4.4 and 4.5 we did not get the expected results:

– By solving the tasks related to the learning objective 4.2, students achieved a high level within all taxonomy levels, so the difference between the number of solved tasks is not statistically significant.

– By solving the tasks related to the learning objective 4.4, students achieved a high level of the recognition, while they achieved an above average in all the remaining taxonomic levels. Therefore, there is a statistically significant difference between the recognition and all other levels ($t(308) = 4.576$, $p = 0.0001$; $t(300) = 3.041$, $p = 0.0026$; $t(288) = 4.015$, $p = 0.0001$; $t(292) = 2.348$, $p = 0.0195$), and between the reproduction and problem solving where it is negative $t(292) = -2.049$, $p = 0.0414$. In all other cases, the difference obtained is not statistically significant. Therefore, expectations have not been met that the level of achievement of this learning objective decreases with the increase in the taxonomic model level, but the students have perfectly understood the operations in the set of natural numbers, since when solving tasks related to this learning objective, they have achieved at least the above average level.

– In case of the learning objective 4.5, a statistically significant difference was not observed in four cases: between the operationality and the first three taxonomy levels, and between the recognition and reproduction. It does exist though in all other cases, and it is highly significant at the significance level 0.01. The analysis of tasks solved led us to the conclusion that students showed poorer results than expected in the comprehension level, specifically in an exercise related to writing in letters the properties of multiplying and dividing sum and difference.

Since in the case of learning objectives 4.2, 4.4 and 4.5 the expected results were not achieved, we cannot say that with the increase in the quality of knowledge, students' success in solving tasks that measure their level of achievement decreases, while we can claim this is the case for all other learning objectives.

In order to identify the learning objectives that can be met in the 4th grade, as well as the highest level that students can reach when achieving these learning objectives, we created the following table which shows the level of complexity that students achieved in relation to the classification criteria for the levels of achievement of learning objectives.

Table 7 Achieved level based on results interpretation

Level of the taxon. model	Learning objectives								
	4.1.	4.2.	4.3.	4.4.	4.5.	4.6.	4.7.	4.8.	4.9.
Recognition	HL	HL	HL	HL	AAL	AAL	AAL	HL	HL
Reproduction	HL	HL	HL	AAL	AAL	AAL	AAL	AAL	AAL
Comprehension	AL	HL	AAL	AAL	AL	AAL	AL	AAL	AL
Operationality	AL	HL	AL	AAL	AL	AL	LL	AL	LL
Creative problem solving	LL	HL	LL	AAL	LL	VLL	LL	LL	LL

Legend: VLL – very low level, LL – low level, AL – average level, AAL – above average level, HL – high level

Based on the data provided in Table 7 and on the formulated minimum criteria of achievement of learning objectives and levels of complexity, we can conclude that 4th

grade students can achieve all the learning objectives required by the mathematics curriculum, given that they achieved high or above average level.

Students have shown a low level of adopted when solving the tasks related to: the seventh and ninth learning objective of the operationality, and the first, third, fifth, sixth, seventh, eighth and ninth learning objective in the level of creative problem-solving. Students have shown an average adopted when solving the tasks related to: the first, fifth, seventh and ninth learning objective in the comprehension level of complexity, and the first, third, fifth, sixth and eighth learning objective in the operationality level. In all other cases, they achieved at least an above average level and met the minimum achievement criteria. This has confirmed the following assumptions: *when it comes to certain learning objectives, students cannot reach all levels of complexity; while students can reach at least the level of reproduction specified by the taxonomic model within all learning objectives.*

5. Discussion

Based on the results on the level of achievement of learning objectives, we can conclude that 4th grade students: in case of *the second and fourth learning objective*, relating to the familiarity with the N and N_0 set, as well as the understanding of mathematical operations possible in N and N_0 set, students were able to *master all levels of complexity* from the taxonomic model, starting from the recognition to the creative problem solving; in case of *the third, sixth and eighth learning objective* relating to assigning points of a number line to a natural number, noting the functional dependency between the results and components of operations, and ability to solve equations and inequalities in the *N* set, *the highest level students could achieve was the level of comprehension;* in case of *the first, fifth, seventh and ninth learning objective,* which are related to reading and writing natural numbers in the decimal numeral system; reading and writing elementary properties of arithmetic operations using letters as well as applying them; solving numerical expressions and expressions with letters with values provided for each letter; solving the tasks given in the textual form – *the highest level students could achieve was the level of reproduction.*

If we compare these results with the levels required by the learning objectives given in the Mathematics curriculum (Table 8), we can see that students achieved required levels of complexity only for 4.2. and 4.4. learning objectives (Malinović-Jovanović, 2017). Given the fact that the majority of these tasks were solved, they need to be reformulated (revised) in the Mathematics curriculum, since the way they are currently formulated presupposes that the reproduction level is achieved. In case of all other learning objectives, students have achieved lower levels than the levels predetermined by the curriculum.

Table 8 The requirements of learning objectives per the Curriculum and research results per taxonomic model levels of complexity

Level of the taxonomy model	Learning objectives	
	Curriculum	Research results
Recognition		
Reproduction	4.2.	4.1.; 4.5.; 4.7.; 4.9.
Comprehension	4.3.; 4.4.	4.3; 4.6.; 4.8.;
Operationality	4.1.; 4.5.; 4.6.; 4.7.; 4.8.; 4.9.	
Creative problem solving		4.2.; 4.4.

The fact that in case of the majority of learning objectives, students achieved the level of reproduction also indicates that teaching process is more focused on memorizing facts than on their understanding and application, and that teaching is still done in a traditional way, as well as that instructional units' objectives are not clearly defined based on the levels of complexity to be measured. Moreover, based on the identified levels for each learning objective, the results indicate which types of knowledge and which levels are the students lacking for each learning objective relating to natural numbers topic. Based on this, it can be determined what types of learning methods and tasks can improve their knowledge, so that these results can serve as guidelines for the changes that should be made in the organization of lessons.

Similar results were obtained in some other studies as well. For example, the results of the study conducted as part of the TIMSS project (Trends in International Mathematics and Science Study), by the International Association for the Evaluation of Educational Achievement – IEA) indicate that Serbian students achieve the best results for the level *knowledge of facts* (recognition and reproduction), then for the comprehension and operationality, while Serbian students achieve the lowest results for analysis, that is, the problem solving level. It is considered that such results are, among other things, the consequence of the fact that the teaching process "pays less attention to more complex mental operations, and highly emphasizes procedurality, that is, students are enabled to master the process and steps of solving the tasks, thus it could have been expected that students' performance would be poorer when it comes to more complex cognitive abilities and skills" (Antonijević & Veljković, 2005, 104). Furthermore, these results are also seen as a consequence of the faults in our mathematics curriculum which "does not specify the precise scope and broadness of learning contents and does not provide the basis for an objective assessment of student performance, as well as successful individualization of teaching, thus the changes that ought to be made are reflected in embracing such an approach to science and mathematics where knowledge is hierarchically linked" (Milanović-Nahod, 2005, 350). In the previous two research cycles (2011, 2015), the results for *knowledge of facts* were significantly better in 2011 than it was the case in 2015 (Mullis, Martin, Foy, & Arora, 2012, Exhibit 2.5), while there were no changes regarding the *analysis (creative problem solving)* domain. Students have made significant progress in the field of knowledge application in 2015 (Mullis, Martin, Foy, & Hooper, 2016, Exhibit 3.7). when compared to 2011. Also, the percentage of students who solved the most demanding TIMSS tasks in these two research cycles was satisfactory, but it is lower by more than 30% compared to the students from the top-ranked countries who successfully solve the advanced level tasks (Milinković, Marušić Jablanović, & Dabić Boričić, 2017, 44).

Furthermore, PISA research results (Programme for International Student Assessment) indicate that around 40% of Serbian students in 2009 (Baucal & Pavlović Babić, 2010, 50) and 39% of students in 2012 (Pavlović Babić & Baucal 2013, 62) belong to the group of students who are not functionally literate in the domain of mathematical literacy.

These students can use mathematical knowledge and skills only within a familiar context where all relevant information is explicitly given. They can identify relevant information within that familiar context and apply routine processes. Any other situation that would be more complex than solving basic and relatively familiar mathematical tasks would pose a significant problem for these students. On the other hand, when looking at the percentage of students who have reached the highest levels of mathematical literacy, it is the case with around 3.5% of students in Serbia, which is three times less than the average for European countries. The obtained results could also be interpreted in the social context of education in the 21st century. The modified social reality in Serbian society imposed the need for dynamic professional development of teachers, as a perspective model for changing the organization of teaching. Teachers' profession in transition societies, such as in Serbia, impose new tasks and roles of their education: educated and highly competent, consistent teachers must be trained to track innovation and research and respond to the challenges of the „knowledge society". In this regard, it is important to define and explain the expected professional competencies of teachers based on the contemporary model of initial education (Zdravković, 2017, 30-31).

6. CONCLUSION

The results obtained in this research indicate that with the increase in the quality of knowledge, students' success in solving tasks related to natural numbers domain decreases. Moreover, by looking at these results in relation to each learning objective required by the Primary School Mathematics Curriculum, it can be concluded that the same applies for all learning objectives. There is an inconsistency with two learning objectives relating to familiarity with the N and N_0 set, as well as the understanding of mathematical operations possible in natural numbers set, where the results indicate that by solving the tasks related to these learning objectives, students have achieved a higher level of complexity than expected in certain categories of knowledge.

On the other hand, in relation to the predetermined minimum criteria for the achievement of learning objectives, the conclusion is that 4th grade primary school students can achieve all the learning objectives required by the Mathematics curriculum. Based on the predetermined criteria and the results obtained, the levels of complexity that students can achieve for each separate learning objective were also identified. Given the obtained results and the classification of learning objectives based on the taxonomic model, it can be said that the quality of knowledge that the students showed on the tests does not correspond to most of the requirements given in the Curriculum. Therefore, they need to be reformulated and aligned with the levels of knowledge that students can achieve at this stage of development.

Moreover, the obtained results also indicate which types of knowledge and which levels quality wise are the students lacking, based on which it can be determined what type of learning methods and what tasks can help improve their knowledge, which means that these results can serve as guidelines for the changes that should be made in the organization of lessons.

In addition to changing and innovating mathematics curriculum, to identifying and formulating educational goals and objectives, to evaluating the level of achievement of learning objectives and to changing the way of teaching and presenting program contents, the results obtained in this research can contribute to a more efficient individualization of the learning process, to a better formulation of the assessment criteria and standards, and to the adoption of more permanent and better knowledge, etc.

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STEPEN OSTVARENOSTI PROGRAMSKIH ZADATAKA NASTAVE O PRIRODNIM BROJEVIMA U IV RAZREDU OSNOVNE ŠKOLE

U radu su predstavljeni rezultati istraživanja stepena ostvarenosti programskih zadataka nastave o prirodnim brojevima u IV razredu osnovne škole uz pomoć taksonomskog modela konstruisanog za potrebe istraživanja. Taksonomski model sadrži pet kategorija: prepoznavanje, reprodukcija, shvatanje, uopštavanje i primena, rešavanje problema. Usklađivan je sa Blumovom taksonomijom u kognitivnom području sa jedne, i zahtevima koji se odnose na vrednovanje znanja učenika datim u Nastavnom programu matematike za osnovnu školu, sa druge strane. Korišćena je deskriptivna metoda u analitičkoj i klasifikacionoj varijanti, pri čemu se došlo do podataka o stepenu operacionalizacije i klasifikacije programskih zadataka nastave u pogledu konkretizacije, realizacije i mogućnosti provere ostvarljivosti zahteva. Istraživanje je sprovedeno na uzorku od 315 učenika IV razreda. Dobijeni rezultati ukazuju na to da se sa povećanjem nivoa znanja taksonomskog modela smanjuje stepen ostvarenosti programskih zadataka nastave o prirodnim brojevima u IV razredu osnovne škole. Takođe, učenici su u slučaju dva programska zadatka, postigli sve nivoe znanja, u slučaju tri programska zadatka dostigli su nivo shvatanja. U okviru ostala četiri programska zadatka dostigli su nivo reprodukcije, tj. stekli su samo osnovna znanja koja treba da poseduje svaki učenik na kraju procesa učenja. Dobijeni rezultati mogu doprineti promeni u pristupima sadržajima nastave i to u: menjanju i inoviranju nastavnog programa matematike, identifikovanju i formulisanju obrazovno-vaspitnih ciljeva, vrednovanju stepena ostvarivanja programskih zadataka, efikasnijoj individualizaciji procesa učenja, određivanju kriterijuma i standarda ocenjivanja znanja učenika, sticanju trajnijeg i kvalitetnijeg znanja i dr.

Ključne reči: *taksonomija, programski zadaci, prirodni brojevi, stepen ostvarenosti programskih zadataka.*