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## АНАЛІЗ РЕЗУЛЬТАТІВ МАТЕМАТИЧНОЇ КОМПЕТЕНТНОСТІ УЧНІВ ЗАКАРПАТСЬКИХ ШІКІЛ

Оцінювання академічних досягнень учнів у зв'язку з різними соціально-демографічними чинниками є одним із ключових напрямів сучасних освітніх досліджень. Серед численних шкільних предметів особливе місце займає математична компетентність, яка не лише відображає рівень засвоєння навчального матеріалу, але й вважається важливим показником когнітивного розвитку учнів, їхньої здатності до логічного мислення, аналітичного підходу та готовності до життя у високотехнологічному суспільстві. Саме тому результати з математики часто використовуються для оцінки якості освіти на національному та міжнародному рівнях.

Міжнародні порівняльні дослідження, зокрема Програма міжнародного оцінювання учнів (PISA), не обмежуються аналізом лише предметних знань учнів. Вони акцентують увагу на більш широкому контексті навчання, включаючи справедливість в освіті, доступність ресурсів, соціально-економічні умови та культурне середовище. Зокрема, результати цих досліджень свідчать про значний вплив таких чинників, як рівень освіти батьків, стать учнів, а також економічне становище родини на академічні досягнення.

Разом з тим, хоча міжнародні дослідження надають важливу порівняльну інформацію, вони не завжди відображають регіональні особливості освітнього середовища. Саме тому важливим є проведення локальних або регіональних оцінювань, які дозволяють краще зрозуміти специфіку навчального процесу в окремих регіонах, виявити проблемні зони та сприяти прийняттю ефективних рішень у сфері освітньої політики.

У даному дослідженні представлено результати регіонального оцінювання математичної компетентності, проведеного у 2024 році серед учнів 6-х і 8-х класів закладів загальної середньої освіти Закарпаття, у яких навчання здійснюється угорською мовою. Основною метою дослідження є оцінка впливу статі, рівня освіти батьків, та багатомовності на успішність учнів з математики.

Ключові слова: математична статистика, інформаційні технології, компетентності учнів, багатомовність.

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## ANALYSIS OF MATHEMATICAL COMPETENCE AMONG STUDENTS OF TRANSCARPATHIAN SCHOOLS

The assessment of students' academic performance in relation to various socio-demographic factors remains a central focus in contemporary educational research. Mathematical competence occupies a particularly significant role among school subjects, as it reflects students' mastery of curricular content and foundational knowledge. It also serves as a key indicator of cognitive development, logical reasoning skills, analytical thinking, and preparedness for participation in a knowledge-based, technologically advanced society. Consequently, mathematics performance is frequently used as a benchmark for evaluating educational quality at both national and international levels.

International large-scale assessments, such as the Programme for International Student Assessment (PISA), extend beyond subject-specific evaluations by highlighting the broader educational context, including issues of equity, access to resources, socio-economic conditions, and cultural background. Findings from such studies consistently demonstrate that variables such as parental education level, student gender, and family socio-economic status have a substantial impact on academic outcomes.

At the same time, while international studies provide valuable comparative insights, they do not always capture the regional specificities of educational systems. Therefore, local or regional assessments are essential for better understanding the particular challenges and opportunities within local education systems. Such assessments help identify problem areas and support the development of effective education policies.

This study presents the findings of a regional mathematics competence assessment conducted in 2024 among 6th and 8th grade students in schools in Transcarpathia, where the teaching is conducted in Hungarian. The main objective of the research is to evaluate the impact of gender, parental education level, and multilingualism on students' mathematical performance.

Keywords: Mathematical statistics, information technologies, students' competencies, multilingualism.

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### General statement of the problem and its connection with important scientific or practical tasks

The relationship between education and economic development has been the focus of extensive research. Initial studies typically relied on indicators such as enrollment rates and the average years of schooling as proxies for educational attainment. However, more recent empirical evidence indicates that the quality of education is a far more

critical determinant of long-term economic growth than educational quantity alone [1]. This has revealed substantial limitations in earlier analyses, which often failed to capture variations in educational outcomes across systems. Notably, research by Gabriel Heller-Sahlgren and Henrik Jordahl reinforces the finding that the share of high-performing students exhibits a significantly stronger correlation with economic growth than the proportion of students attaining only basic proficiency levels [2].

The quality of education is commonly evaluated through student competency assessments. One of the most important of these is the Programme for International Student Assessment (PISA), conducted by the Organisation for Economic Co-operation and Development (OECD). PISA measures students' skills in three key areas: mathematics, reading, and science. Student performance is reported on a six-level scale, defined as follows [3]:

Table 1

PISA levels			
Level 1	Level 2	Level 3-4	Level 5-6
Students with low understanding	Basic level of ability	Students with moderate ability	Students with high ability

The initial PISA assessment was administered in 2000, primarily across OECD member states and four partner countries. In 2002, the programme expanded to include an additional eleven countries. Since then PISA is repeated in three-year cycles. Ukraine participated in PISA for the first time in 2018, with subsequent assessments conducted in 2022 and 2025.

The Ferenc Rákóczi II Transcarpathian Hungarian College of Higher Education also initiated a similar competency assessment aimed at evaluating the mathematical (logical), reading, foreign language (English), and Ukrainian language competencies of students attending Hungarian-language schools in Transcarpathia. The first assessment was conducted in 2023, involving 26 schools and a total of 760 students. The second assessment was conducted in 2024, with the participation of 39 schools and 1057 students.

#### Analysis of research and publications

In recent years, gender differences have been observed in PISA competency assessments. For example, in the 2022 PISA assessment, boys outperformed girls in mathematics by an average of 9 points across OECD countries [4]. On the other hand, girls performed better in reading, surpassing boys by an average of 24 points in OECD countries [4]. Similar trends can be found in the PISA report for Ukraine, where boys scored on average 10 points higher than girls in mathematics, while girls outperformed boys in reading by an average of 23 points [5]. The PISA results from Hungary reveal comparable patterns: boys scored on average 15 points higher than girls in mathematics, whereas girls outperformed boys by 17 points in reading [6]. In the present study, we also investigated whether similar gender differences in mathematics performance can be observed among students in Transcarpathia, based on the findings of previous publications.

Numerous studies have addressed the relationship between parental education attainment and students' academic performance. The research conducted by Idris M. et al., indicates a strong correlation between the level of parental education and children's academic outcomes [7]. Similarly, the study by Maulidah et al. concludes that parental education has a significant impact on students' school performance [8]. Therefore, besides examining gender differences, this study also focuses on how parental education affects the academic performance of students in Transcarpathia.

#### Formulation of the article's objectives

**The aim of our study** is to analyze the mathematical (logical) competence of students in Transcarpathian schools (6th and 8th grades). An additional objective is to examine how various factors — particularly environmental, and social conditions — affect students' academic performance.

In our study, we aimed to answer the following research questions:

1. Is there a significant difference in mathematical competence scores based on gender?
2. Is there a significant difference in mathematical competence scores based on parental education level?
3. Is there a significant difference in mathematical competence scores between students from urban and rural areas?
4. Is there a significant difference in mathematical competence scores based on students' multilingualism?

The hypothesis of this study is as follows.

1. The null hypothesis ( $H_0$ ) and the alternative hypothesis ( $H_1$ ) of the research question number one are as follows.

$H_0$ : There is no significant difference in students' mathematical competence scores between male and female students.

$H_1$ : There is a significant difference in students' mathematical competence scores between male and female students.

2. The null hypothesis ( $H_0$ ) and the alternative hypothesis ( $H_1$ ) of the research question number two are as follows.

$H_0$ : There is no significant difference in students' mathematical competence scores based on their parents' educational attainment.

H<sub>1</sub>: There is a significant difference in students' mathematical competence scores based on their parents' educational attainment.

3. The null hypothesis (H<sub>0</sub>) and the alternative hypothesis (H<sub>1</sub>) of the research question number four are as follows.

H<sub>0</sub>: There is no significant difference in students' mathematical competence scores based on the number of languages they speak.

H<sub>1</sub>: There is a significant difference in students' mathematical competence scores based on the number of languages they speak.

#### Presentation of the main material

As previously mentioned, a total of 1,057 students from the 6th and 8th grades of 39 schools participated in the competency assessment conducted in 2024. Based on the completed assessment, the minimum, average, and maximum scores in mathematics were obtained, as presented in Table 2.

Table 2

Results of the Mathematics Competency Assessment		
Minimum	Average	Maximum
1014.25	1422.86	1975.75

As a first step, we examined whether there was a statistically significant difference between students based on gender in schools in Transcarpathia that have Hungarian-language classes. To assess gender differences, we analyzed responses from 474 boys and 540 girls. The results of the statistical analysis are presented in Table 3.

Table 3

Gender Differences in the Results of the Mathematics Competency Assessment					
Gender	Mean	Median	Std. Deviation	Minimum	Maximum
Male	1426.22	1421.47	178.69	1067.63	1975.55
Female	1419.99	1409.62	179.38	1014.25	1884.14

As a next step, we examined whether the sample distributions of boys' and girls' scores could be derived from a normal distribution. To test this, we applied the Kolmogorov–Smirnov test, which indicated that the distribution of boys' scores significantly deviates from normality ( $p < 0.001$ ).

Using the Mann–Whitney U test, we compared the performance of boys and girls in the mathematical (logical) competence assessment. The results showed no statistically significant difference between the scores of boys (Mdn = 1421.47) and girls (Mdn = 1409.62),  $U = 126451$ ,  $Z = -0.329$ ,  $p = 0.742$  (2-tailed),  $r = 0.003$ . Therefore, the gender-based analysis revealed no significant differences in the mathematical (logical) test scores between boys and girls.

In the next phase of the analysis, we examined whether there was a statistically significant difference between students' mathematics performance and the educational attainment of their parents. Parental education was classified into four categories: primary education, vocational education, secondary education, and higher education. The influence of the father's and mother's educational background on student outcomes was analyzed separately.

We first focused on how the mother's educational level affected students' results in the mathematics competency assessment. For students whose mothers had completed only primary education or less, the distribution of scores did not follow normality (while the distributions in the other groups did). After performing Levene's test, we found no significant difference in the variances between the groups based on medians,  $F(3, 992) = 1.960$ ,  $p = 0.118$ . Therefore, to compare the group outcomes, we applied the Kruskal–Wallis test, which revealed a statistically significant difference:  $H(3, N = 992) = 32.48$ ,  $p < 0.001$ . For post hoc groupwise comparisons, Dunn's test was used, and the results are presented in the table below.

Table 5

Mother's Highest Level of Education and Students' Performance in Mathematics				
Group by Mother's Highest Educational Attainment with Median Values	Group by Mother's Highest Educational Attainment with Median Values	Significant Difference	Dunn Test (p-value)	Effect size, r
Lower secondary education (mdn= 1384)	Vocational education (mdn= 1404)	No	0,715	
Lower secondary education (mdn= 1384)	Secondary education (mdn= 1454)	Yes	0,003	0,16 Small effect
Lower secondary education (mdn= 1384)	Higher education (mdn= 1463)	Yes	0,000	0,24 Small effect
Vocational education (mdn= 1404)	Secondary education (mdn= 1454)	No	0,456	
Vocational education (mdn= 1404)	Higher education (mdn= 1463)	Yes	0,003	0,15 Small effect
Secondary education (mdn= 1454)	Higher education (mdn= 1463)	No	0,555	

The analysis showed that students whose mothers have a higher level of education tend to perform significantly better in mathematics.

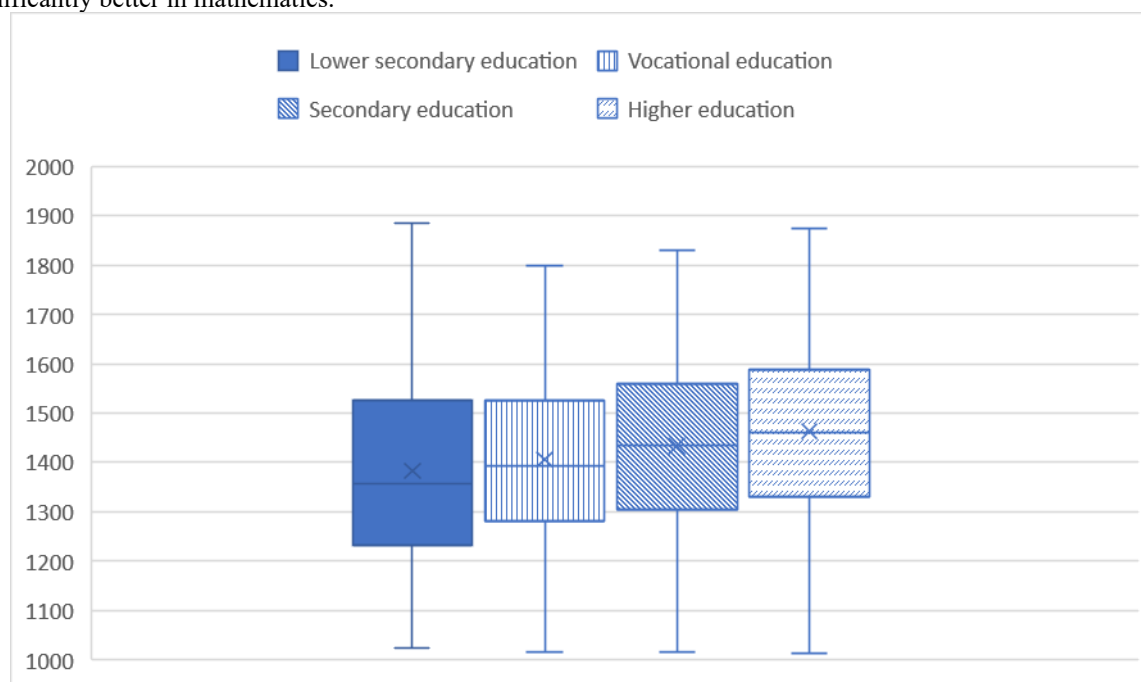


Fig. 1. Results of the Groupwise Comparison Displayed in a Boxplot by Mother's Highest Educational Attainment

Next, we examined how the father's level of education influences students' performance on the mathematics competency assessment. For students whose fathers had completed only primary education or less, the score distribution did not follow normality (while the distributions in the other groups did). After conducting Levene's test, we found no significant difference in the variances between the groups based on medians,  $F(3, 978) = 0.218, p = 0.88$ . Therefore, we used the Kruskal–Wallis test to compare the groups, which revealed a statistically significant difference:  $H(3, N = 978) = 40.998, p < 0.001$ . For post hoc groupwise comparisons, Dunn's test was applied, and the results are presented in the table below.

Table 6

Father's Highest Level of Education and Students' Performance in Mathematics

Group by Father's Highest Educational Attainment with Median Values	Group by Father's Highest Educational Attainment with Median Values	Significant Difference	Dunn Test (p-value)	Effect size, $r$
Lower secondary education (mdn= 1342)	Vocational education (mdn= 1419)	Yes	,003	0,14911 small effect
Lower secondary education (mdn= 1342)	Secondary education (mdn= 1472)	Yes	,000	0,248759 small effect
Lower secondary education (mdn= 1342)	Higher education (mdn= 1452)	Yes	,000	0,248759 small effect
Vocational education (mdn= 1419)	Secondary education (mdn= 1472)	No	,392	
Vocational education (mdn= 1419)	Higher education (mdn= 1452)	No	,136	
Higher education (mdn= 1472)	Higher education (mdn= 1452)	No	1,000	

The group-wise comparison revealed that a lower level of paternal education has a negative impact on students' mathematics performance.

Next, we analyzed the impact of multilingualism on students' performance in the mathematics competency assessment. Students were divided into three groups: those who speak only their native language only, those who speak a foreign language with minor mistakes, and those who are fluent in multiple languages. The distribution of scores across these groups is shown in Table 7.

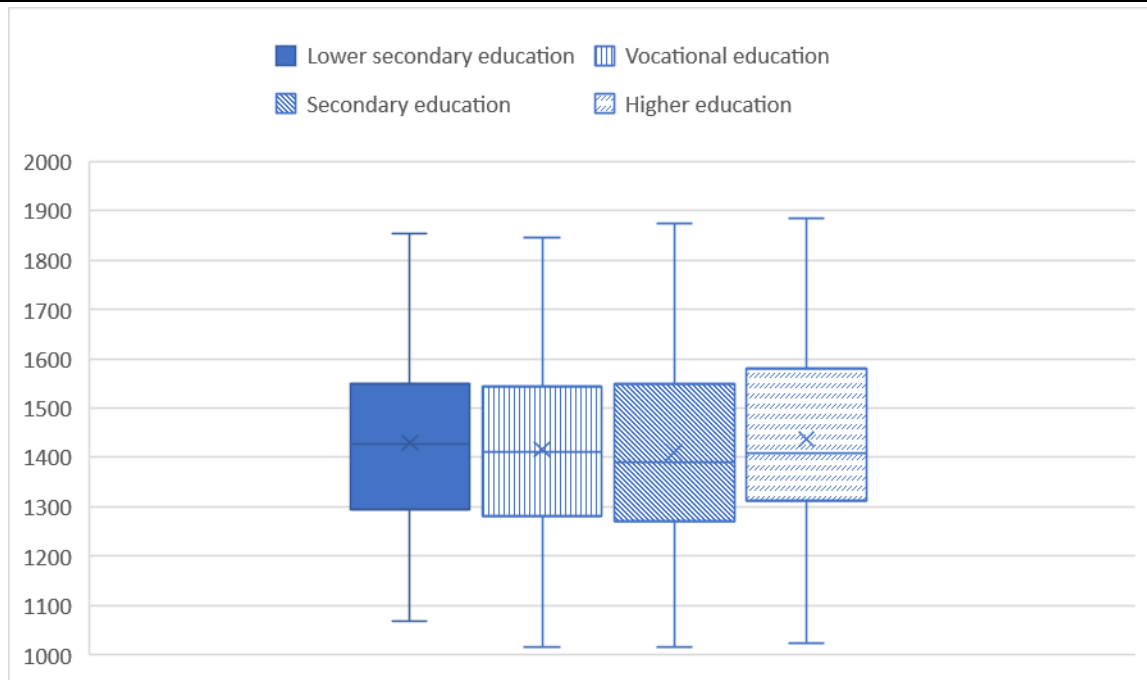


Fig. 2. Results of the Groupwise Comparison Displayed in a Boxplot by Father's Highest Educational Attainment

Table 7

Analysis of Students' Scores by Level of Multilingualism

Language skills	Mean	Median	Std. Deviation	Minimum	Maximum
Native language only	1400,74	1394,48	186,24	1014,25	1829,92
Basic foreign language skills	1451,02	1441,17	170,75	1024,43	1853,37
Fluent multilingual speakers	1472,33	1486,55	176,41	1123,18	1975,55

The next stage of our research focused on examining the impact of language proficiency on students' mathematics competency scores. The effect of language proficiency on mathematics scores was examined using a contrast test. First, we compared the group of students who speak only their native language with two other groups: those who speak a foreign language with minor errors and those who are fluent in multiple languages. In the second step, we examined whether a significant difference exists between the latter two groups. The coefficients used in the contrast test are provided in Table 8, and the results of the statistical analysis are presented in Table 9.

Table 8

Contrast Coefficients

Contrast	Native language only	Basic foreign language skills	Fluent multilingual speakers
1	-2	1	1
2	0	-1	1

Table 9

Results of the Contrast Test

	Contrast	Value of Contrast	Std. Error	t	df	p
Assume equal variances	1	121,90	27,08	4,50	824	,000
	2	21,31	15,85	1,34	824	,179
Does not assume equal variances	1	121,90	27,89	4,37	477,34	,000
	2	21,31	15,63	1,36	353,67	,174

The analysis suggests that students who speak a foreign language—either with minor errors or fluently—perform significantly better on the mathematics test than those who speak only their native language. However, no significant difference was found between the mathematics scores of students who are fluent in multiple languages and those who speak a foreign language with minor errors.

### Conclusions from this study and prospects for further exploration in this direction

This study presents a statistical analysis of the results of a mathematics competence assessment conducted in 2024 among students attending schools in Transcarpathia that have Hungarian-language classes. The research involved 1057 students from 39 schools and examined how factors such as gender, parental education, and multilingualism influence students' mathematical performance.

The analysis revealed no statistically significant difference in mathematics scores between male and female students, as indicated by the Mann–Whitney U-test ( $p = 0.742$ ). However, parental education level showed a significant effect on performance. Students whose parents had completed secondary or higher education performed significantly better in mathematics than those whose parents had only primary education, as demonstrated by Dunn tests ( $p < 0.001$ ).

Furthermore, multilingualism was also a significant factor. Students who spoke at least one additional language — either with minor errors or fluently — achieved significantly higher mathematics scores compared to students who spoke only their native language ( $p < 0.001$ ). However, no statistically significant difference was found between the two multilingual groups.

These findings highlight the importance of parental education and language skills in shaping students' mathematical competence and suggest the potential benefits of fostering multilingual environments and supporting families in education.

In our future research, we aim to examine additional external factors that may influence students' performance in mathematical competence assessments. One of our main objectives is to develop an ESCS index — similar to the one used in the PISA tests — which will allow us to analyze how students' socio-economic background affects their academic outcomes.

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