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Original research paper

ANALYSIS OF ACHIEVEMENTS IN SOLVING GEOMETRIC PROBLEMS AT DISTRICT LEVEL COMPETITIONS OF FOURTH GRADE PRIMARY SCHOOL STUDENTS*

Nenad Vulović** ➢ ORCID 0000-0002-6606-2357
University of Kragujevac – Faculty of Eduction, Jagodina, Serbia

Sanja Maričić ➢ ORCID 0000-0002-0464-3527
University of Kragujevac – Faculty of Eduction, Užice, Serbia

Branislav M. Ranđelović ➢ ORCID 0000-0002-0643-0955
University of Priština, Kosovska Mitrovica – Faculty of Teachers Education in Leposavić, Serbia

A B S T R A C T

Numerous studies and international assessments indicate that students show weaker results in geometry items compared to the results on items in other areas of mathematics in the lower grades of elementary school. In this paper, we discuss achievements in geometry-related tasks of students who qualified throughselection for the district level of mathematics competitions. Specifically, the focus of the research is on analyzing the achievements of fourth grade students from elementary schools in Serbia, when solving geometry tasks in district level competitions in mathematics, during the period 2015 to 2024. The research is based on analysis of the content of geometry items and analysis of the performance of 18.491 students who participated in competitions over a period of ten years. We tried to identify the geometry topics in which students perform best and to explore whether students' achievements in geometry competitions differ based on gender and the developmental level of the region they come from. The obtained results show that students achieve the best results in tasks requiring clear procedural application, but that they are less successful when they need to demonstrate conceptual knowledge.

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** E-mail: vlnenad@gmail.com

Furthermore, there are no statistically significant differences in achievements between boys and girls, while students from more developed regions achieve the highest results.

Key words:
math competitions, fourth grade of primary school, gender, municipality development level, geometric problems.

INTRODUCTION

Mathematics competitions for primary school students in the Republic of Serbia have been organized since the 1960s. Initially, only lower-levels competitions were held, with the first national competition organized in 1967 (Mićić et al., 2008). These competitions are the most popular among primary school students, with an estimated annual participation of between sixty and seventy thousand students (Vulović et al., 2023). The Ministry of Education entrusted the organization, preparation, and execution of mathematics competitions to the Mathematical Society of Serbia, making these competitions highly relevant, widely recognized by all stakeholders, and an integral part of the educational process and mathematics teaching in Serbia.

The initial levels of mathematics competitions are the school and municipal levels. They cannot be considered as representative of the population of students identified as the best in mathematics within their respective communities during the observed period. This is due to the lack of organized school-level competitions and the potential influence of teachers' subjective attitudes toward students and their mathematical inclinations (Leedy et al., 2003). Consequently, it is only at the district-level competition that the issue of student selection is resolved, and the results at this level more accurately reflect the mathematical knowledge of top-performing students.

Considering that at each level of competition, students participate who "not only demonstrate specific aptitudes and interests in engaging with mathematics but also achieve outstanding success in mathematics education, both in terms of knowledge and skills and in their ability to apply that knowledge to solve concrete problems, mathematics competitions can also be viewed as indicators of the effectiveness of mathematics teaching" (Špijunović & Maričić, 2013: 133–134). This form of knowledge assessment is significant because it evaluates student achievements across the entire student population based on uniform criteria, under approximately identical conditions, and with identical content.

The results obtained are valuable as they offer insights into critical areas in teaching mathematics to younger primary school students across the entire population, serving as a key indicator for implementing measures to improve the educational system. Numerous research studies emphasize the importance of competitions within the educational system as indicators for assessing the success of mathematics education, particularly for identifying and evaluating students with mathematical talent (Bicknell & Riley, 2012; de Losada & Taylor, 2022; Geretschläger, 2017; Kontorovich & Koichu, 2016; Leder, 2011; Riley & Karnes, 2007; Taylor, 2017; Udvari & Schneider, 2000). Today, competitions play "a crucial role in the educational process and represent an integral part of the educational system" (Kenderov, 2022: 989).

The aim of this study is to examine the achievements of fourth-grade students in district-level mathematics competitions with geometry-related content. The focus is on fourth-grade students because they represent the final grade of the first cycle of compulsory education, while geometry was chosen due to numerous national and international studies showing that students tend to perform weaker in this area compared to other domains of mathematics (Gal & Linchevski, 2010; Kuzniak & Rauscher, 2011; Sulistiowati et al., 2019; Milinković et al., 2017; Đokić & Popović, 2023). In particular, the poorest results are observed in tasks related to geometric measurement (Antić & Đokić, 2019; Đokić & Spasić, 2023; Zeljić & Ivančević, 2019; Đokić, 2013; Jelić & Đokić, 2017; Martin & Strutchens, 2000; Bragg & Outhred, 2001; Kamii & Kysh, 2006; Curry et al., 2006; Tan Sisman & Aksu, 2015).

These findings suggest that the teaching of geometry is often less effective compared to the teaching of other mathematical domains (Đokić & Zeljić, 2017). Furthermore, research indicates that students tend to perform worse on geometry-related tasks in mathematics competitions compared to tasks from other areas of mathematics (Facciaroni et al., 2023; Špijunović & Maričić, 2013).

An important starting point for this research was the results achieved by ten-year-old students from Serbia in the international TIMSS studies (2011, 2015, 2019). These results consistently indicated poorer performance on geometry-related tasks across multiple cycles (Figure 1).

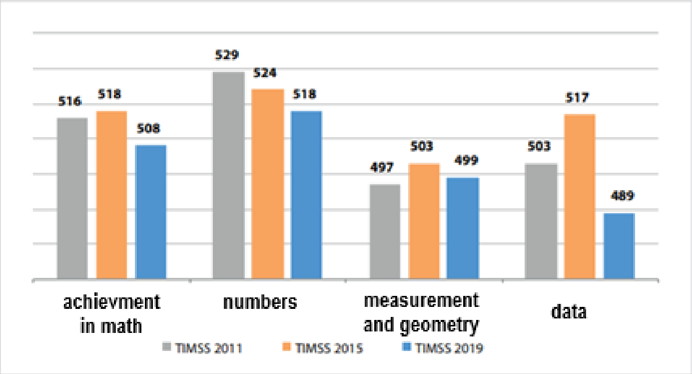

Figure 1. Achievements of ten-year-old students in Serbia in the domain of mathematical literacy in the TIMSS 2011, 2015, and 2019 studies (Đerić et al., 2020: 51).

The results achieved in the TIMSS assessments in the domain of Measurement and Geometry in the 2011 and 2015 cycles were "the weakest compared to the overall mathematics averages achieved in Serbia" (Milinković et al., 2017: 44). In the 2019 assessment, Serbian students scored slightly lower in the domain of Measurement and Geometry compared to the 2015 cycle, although this difference was not statistically significant (Đerić et al., 2020: 51). It is also noteworthy that Serbian students performed better than the international average overall, but in the domains of Measurement and Geometry and Data, their results were below the international average (Đerić et al., 2020).

Finally, results from the PISA assessments (OECD, 2019; OECD, 2023), where fifteen year old students participate, indicate that the trend of weaker performance on geometry-related problems continues, suggesting that the educational system may not have implemented adequate measures to address this issue in the interim.

In order to gain a more comprehensive understanding of the achievements of fourth-grade students in geometry content at district-level mathematics competitions, we investigated whether the economic development of the students' environment and their gender influence their performance. Numerous studies have indicated a connection between the economic development of an environment and students' achievements in mathematics (Broer et al., 2019; Mert Kalender, 2010; Özel et al., 2013; Li et al., 2021). These disparities are evident even at the preschool education level (Duncan & Magnuson, 2005; Nores & Barnett, 2014) and tend to widen as students progress in their education (Johnson et al., 2022). Unequal educational opportunities for students in environments with varying levels of development contribute to these achievement gaps (Kang & Cogan, 2022). Factors such as increased educational support from parents, more qualified teaching staff, and the opportunity for additional work with students from more developed areas playing a role. Furthermore, the study conducted by Kang and Cogan suggests that students from more developed environments perform better in TIMSS and PISA assessments and show greater progress in applied knowledge, even when they have the same level of understanding of basic mathematical concepts as students from less developed environments. Global research also indicates that economic development influences the development of early geometric skills in children (Uyanik Aktulun & Keser, 2021) and is cited as a contributing factor to weaker performance in this domain later on (Adah, 2021).

The influence of gender on student achievement in mathematics has been widely discussed in the literature, but the impact of gender on students' performance in mathematics competitions has received much less attention (Steegh et al., 2019). Regarding gender differences in overall mathematical achievement, the results of the TIMSS 2019 study indicate that these differences are not visible in Serbia (Jošić et al., 2020). However, gender differences among high-achieving students in mathematics are evident both in Serbia and globally, and tend to favor boys, particularly at the upper end of the performance distribution (Vulović et al., 2023; Bahar, 2021; Wai, et al., 2018). Therefore, it is of interest to include this variable in our research to determine whether achievements in the domain of geometry at the competitive level align with students' overall mathematical performance in competitions.

RESEARCH METHODOLOGY

The aim of this research is to analyze the achievements of fourth-grade students in geometry content at district-level mathematics competitions. The focus is on the following research questions (tasks):

- In which geometry content areas do students achieve the best results?
- Do students' achievements in geometry at competitions differ based on gender and the level of development of their environment?

The population of students whose achievements are examined consists of all students who participated in district-level mathematics competitions from 2015 to 2024, totaling 18.491 fourth-grade students. The structure of the student population is presented in Table 1.

Table 1. Structure of participants on district-level competitions for fourth-grade elementary school students by year of participation and gender

Year	Number	Girls		Boys	
		Number	%	Number	%
2015.	2404	1102	45.84	1302	54,16
2016.	2494	1175	47,11	1319	52,89
2017.	1839	849	46,17	990	53,83
2018.	2246	991	44,12	1255	55,88
2019.	1843	790	42,86	1053	57,14
2020.	1993	856	42,95	1137	57,05
2021.	1225	483	39,43	742	60,57
2022.	1348	577	42,80	771	57,20
2023.	1668	662	39,69	1006	60,31
2024.	1431	569	39,76	862	60,24

The results of Mann-Kendall test lead us to conclusion that, over the past ten years, there has been a positive trend in the higher participation of boys compared to girls in the district-level competition for fourth-grade students (s = 31, n = 10, Z = 2.683). This finding is not surprising, considering the fact that similar trends are observed in competitions in other countries, such as the United States (Bahar, 2021).

The district-level mathematics competition is organized across 26 administrative districts in the Republic of Serbia, and the number of participants in each district is provided in Table 2.

Table 2. Number of fourth-grade primary school students on district-level mathematics competitions by district

district	year									
	2015.	2016.	2017.	2018.	2019.	2020.	2021.	2022.	2023.	2024.
Borski	62	93	62	71	43	35	18	13	20	13
Braničevski	56	71	26	78	21	73	30	42	52	24
City of Belgrade	393	352	260	275	310	254	129	226	211	184
Jablanički	106	101	101	105	59	61	53	55	57	54
Južnobački	161	157	139	155	160	164	78	80	88	104
Južnobanatski	108	90	51	67	70	109	50	38	61	31
Kolubarski	88	79	67	79	56	49	44	42	48	43
Kosovsko-metohijski	2	13	22	25	4	27	20	26	33	35
Mačvanski	140	133	98	87	97	99	92	98	117	77
Moravički	105	105	88	91	77	92	49	48	83	87
Nišavski	146	147	119	148	73	139	118	101	118	116
Pčinjski	47	48	50	56	51	46	36	50	60	33
Pirotski	89	76	69	85	44	83	72	50	52	62
Podunavski	63	81	37	95	54	50	23	32	30	39
Pomoravski	97	69	72	49	66	41	55	39	56	40
Rasinski	84	121	83	102	123	118	83	80	88	108
Raški	103	142	0	109	67	89	42	41	92	61

Severnobački	82	50	51	47	37	44	28	37	39	34
Severnobanatski	20	33	23	24	25	29	14	22	16	13
Srednjobanatski	53	85	49	44	38	43	18	19	64	23
Sremski	60	75	82	86	63	54	32	28	24	17
Šumadijski	123	147	100	101	138	126	47	74	138	109
Toplički	30	24	39	34	18	39	16	15	11	18
Zaječarski	54	59	56	68	55	50	40	30	42	38
Zapadnobački	41	65	36	65	44	40	16	22	21	24
Zlatiborski	91	78	59	100	50	39	22	40	47	44

In order to compare student results, regions, districts, and municipalities where the students' schools are located were considered. According to the Regulation from 2014 (Government of the Republic of Serbia, 2014), regions and municipalities in the Republic of Serbia were categorized based on the value of the gross domestic product (GDP) per capita in each region and municipality. Regions with a GDP above the national average are classified as developed, while others are classified as underdeveloped regions. According to this classification, the developed regions are the Belgrade region and the Vojvodina region, while all other regions fall into the underdeveloped category. The distribution of competition participants in relation to regional development is presented in Table 3.

Table 3. Number of fourth-grade elementary school students on district-level competitions based on regional development

regions	year									
	2015.	**2016.**	**2017.**	**2018.**	**2019.**	**2020.**	**2021.**	**2022.**	**2023.**	**2024.**
developed	918	907	691	763	747	737	365	472	524	430
under-developed	1486	1587	1148	1483	1096	1256	860	876	1144	1001

Based on the mentioned Regulation, all municipalities in the Republic of Serbia are divided into five groups, according to their level of development relative to the national average. The criteria for dividing municipalities and the number of participants in relation to the development level of municipalities are provided in Tables 4 and 5.

Table 4. Criteria for classifying local community units

group	I	II	III	IV	V
GDP relative to the national average	> 100%	80%-100%	60%-80%	50%-60%	< 50%
number of municipalities	20	34	47	25	19

Table 5. Number of fourth-grade elementary school students on district-level competitions based on the development level of municipalities

year	group				
	I	II	III	IV	V
2015.	2730	1282	1193	388	225
2016.	2997	1484	1253	433	317
2017.	2567	1205	1024	325	320
2018.	2631	1389	1096	352	349
2019.	2612	1278	1051	335	245
2020.	2740	1296	1004	407	334
2021.	2002	996	734	253	210
2022.	2326	1081	762	256	287
2023.	2311	1114	902	249	274
2024.	2644	1544	1081	309	325

The study and analyzed data and results are of fourth-grade elementary school students who participated in district-level mathematics competitions between 2015 and 2024. The data collected by the author included: the students' gender, the name and location of their schools, the results achieved on each task, and the total scores. For each student, parents/guardians signed consent forms permitting the use of student data and results for statistical data processing.

This research involved a secondary analysis of the achievements of fourth-grade students in district-level competitions. Students solved five tasks during the competition, among which were the types of tasks covered by this analysis, designed by the State Commission for the Mathematics Competition for Elementary School Students. Each task was scored with a maximum of 20 points, according to a standardized scoring key, where each step of the solution was assigned a specific point value.

The collected data were analyzed using the SPSS 24 statistical software package and Microsoft Excel. Statistical measures and procedures included: percentages, frequencies, arithmetic means, statistical tests for assessing the normality of numerical data distributions, the Mann-Whitney test, the Kruskal-Wallis test, the Dunn post-hoc test, and the Mann-Kendall test for detecting trends over a specific time interval. The Mann-Kendall test is non-parametric and does not require assumptions about a specific data distribution function. Calculations related to the Mann-Kendall test, trend determination, and significance testing were performed in Microsoft Excel using functions independently developed by the authors based on the relevant formulas.

RESULTS AND DISCUSSION

Due to differences among the generations of students participating in the competitions and variations in the difficulty levels of the tasks, the results achieved by students across different years are not entirely comparable. However, a content analysis of the geometry tasks can help identify the areas where students achieved the best results.

An analysis of the competition task content reveals that, in each competition from 2015 to 2024, one out of the five tasks was from the domain of geometry, specifically geometry of measurement. All these tasks required determining the area of a square, rectangle, or cube. Over the ten-year period, tasks predominantly appeared in a purely mathematical context, with only four years featuring tasks set in a real-world context that required solving problems based on contextual scenarios (Table 6). In the last five years, all geometry tasks have been presented exclusively in a purely mathematical context.

Table 6. Average score per student on measurement geometry tasks

year	2015.	2016.	2017.	2018.	2019.	2020.	2021.	2022.	2023.	2024.
task context*	P	P	P	M	P	M	M	M	M	M
average points	10,61	9,40	2,65	3,23	5,56	6,70	8,42	12,50	16,26	13,09

*P – real-life context M – mathematical context

An analysis of the data presented in Table 6 reveals that the weakest performance in geometry was recorded by students participating in district-level competitions between 2017 and 2020. Notably, the context in which the mathematical problem was posed does not appear to significantly affect students' success.

Since each task was graded according to a unique key that allocated points for each step of the solution, it was possible to determine how far each student progressed in solving the task, based on the number of points achieved, a content analysis was possible to conduct.

A task content analysis where students demonstrated the weakest performance shows that they struggled the most with problems requiring an understanding of perimeter concepts and the calculation of side lengths for rectangles or squares formed by combining two or more such. In the 2017 competition, more than three-quarters of fourth-grade students (78.85%) earned no points on such tasks, while only 9.46% successfully solved them. The following cohort of fourth-grade students faced a similar task related to perimeter and achieved comparable results, with 79.39% earning no points and only 13.27% solving the task correctly. The reasons for these outcomes may lie in how the concept of perimeter is introduced and developed during mathematics instruction. "A robust understanding of the concept of perimeter includes reasoning based on the relationships between the sides of a given shape, as students who do not sufficiently understand the concept often struggle to deduce the relationships between the sides of a shape" (Milikić, Maričić, & Vulović, 2022: 132). This observation is supported by other studies, which conclude that students often learn procedures and patterns without fully grasping the meaning of the perimeter concept (Vighi & Marchini, 2011; Moyer, 2001; Outhred & Mitchelmore, 2000; Tan Sisman & Aksu, 2015; Zacharos, 2006).

In addition to difficulties with understanding the concept of perimeter, students performed poorly in a geometry task in the 2019 district-level competition (M = 5.56) that required understanding the concept of area, specifically the idea of tiling. The tiling concept, i.e. dividing a surface into unit measures of area, is a fundamental idea that underpins understanding *the concept of area* (Battista, 2007). Without grasping this concept, students tend to perceive area as merely a procedure involving the multiplication of dimensions. Numerous authors have highlighted low achievement levels on tasks involving area measurement (Jelić & Đokić, 2017; Lin & Tsai, 2003; Outhred & Mitchelmore, 2000; Tan Sisman & Aksu, 2015; Zeljić & Ivančević, 2019). The reasons for these low achievements can be traced to the dominance of algorithmic approaches when introducing the concept of *area*, characterized by an emphasis on procedural skills and formula application (Zeljić & Ivančević, 2019: 64). Similarly, in the TIMSS 2015 study, Serbian students performed below the international average by solving items requiring the calculation of the area of rectangles and squares, achieving the weakest results in the subdomain of two-dimensional and three-dimensional shapes, with only 40.9% of tasks solved correctly (Milinković et al., 2017: 39).

The best results in geometry tasks were achieved by fourth-grade students starting in 2022 (M=12.50), when 55.20% of students successfully solved a task that required determining the side lengths of a rectangle from a composite figure and calculating its area. A similar task was presented in 2023, and students performed even better (M=16.26), with 70.44% solving it correctly. Both tasks were presented with a figure, suggesting that visual representation contributes to better task performance. In 2024, students also achieved satisfactory results on a geometry task (M=13.09), with 55.49% solving it successfully. This task required the execution of procedural steps to reach the solution. The improved student performance in geometry tasks in recent years indicates a trend favoring procedural knowledge over conceptual understanding in competition settings.

The improved results in recent years can be attributed to the updated teaching curriculum, which introduces the concepts of perimeter and area earlier than the previous curriculum. In the second grade, the concept of perimeter is introduced without formulas, focusing on conceptual understanding, while the formula for calculating perimeteris introduced in the third grade. Similarly, the concept of area is introduced in the third grade through the tiling method and an understanding of surface area, with formulas being introduced in the fourth grade. This approach promotes a deeper understanding of perimeter and area concepts rather than mere procedural or formulaic application.

Another objective of this study was to examine whether differences in geometry task performance exist between boys and girls. Student achievements by gender are presented in Table 7.

Table 7. Average scores in geometry achieved by fourth-grade students in the district-level mathematics competition by gender on measurement geometry tasks

year	average (M)	girls	boys	Mann-Whitney test
2015.	10,61	10,37	10,80	no statistically significant difference
2016.	9,40	9,09	9,67	no statistically significant difference
2017.	2,65	2,36	2,90	U = 396504.5, Z = -2.933, p = .003
2018.	3,23	2,83	3,55	U = 600186,5, Z = -2.013, p = .044
2019.	5,56	5,91	7,56	U = 372257,5, Z = -4,095, p < .001
2020.	6,70	6,78	7,49	U = 427520,0, Z = -5,142, p < .001
2021.	**8,42**	**8,55**	8,33	no statistically significant difference
2022.	**12,50**	**12,63**	12,40	no statistically significant difference
2023.	**16,26**	**16,64**	16,01	no statistically significant difference
2024.	13,09	12,93	13,20	no statistically significant difference

The obtained results indicate that between 2015 and 2020, as well as in 2024, boys achieved higher average scores than girls, while from 2017 to 2020, the differences in achievements were statistically significant. This period of statistically significant differences coincides with the years in which students achieved the lowest results in geometry tasks. Although these differences have not been statistically significant in the past four years, it is notable that, for the first time, girls achieved higher average scores than boys from 2021 to 2023. The end of the period of statistically significant differences and the higher scores of girls coincide with the onset of the pandemic in our country, which could be one of the reasons. However, another possible reason is that this period aligns with the time when students who had been taught under the new curriculum since first grade began participating in competitions. Therefore, some future research might provide further insights into the reasons behind the disappearance of these differences. The obtained results can be compared with a study conducted by (Vulović et al., 2023) which examined whether there were statistically significant differences in achievements between boys and girls in district-level mathematics competitions. Their findings indicate that students' achievements in geometry tasks did not directly correspond to their overall performance in district-level competitions. Comparing the current results with those reported by (Vulović et al., 2023) reveals that, although boys achieved better overall results than girls every year (e.g., in 2024, the average total score of boys was 59.32 compared to 52.71 for girls, with a statistically significant difference in total achievements (U=208374.0, Z= -4.822, p=.000\)), girls performed better on geometry tasks between 2021 and 2023. Furthermore, in years when there was a statistically significant difference in overall student performance by gender (2016, 2021, and 2024), this difference was not statistically significant for geometry tasks. An analysis of the top-performing students cannot be limited to the top 5%, as significantly more than 5% of students achieved the maximum score of 20 points on geometry tasks during the observed period. If we restrict our analysis to students with the maximum score, we find that boys outnumbered girls in 9 out of 10 years. However, no consistent trend was observed in the proportion of boys achieving the maximum score. The only year in which girls outnumbered boys was 2021 (52.50% girls), followed by a decline in their numbers (43.46%, 41.02%, and 39.29% from 2022 to 2024).

Overall results suggest that geometry content does not play a decisive role in distinguishing the top-performing students in mathematics.

However, an analysis of students' achievements on geometry measurement tasks in relation to the economic development of their regions reveals that students from developed regions scored, on average, 20.17% higher than those from underdeveloped regions (Table 8). Data show that in 7 out of 10 observed years, there was a statistically significant difference in student performance based on the level of regional development. Interestingly, the smallest difference in performance was observed in 2021, the year when all students in the Republic of Serbia experienced online or hybrid learning.

Table 8. Average score of fourth-grade students on measurement geometry tasks by regional development level

year	regions		Mann-Whitney test
	developed	underdeveloped	
2015.	10,89	10,43	no statistically significant difference
2016.	10,12	8,99	U = 666733.5, Z = -3.219, p = .001
2017.	2,84	2,54	no statistically significant difference
2018.	4,07	2,80	U = 531088.5, Z=-3.378, p = .001
2019.	6,60	4,85	U = 354015.5, Z =-5.214, p < .001
2020.	7,75	6,08	U = 420274, Z =-3.796, p < .001

2021.	8,47	8,40	no statistically significant difference
2022.	13,90	11,74	U =172173, Z =-3.989, p < .001
2023.	18,05	15,44	U = 250811, Z =-6.650, p < .001
2024.	15,45	12,08	U = 171924, Z = -6.687, p < .001

To compare the performance of students by districts on measurement geometry tasks over a ten-year period, we created an annual ranking of districts based on student achievements within each competition year. Each district was assigned index points ranging from 1 to 26, with the district having the lowest average student score receiving 1 index point, and the district with the highest average score receiving 26 index points. By summing the index points assigned in this manner, we obtained the results presented in Table 9.

Table 9. District rankings based on student performance on measurement geometry tasks

district	the total number of index points
City Belgrade	245
Zlatiborski	228
Nišavski	198
Južnobački	191
Pirotski	167
Pomoravski	161
Sremski	158
Moravički	151
Severnobački	149
Podunavski	143
Mačvanski	138
Braničevski	136
Južnobanatski	135
Severnobanatksi	134
Raški	133
Pčinjski	127
Šumadijski	123
Srednjobanatski	118
Rasinski	112
Zapadnobački	111

Kolubarski	111
Jablaninčki	99
Borski	87
Zaječarski	75
Toplički	50
Kosovsko-metohijski	29

Based on the obtained data, it can be concluded that the highest performance on geometry measurement tasks in the competition is achieved by students from districts encompassing major cities in Serbia, with scores exeeding 190 index points. In contrast, the lowest results are observed among students from districts in Eastern and Southern Serbia, with less than 100 index points.

The greatest disparity in student achievement arises when considering the level of development of the municipalities where the schools they attend are located. The results indicate that during the observed period, a statistically significant difference in performance on *geometry measurement* tasks was recorded each year (Table 10).

Table 10. Average number of points on geometry measurement tasks by municipal development level

year	aver-age	Average by municipalty development level					Kruskal-Wallis test
		I	II	III	IV	V	
2015	10,61	11,41	10,64	9,71	8,98	9,66	H(4) = 23.024, p < .001
2016	9,40	10,66	9,41	8,29	6,74	7,67	H(4) = 50.655, p < .001
2017	2,65	3,57	2,41	1,68	1,86	1,09	H(4) = 24.735, p < .001
2018	3,23	4,52	2,76	1,85	2,52	2,04	H(4) = 52.170, p < .001
2019	5,56	6,82	5,17	4,06	3,52	4,00	H(4) = 54.410, p < .001
2020	6,70	7,61	6,12	6,39	5,85	4,65	H(4) = 17.812, p = .001
2021	8,42	9,18	8,45	7,89	7,95	5,81	H(4) = 47.504, p < .001
2022	12,50	14,06	12,59	11,37	9,22	7,78	H(4) = 54.619, p < .001
2023	16,26	17,55	16,51	15,23	15,06	11,34	H(4) = 70.474, p < .001
2024	13,09	14,55	12,73	12,31	10,49	8,96	H(4) = 46,271, p < .001

The results of the Dunn's post-hoc test shows that the differences are particularly pronounced between students from Group I municipalities compared to the others. In contrast, the differences among students from municipalities in Groups III, IV, and V are minimal. Over the ten-year period, the trend in student performance, in relation to the level of development of the municipalities they come from, shows a stable pattern. Table 11 illustrates the average percentage difference in student achievement based on municipality development level compared to the national average.

Table 11. Difference fourth grade student achievement by municipality group, relative to the national average on geometry measurement tasks

I	II	III	IV	V
+17,24%	–3,90%	–15,89%	–20,39%	–31,23%

The results show that students from more developed areas achieve higher scores. This outcome may be a consequence of the fact that in more developed areas, there is a more rigorous selection process for those who will participate in the district-level competition. This is not the case in areas where fewer students participate at each previous level of competition.

CONCLUSION

This paper presents a comprehensive quantitative and qualitative analysis of the performance and achievements of fourth-grade students in primary schools in Serbia when solving geometric problems at district-level mathematics competitions. The study covers the period from 2015 to 2024, with a total sample of 18,491 students, making the sample both representative and relevant for drawing conclusions.

The content analysis of the tasks revealed that all geometry problems at the district-level mathematics competition for fourth-grade students belongs to the area of measurement geometry. Among these tasks, those framed within a mathematical context predominate. The task analysis showed that students were most successful in solving tasks that required the application of clear procedures during the problem-solving process, but less successful when required to identify relationships between elements, demonstrate conceptual knowledge, and show a deeper understanding rather than merely applying a formula. These results may also be a consequence of the fact that, as pointed out by researchers, tasks in the area of measurement in mathematics textbooks are highly procedural, with "little attention paid to the conceptual understanding of measurement, which can limit measurement procedures" (Đokić & Spasić, 2023: 97). Similar views are expressed by Milinković and Ševa when analyzing the typology of student errors in geometry content on TIMSS, stating: "The basis of success in solving geometry problems is not the knowledge of formulas but conceptual understanding, considering the conditions arising from the real-world context of the task, and the ability to provide reasoning. Generally speaking, students in our country lack the flexibility that comes with experience in solving differently formulated tasks with diverse examples of geometric shapes, often requiring changing solution strategies" (Milinković & Ševa, 2021: 188).

The results indicated that statistically significant differences between boys and girls exist in some years, favoring boys, and these differences were only present in the years when both groups achieved the lowest results. However, the data cannot be a reliable basis for drawing conclusions about the relative success of boys or girls, as the differences were not consistent.

The analysis reveals that there are differences in students' achievements based on the economic development of the regions where their schools are located. Students from more developed regions and the most developed local government units achieved the best results in the competitions, while students from less developed environments showed minimal differences in achievement.

The data obtained in this study provide a clearer picture of students' performance in geometry. Furthermore, they highly correlate with the results of other research studies and TIMSS testing, which point to the same difficulties encountered by students when solving geometry problems. These findings are particularly significant given that they represent the performance of students in Serbia who achieve the best results in mathematics. The results should serve as a starting point for more comprehensive research into the learning of geometry content in the lower grades of primary school, as well as an analysis of student achievements within regular mathematics instruction, which should result in clearer implications for teachers' practices. It is evident that, based on our findings, the reform of the mathematics curriculum for lower primary grades, has had a positive impact on improving student performance, and we expect this trend to continue and expand across all areas.

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