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INTEREST IN STEM AND ITS RELATIONS TO THE EDUCATIONAL ACHIEVEMENT AND SOCIO-DEMOGRAPHIC CHARACTERISTICS OF GRAMMAR SCHOOL STUDENTS IN SERBIA

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Abstract. *Despite the growing prominence of STEM disciplines in contemporary society, relevant studies indicate a concerning trend: a decline in students' interest and engagement in these fields. This research included 1,045 students from four grammar schools in Serbia. The study utilizes a quantitative research design: data were collected through an online questionnaire. Key variables: end-of-term marks in STEM subjects, gender, parental education, family size, and place of residence were analyzed following the answers of respondents. Students were divided into two groups, STEM (435) and Non-STEM (610). The results indicated that the students enrolled in STEM-focused programs demonstrated significantly higher academic performance in STEM subjects during primary education compared to their peers in Non-STEM tracks. Additionally, the study identifies potential relations between students' interest in STEM and factors such as gender, parental education, and place of residence, with no significant effect found for the number of siblings. Specific sample and custom-designed questionnaire, highlight the need for future research with a broader and more diverse sample, incorporating additional socio-demographic factors and qualitative methods for a deeper understanding of students' engagement with STEM fields.*

Keywords: *STEM education, STEM interests, quantitative research, Serbia, grammar school*

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Introduction

STEM (Science, Technology, Engineering, Mathematics) proficiency is increasingly fundamental for informed decision-making, innovation, and active participation in the global economy as society continues to evolve. There is a worldwide consensus that expanding the pool of STEM experts enhances essential resources, promotes health, and maintains well-being (Murphy et al., 2019). From this perspective, STEM education has become central to many educational reforms, as it is vital for developing future work skills (Chiriacescu et al., 2023) and opens greater opportunities in various fields and lucrative careers (Kiernan et al., 2023). Understanding the natural sciences is integral to students' opportunities to create marketable and socially valuable products applicable in fields such as medicine, industry, and ecology (Divac et al., 2022; Nicolaou et al., 2021). Engaging with natural sciences and mathematics fosters essential knowledge and skills for active and responsible participation in modern society, including analytical thinking, critical thinking, and argumentative skills (Pertiwi et al., 2024). Further, it is essential to consistently raise the scope of experts in natural sciences and mathematics, as their shortage poses a risk to the anticipated and desired advancements in social, economic, and technological domains (Avargil et al., 2020).

Researchers analyzing educational trends (John et al., 2022), along with representatives from professional bodies (Committee on STEM Education, National Science & Technology Council, 2018) and international organizations (OECD, 2013), have emphasized the critical need to develop strategies that encourage greater participation of young people in STEM education. The U.S. government has established science as an "area of national need", highlighting that the global potential of the American nation is compromised if more students do not engage in STEM programs (Kanny et al., 2014). However, concerns have arisen regarding the promotion of STEM education across

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many OECD member countries, where students' interest in STEM disciplines has significantly declined over the past 20 years (Clark et al., 2016; Thomson et al., 2017).

Research Problem

Studies indicate that primary and secondary education is a critical period for determining a student's decision to pursue a career in the natural sciences (Sheldrake & Mutjaba, 2020). It is important to examine when students' interest in STEM sciences intensifies or wanes throughout their education and what factors contribute to these changes (Hacieminoglu, 2016; Luo et al., 2021; Ševkušić, 2022; Wakhata et al., 2022). Researchers note that most students begin their education with positive attitudes toward mathematics, but negative attitudes that develop later often result from lower achievements, unsuccessful experiences, and the emotional impact that accompanies failure (Japashov et al., 2022; Song et al., 2021; Vidić & Đuranović, 2020). Students generally recognize the importance of natural sciences in everyday life and find these subjects both interesting and challenging (Nugent et al., 2015): they often perceive these subjects as "not for everyone" (van Tuijl & van der Molen, 2016, p. 172). Research has described students' interest in STEM education as a pipeline, wherein the number of students engaged in these subjects diminishes as they progress through higher grades, a trend that is particularly pronounced among girls (Hacieminoglu, 2016; Luo et al., 2021; Nugent et al., 2015). Studies have explained that STEM interests are changeable and that various aspects, such as family influence, school performance, and the educational context, should be considered. More precisely, the factors can be divided into:

1. Socio-demographic and family background (gender, family size, parental education, place of residence, income and parents' attitude towards mathematics and natural sciences) (Balta et al., 2023; Dönmez, 2023);
2. Student achievements in subjects from natural and mathematical fields, students' attitudes towards these subjects and self-assessment of efficiency in those subjects (John et al., 2022; Ketenci et al, 2020);
3. School infrastructure and educational resources (Wakhata et al., 2022).

The relevant literature indicates significantly minor enrollment of students in grammar schools, especially in STEM-focused departments, in the Republic of Serbia, in contrast to the standard of the developed countries (Ivić, 2023). Furthermore, as far as present researchers know, prior domestic studies have not considered students' grammar school orientations alongside their socio-demographic characteristics (Maksimović et al., 2020). This study, therefore, provides a significant contribution to the current literature by offering a more comprehensive analysis of STEM education. A recent study in Serbia has examined students' perceptions of STEM subjects and grade point average (GPA), revealing that STEM-focused students achieve higher academic performance than their Non-STEM counterparts (Maksimović et al., 2024). Also, those students view STEM subjects as less challenging, more engaging, and more valuable, with biology being an exception.

Despite ongoing efforts to promote STEM education, disparities in student interest persist across different groups. Insufficient understanding of factors contributing to STEM interests hinders the development of effective, targeted interventions. This study considered several factors that impact students' interest in STEM, including gender, family background (such as family size, parental education, and location), and marks in STEM subjects. By understanding these determinants, the study can contribute to the development of more effective strategies and interventions on the national level, ensuring that local educational systems can better support diverse groups of students. Internationally, the findings from this case study can enrich global discussions about STEM education.

Educational System in Serbia

Education in Serbia is organized into four stages: pre-primary, primary, secondary, and tertiary. Children ranging from six months to seven years old are part of the pre-primary program. Primary education is mandatory for children aged 7 and lasts eight years, and is organized into two cycles. In the first cycle, which includes the first four grades, students are taught by a single-class teacher. The second cycle, from grades five to eight, incorporates different school subjects that subject-specific teachers teach. The secondary level comprises four years of education in grammar school (4 grades from age 15 to 19) or three to four years in vocational school (medical, technical, arts, industrial, craft). A grammar school is a type of secondary school that selects students based on academic ability, typically through an entrance examination. This type of school emphasizes a curriculum that aims to provide students with a strong foundation of knowledge for future academic pursuits. At the tertiary level, students can

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continue their education in high schools of applied studies (3 years) or university (Bachelor programs lasting 4–6 years, Master programs lasting 1-2 years and PhD programs lasting 3 years).

Regarding STEM-related subjects in primary school, students have mathematics from the first grade until the end of primary education. During the first four years, they study an integrated science curriculum that combines knowledge from various natural science disciplines. At the same time, children learn about technology and develop digital competencies through different school subjects. In the second cycle in primary school, students in Serbia begin studying physics, chemistry, and biology as separate subjects. Starting in the fifth grade, they also take the subjects of technical education and technology, as well as computer science. Additional support for mathematics and science education in grammar schools in Serbia has been facilitated through the establishment of specialized departments for STEM disciplines.

Students' Marks in STEM Subjects

Previous research has shown that students who achieve high marks in STEM subjects are more inclined toward pursuing careers in STEM fields (Koyunlu Ünlü & Dökme, 2020). High academic achievement and grades in science subjects are recognized as key factors influencing early interest in STEM careers (Lichtenberger & George-Jackson, 2013). A relevant study by Balta et al. (2023) has highlighted several findings: students with high marks in mathematics and chemistry showed significantly greater interest in science, mathematics, and engineering careers; those excelling in biology were more inclined toward science and engineering; and students who performed well in physics exhibited a stronger interest in pursuing STEM-related fields compared to their peers with lower grades.

Japashov et al. (2022) have revealed a strong positive correlation between students' performance in physics and their interest in science and mathematics. The study has also shown that success in mathematics, biology and chemistry was significantly correlated with a strong interest in STEM fields. However, no significant correlation has been found between academic success in any STEM subject and students' career interests in engineering. Other studies have also observed a positive correlation between students' final grades and their interest in STEM careers (Ing, 2014; Koyunlu Ünlü & Dökme, 2020). Moreover, the relation between academic performance and motivation for STEM learning and careers has been supported by research emphasizing the impact of social and motivational factors on STEM achievement (Ketenci et al., 2020; Nugent et al., 2015). These findings suggest that academic achievement plays a role in shaping interest in STEM careers, as students who perform well in STEM-related subjects are more likely to develop a stronger inclination toward these fields.

Gender

Despite the substantial integration of women into the labor market, particularly in developed states, empirical studies demonstrate that gender segregation persists in occupational structures, wage disparities, and educational domains (Codiroli Mcmaster, 2017; Prix & Kilpi-Jakonen, 2022). This phenomenon is especially pronounced in STEM disciplines, which remain heavily male-dominated (Sinnes and Løken, 2014). Furthermore, even in countries widely recognized as pioneers of gender equality, such as those in Northern Europe with long-standing equality policies, younger generations continue to exhibit a preference for traditionally gendered fields of study and career trajectories (Lahelma, 2014; Nylund et al., 2018). The case of Finland presents an illustrative example: despite girls consistently scoring better than boys in science and math tests since 2015, they show significantly less interest in engineering education and careers (Naukkarinen & Bairoh, 2020). Therefore, the influence of gender stereotypes is often pointed out, which determines the professional direction of young people by certain gender expectations, although, based on their achievements, they have had the opportunity to choose differently (Pihl et al., 2018; Saavedra et al., 2014).

The focus of this research is particularly significant to the issue related to the segregation of educational paths of boys and girls already when transitioning from primary to secondary school. The analysis of the career expectations of adolescents regarding gender, as examined in the framework of PISA 2018, has shown differences in educational aspirations between boys and girls. The list of desired occupations indicates that girls prefer positions in the sector of caring for others, such as health or education, while boys see themselves in the areas of protection (army, police), economics and technology (Schleicher, 2019). These findings are important, as occupational values strongly influence students' decisions regarding their fields of study. Boys with conventional values often elect science or mathematics tracks, which are commonly associated with higher prestige and better financial prospects. On the other hand, girls tend to prefer fields that are more socially oriented and centered around interpersonal connec-

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tions (van der Vleuten et al., 2016). In line with this, the results from the PISA 2018 testing show that, on average, only 1% of 15-year-old girls in OECD countries expressed an interest in pursuing ICT-related careers, compared to 8% of boys. On the other hand, in Bulgaria, Estonia, Lithuania, Poland, Serbia, and Ukraine, more than 15% of boys have expressed an interest in pursuing careers in ICT. However, in none of the PISA-participating countries, more than 3% of girls have reported the same. More than one in four boys surveyed by PISA said they expected to work as engineers, scientists, and researchers when they were 30, but less than one in six girls expressed such expectations. Nearly one in three girls with high educational attainment, and only one in eight boys at the same level of attainment, have indicated that they expected to work as health workers (Schleicher, 2019). Such findings indicate that, despite achieving success in mathematics or natural sciences, boys and girls tend to have distinctly different expectations regarding their prospective careers. At the same time, these results are consistent with indicators in earlier PISA cycles when it has been observed that careers in engineering and computing have attracted a relatively small number of girls (OECD, 2013).

Parental Education

The educational level of parents could be an important determinant of their children's educational achievement and future educational pursuits, especially in STEM disciplines (Archer et al., 2012; Ozfidan et al., 2020; Starr et al., 2022). Research consistently shows that students whose parents have had higher education levels, particularly those with degrees in STEM disciplines, are more inclined to choose postsecondary options and succeed in STEM subjects (Šimunović & Babarović, 2020). Parents with a bachelor's degree or STEM-related careers often serve as role models, influencing their children's choices in STEM subjects. Their educational background and professional experiences provide a foundation for comprehending the value of STEM education (Holmes et al., 2017). Parental expectations significantly impact students' aspirations in STEM (Lissitsa & Chachashvili-Bolotin, 2021). When parents encourage school achievement and express positive beliefs about STEM fields, students are more likely to develop an interest in these subjects (Hsieh & Yu, 2022). Educated parents tend to engage more actively in their children's education, which can enhance their learning experiences. This involvement includes providing resources, guidance, and encouragement related to STEM, fostering an encouraging environment for academic success (Šimunović et al., 2018). The support and resources provided by educated parents, creating a stimulating home environment using games and educational material, can lead to better school performance (Feser, 2024; Perera, 2014; Siregar et al., 2023). While many studies emphasize the positive influence of parental education, some research suggests that its impact is not uniform across all students (Chachashvili-Bolotin et al., 2016). Factors such as socioeconomic status, cultural background, and individual students' circumstances can mediate the effects of parental education on STEM choices (Šimunović et al., 2018).

Number of Siblings

The concept of resource dilution suggests that larger families may face constraints in terms of parental time, attention, and financial resources, which can negatively impact educational attainment (de Haan, 2010). The parents' influence remains important in shaping children's educational paths, but siblings can also contribute in fostering interest in STEM fields. Siblings often learn from each other, with older siblings serving as role models. This dynamic can shape younger siblings' attitudes toward education, including their interest in STEM subjects (Gabay-Egozi et al., 2022). For example, if an older sibling excels in math or science, it may inspire younger siblings to pursue similar paths (Chakraverty et al., 2018). In smaller families, older brothers and sisters often have greater access to these resources, which can enhance their school achievements and, by extension, influence their younger siblings (Ho et al., 2020). Older siblings' academic success, particularly in subjects like math, can significantly shape younger siblings' interests and motivations. Research has indicated that younger siblings may experience increased motivation or anxiety about STEM fields based on their older siblings' performance and attitudes toward these subjects (Antonijević & Radenović, 2024; Legewie & DiPrete, 2014). The composition of the sibling group, such as the number of siblings and their genders, can also influence the formation of STEM-related interests. For instance, a family with multiple siblings in STEM fields may create an environment that emphasizes the importance of these subjects, leading to higher collective interest and achievement (Shahbazian, 2021).

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Place of Residence

The difficulties encountered by rural students, particularly in STEM education, highlight significant disparities between rural and urban/suburban educational experiences. Geographic isolation, limited funding, and a shortage of qualified teachers are critical barriers that contribute to lower educational aspirations and achievements in these areas (Murphy, 2023; Siew et al., 2016). Rural schools often struggle to recruit and retain highly qualified STEM educators, leading to a reliance on teachers with multiple subject endorsements (Gándara et al., 2001). This can dilute the quality of teaching and limit students' exposure to advanced coursework. Additionally, community attitudes toward postsecondary education can further discourage students from pursuing STEM fields, especially when role models are scarce. The tension that rural youth experience – balancing the desire for educational and vocational opportunities with the pull of their home communities – adds another layer of complexity. Many students may feel pressured to stay close to family, which can hinder their pursuit of advanced education in STEM (Meece et al., 2013). Without access to quality educational materials and training, students face barriers in preparing for careers in STEM fields. This cycle of underachievement in STEM can have long-term effects on both individual students and the broader rural community (Peterson et al., 2015).

Research Aim and Research Questions

Along the lines of researchers who believe that education can catalyze social changes and the development of both individuals and the state, this study deals with certain aspects of education in STEM disciplines. The present research specifically examined grammar school students' prior academic experiences, to identify relations with students' interests in STEM, comparing the responses of students in STEM-focused departments with those in other tracks. Therefore, the aim of this study was to examine the relations of some socio-demographic characteristics as well as school achievement on students' STEM interests. In alignment with the aim of the research, the following research questions have been formulated:

1. Are end-of-term marks in STEM subjects related to students' interest in STEM fields?
2. Is gender related to students' interest in STEM fields?
3. Is parental education related to students' interest in STEM fields?
4. Is the number of siblings related to students' interest in STEM fields?
5. Is the place of residence related to students' interest in STEM fields?

Research Methodology

General Background

This research was carried out between October 2023 and July 2024 using a quantitative research design. The study included grammar school students from the Republic of Serbia, encompassing both, specialized departments and regular departments, allowing for a comparative analysis of the factors influencing students' choices across different types of academic tracks. The theoretical framework of the research focused on the socio-demographic and individual factors that could shape students' academic trajectories. The students were surveyed about their previous educational experience and socio-cultural characteristics to identify predictors of enrollment in specialized (STEM) departments in grammar school.

Sample

A sampling procedure was utilized due to its effectiveness and ability to access a large, geographically distributed student population (Lefever et al., 2006). The sample encompassed 1045 grammar school students, both male (330) and female (715). These students were from four grammar schools in two cities in the Republic of Serbia, two in Kragujevac (551) and two in Novi Sad (494). The four schools adhered to the national educational framework set by the Ministry of Education of the Republic of Serbia. (Law on the Foundations of the Education System in the Republic of Serbia, 2024). In order to answer research questions, the students were classified into two groups, STEM (435) and Non-STEM (610) according to the methodology presented by Weeden et al. (2020), adapted to the educational context in Serbia. The distribution of sample students across two groups, along with their respective departments, is presented in Table 1.

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Table 1
Distribution of Students Within Sample Across Grammar School Departments

Group	Department	*n*
STEM	Natural sciences and mathematics department	222
	Specialized department for mathematics	63
	Specialized department for computer science	84
	Specialized department for physics	11
	Specialized department for biology and chemistry	55
Non-STEM	General stream of studies	464
	Socio-linguistic department	48
	Bilingual department	55
	Specialized department for sports	14
	Specialized department for philology	29
Total		1045

Ethics

All students took part in the research on a voluntary basis and were approached in line with the highest ethical principles upheld in educational research. Prior to gathering empirical data, a comprehensive form was prepared outlining all relevant details, including the study's purpose, procedures, and requirements. The research adhered to applicable laws and institutional regulations and received ethical approval from the Ethics Committee of the Faculty of Science, University of Kragujevac (No. 01-06/24).

Instrument and Procedures

Data were collected using an online questionnaire (see Appendix) administered via Google Forms. The questionnaire was designed to gather information on students' socio-demographic background, family characteristics, and academic performance, including gender, number of siblings, parental education, place of residence, and end-of-term marks in STEM subjects. The study aimed to examine potential relations between socio-demographic factors and educational achievements and students' enrollment in specialized STEM departments. Given the focus on identifying patterns and associations rather than assessing subjective attitudes or perceptions, the questionnaire was designed to include only key background characteristics that have been recognized in previous research as influential in educational decision-making. The instrument was created by adopting some of the questions from different questionnaires (Hoffmeyer-Zlotnik & Warner, 2007; Japashov, et al., 2022). Two independent experts checked the validity of the questionnaire content.

Data Analysis

Statistical measures and procedures included: frequencies, percentages, arithmetic means, and standard deviations, as well as a statistical test for determining the normality of data distribution (the Kolmogorov-Smirnov test), followed by the Mann-Whitney test and the Chi-square test. The collected data were processed using the IBM SPSS Statistics 20 software package.

Research Results

Interest in STEM and Students' End-of-Term Marks in STEM Subjects

Marks in the Serbian educational system are numerical and on a scale from 1 (insufficient) to 5 (excellent) (Law on Education System Foundations in the Republic of Serbia, 2024). The arithmetic mean is considered during

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evaluation; for example, students who have an average grade between 3.5 and 4.5 have very good success (grade 4), or higher than 4.5 have excellent success (grade five) in that subject. To address the first research question, it was examined whether the achievements in the STEM subjects during primary education differ between the two groups. Bearing in mind that the distribution of students' end-of-term marks did not follow the normal distribution, potential differences among the three groups were examined using the appropriate Mann-Whitney test.

Table 2
End-of-Term Marks in STEM Subjects Between STEM and Non-STEM Students During

Subject	Group	*M*	*SD*	Mann-Whitney U test	
				Z	*p*
Biology	STEM	4.86	0.50	-3.143	.002
	Non-STEM	4.76	0.59		
Physics	STEM	4.78	0.61	-7.557	<.001
	Non-STEM	4.44	0.85		
Chemistry	STEM	4.76	0.66	-6.472	<.001
	Non-STEM	4.38	0.84		
Mathematics	STEM	4.77	0.61	-7.965	<.001
	Non-STEM	4.38	0.92		
Computer Science	STEM	4.94	0.40	-3.624	<.001
	Non-STEM	4.87	0.42		
Technical education and technology	STEM	4.90	0.49	-0.636	.525
	Non-STEM	4.91	0.39		

According to Table 2, it is evident that the students from the STEM group were excellent in all six subjects. On the other hand, the Non-STEM students were excellent in three subjects (technical education and technology, computer science and biology), whilst they were very good in the other three (physics, chemistry and mathematics). The differences between the two groups are statistically significant in 5 out of 6 subjects (biology, physics, chemistry, mathematics and computer science). Statistical indicators (Table 2) indicate that students from STEM departments achieved significantly better results in STEM subjects during primary school education.

Interest in STEM and Gender

Furthermore, there was an examination of gender representation between the two groups. The distribution of students by gender in the STEM and Non-STEM departments is presented in Table 3.

Table 3
Gender Distribution of Students in STEM and Non-STEM Groups

Group	*n*	
	Gender	
	Male	Female
STEM	196	239
Non-STEM	134	476
Total	330	715

Based on the results gathered, nearly 60% of the boys were directed toward studying STEM, while only one in three girls from the sample (33.43%) chose to pursue STEM education in more detail. These differences are statisti-

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cally significant ($\chi^2 = 61.59$; $df = 1$; $p < .001$). Therefore, according to the research sample, it can be concluded that boys decide to study STEM departments to a significantly greater extent than girls.

Interest in STEM and Parental Education

Summarized data about mothers' education of students among both groups are presented in Table 4. To meet the assumption of the chi-square test regarding the least cell frequency, 5 responses from mothers who completed only primary school will be joined to the number of mothers who have completed high school. Results from Table 4 reveal an almost similar number of mothers with a bachelor's degree, whilst the number of mothers with a master's degree is significantly higher among STEM group students (65.98% of mothers of STEM students and 52.46% of mothers of Non-STEM students). Observed differences are statistically significant ($\chi^2 = 24.15$; $df = 2$; $p < .001$).

Table 4
Distribution of STEM and Non-STEM Students by Mother's Education Level

Group	*n*			
	Mother's Education Level			
	Elementary Education	Secondary Education	Bachelor's Degree	Master's Degree
STEM	1	88	59	287
Non-STEM	4	202	84	320
Total	5	290	143	607

Table 5 presents the data regarding fathers' educational level. Similar to the data gathered about mothers' education, the number of fathers with a higher level of education is noticeably greater among students from STEM departments. Based on the results of the chi-square test ($\chi^2 = 10.73$; $df = 2$; $p = .013$), it turns out that the differences in the education of the fathers of the two groups of students are also statistically significant.

Table 5
Distribution of STEM and Non-STEM Students by Father's Education Level

Group	*n*			
	Father's Education Level			
	Elementary Education	Secondary Education	Bachelor's Degree	Master's Degree
STEM	4	143	47	241
Non-STEM	13	247	69	281
Total	17	390	116	522

Interest in STEM and Number of Siblings

Since family size could impact students' choice of STEM education, it was investigated whether the size of the family, specifically the number of siblings, differs among the two groups in the research sample. Values from Table 6 show that the majority of students have one sibling (59.31% of students from the STEM group and 55.57% of students from the Non-STEM group). Based on the chi-square test, the STEM interests and the number of siblings are independent variables ($\chi^2 = 8.82$; $df = 4$; $p = .266$). In other words, there are no statistically significant differences in the number of siblings among the two groups of students.

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Table 6
Distribution of STEM and Non-STEM Students by Number of Siblings

Group	*n*				
	Number of Children in Family				
	Single child	Two children	Three children	Four children	Five or more children
STEM	83	258	76	9	9
Non-STEM	103	339	132	21	15
Total	186	597	208	30	24

Interest in STEM and Place of Residence

Bearing in mind the possible influence of students' place of residence on STEM interest, there were examined differences in the allocation of students in STEM and Non-STEM departments depending on whether they live in urban or rural localities. In general, a small number of students grew up in rural places (16% of STEM students and 27% of Non-STEM students), compared to the number of students who grew up in urban environments (84% of STEM students and 73% of Non-STEM students). Differences in distribution (Table 7) are easily noticeable, and they are statistically significant ($\chi^2 = 15.65$; $df = 1$; $p < .001$). It can be concluded that STEM-oriented students grew up in larger and more urban areas.

Table 7
Distribution of STEM and Non-STEM Students by Place of Residence

Group	*n*	
	Place of Residence	
	Rural locality	Urban locality
STEM	71	364
Non-STEM	164	446
Total	235	810

Discussion

The present study reveals that students' interest in STEM varies based on factors such as gender, place of residence, parental education, and end-of-term marks in STEM subjects. However, no significant differences were observed concerning family size, particularly the number of siblings.

In a similar vein, Jiang et al. (2020) argued that STEM intentions can be viewed as the outcome of motivational factors and learning experiences, which are linked to high school seniors' math performance, exposure to math and science courses, and their confidence in their proficiency in solving math problems. According to Chachashvili-Bolotin et al. (2016) math achievements as well as involvement in extra-curricular STEM activities and advanced science courses are strongly associated with higher students' aspirations toward STEM. Kaleva et al. (2019) found that 16-year-old students who chose to learn advanced mathematics had received good marks in mathematics during their previous schooling. A strong sense of STEM identity could be linked to better educational outcomes and success in undergraduate physics courses, especially for female students (Seyranian et al., 2018). In line with this, the link between mathematics and natural sciences achievements and interest is highlighted by the findings of a study conducted by Laine et al. (2020), which examined marks and interest in STEM among Finnish students aged 12–14. The study revealed that, initially, students' interest predicts their marks, but later, their marks become

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predictors of their interest (Laine et al., 2020). Therefore, it can be concluded that students with higher marks in STEM subjects during their education demonstrate greater interest in continuing to learn STEM disciplines.

The results obtained in this research indicate that boys in the Republic of Serbia are more predisposed than girls to study STEM fields. The findings align with the literature on this global phenomenon (European Commission, 2020; National Science Board, 2022). Comparable research conducted in the Netherlands, which included 1062 adolescents, also showed that 38% of those enrolled in the science and technology track were girls (van der Vleuten et al., 2016). Just like previous research in Serbia (Hrnčić et al., 2014; Ševkušić, 2022) and national statistical data (Statistical Office of the Republic of Serbia, 2022), this research also showed gender gap related to the choice of the STEM area. On the other hand, the findings of a recent international study including a significant sample of 11,782 students from different countries are compelling: students from Serbia and Estonia demonstrate the strongest "mathematical identity" (Radišić et al., 2024). Notably, only in the groups from Serbia and Sweden, there were no significant differences between boys and girls regarding their perception of this identity (Radišić et al., 2024). This highlights the importance of fostering a strong mathematical identity in every student, regardless of gender, to promote a more inclusive and effective learning environment.

The role of parental education in shaping students' career choices, particularly in STEM fields, has been widely studied, with many researchers emphasizing its significance. This study showed significant differences in students' STEM interests based on either fathers' or mothers' education levels. Specifically, students whose parents had higher education levels exhibited greater interest in STEM disciplines compared to those with lower parental education levels. These findings align with previous research which highlights the positive impact of parental education on sustained interest and success in STEM disciplines (Dönmez et al., 2022). Numerous studies have highlighted that families with greater educational attainment tend to be more successful in encouraging students' inclination in STEM (Liu et al., 2022; Svoboda et al., 2016). The parents' influence on some aspects of education was observed in a TIMSS 2015 study in Serbia and showed that better educational achievements are performed by pupils whose parents have a higher level of education (Gundogan et al., 2020). On the other hand, no significant differences have been established in terms of interest in STEM subjects among students, regardless of whether considering fathers' or mothers' education levels, in studies conducted in different countries (Jodl et al., 2001; Koyunlu Ünlü & Dökme, 2020; Lichtenberger & George-Jackson, 2013; Saleem et al., 2014). Although the difference is not statistically significant, Chachashvili-Bolotin et al. (2016) noted that students with parents who have less formal education tend to show less interest in STEM subjects than their peers. Some researchers imply that relatives' appreciation of STEM trajectories and parents' active involvement in promoting STEM have a stronger influence on youth career aspirations than parental education or socioeconomic status (Lichtenberger & George-Jackson, 2013; Nugent et al., 2015).

Early research dealt with the effects of family size on education: a negative correlation between family size and educational outcomes has been noted, which was attributed to limited financial and parental resources in larger families (Downey, 1995). Researchers from Kazakhstan revealed the same correlation between family size, in terms of sibling count, and students' enthusiasm for mathematics (Balta et al., 2022). Furthermore, one Swedish study has shown that students from larger families choose STEM only if an older sibling has previously attended or is currently enrolled in a STEM program (Shahbazian, 2021). However, the present study found no significant differences in STEM career interest based on family size, more specifically, the number of siblings. These findings align with results from Pakistan, which also found no significant differences in educational outcomes based on family size (Ali et al., 2017). Furthermore, while previous research highlights that siblings may influence educational choices and interests (Shahbazian, 2021), data from this research suggests that the number of siblings does not significantly impact STEM interests. Reports from other researchers (Japashov et al., 2022) are consistent with the results obtained in this study and suggest that other factors, such as the quality of sibling relationships may have a more significant impact than merely the number of siblings alone.

Relevant sources reported that mathematics and science achievements and interests did not vary notably among students from different geographical areas in national evaluations (Showalter et al., 2017). However, the present research suggests that disparities in STEM interests are becoming more apparent, possibly due to growing regional inequities and evolving educational landscapes in Serbia. Obtained findings that STEM-oriented students predominantly live in urban areas align with prior research highlighting the disparity in STEM participation and performance between rural and metropolitan students (Nissinen et al., 2018; Thomson et al., 2019). Global trends have revealed similar patterns, where rural students exhibit reduced participation in advanced mathematics, chemistry, and physics courses (Dönmez et al., 2022; Murphy, 2023) and typically demonstrate lower academic ambitions (Fray et al., 2020). Moreover, rural students are less inclined to view science as relevant to their future professional endeavors (Murphy, 2023). However, unlike the findings in the studies mentioned above, research from Kazakhstan,

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Turkey, and Israel revealed that rural students showed more interest in STEM subjects compared to those from urban areas (Chachashvili et al. 2016; Japashov et al., 2022; Koyunlu Ünlü & Dökme, 2020). Furthermore, they explained that rural students perceive STEM careers as a pathway to economic improvement, fostering greater intrinsic motivation. Several factors identified in the sources explain the underrepresentation of STEM-oriented students from rural areas. Rural students often lack access to advanced mathematics and science subjects, as well as extracurricular STEM activities, which are known to nurture interest in STEM careers (Franz-Odendaal et al., 2016, Peterson et al., 2015; Siew et al., 2016). Rural environments may impact children with lower expectations for educational attainment and less exposure to STEM professionals, further reducing STEM aspirations (Kilpatrick & Fraser, 2018; Munn et al., 2018).

Research by Ketenci et al. (2020) indicates that students who tend to pursue STEM-related careers are predominantly male, enrolled in non-public schools with a high socio-economic background, and exhibit strong confidence in their mathematical abilities. It is noteworthy to recognize that the advancement of STEM depends on the inclusion of all qualified and capable students (Charlesworth & Banaji, 2019). Furthermore, progress in achieving equality, particularly in the education of girls, students from disadvantaged families and those from rural areas can significantly contribute to economic growth. Enhancing student achievement and helping individuals reach their full potential through education, while effectively promoting and implementing inclusivity, equality, and fairness in school systems, are not just ideals to strive for; they are essential goals. Attaining these objectives can significantly improve the well-being of both society and individuals: a more educated population leads to increased productivity, which in turn fosters higher economic growth and reduces poverty (Maksimović, 2023; Schleicher & Zoido, 2016).

Conclusions and Implications

According to the available sources, it appears that STEM professionals (will) play a crucial role in shaping various aspects of science, economy and society in the future. Despite this critical need, the number of students pursuing STEM subjects remains insufficient globally and in Serbia as well. Given that no comprehensive studies have been conducted in Serbia or neighboring regions to explore the relations between students' interest in STEM subjects, their educational achievements in these disciplines, and their socio-demographic characteristics, this research aims to contribute to understanding these connections.

The study highlights the significant relation of early academic success on students' interest in STEM fields. Students who engage more intensively in STEM subjects during grammar school demonstrated considerably higher academic achievement in subjects like biology, physics, chemistry, mathematics, and computer science during their primary education. This underscores the importance of fostering early interest and confidence in STEM disciplines. Moreover, interest in STEM is found to be significantly associated with gender, parental education, and place of residence, whereas the number of siblings does not appear to influence STEM motivation. The typical student gravitating toward STEM education in Serbia is male, comes from a highly educated family, and resides in an urban area. These findings point to disparities in access to STEM opportunities that are linked to socio-cultural and environmental factors. Gender imbalances, in particular, suggest a need for targeted interventions to engage female students and address existing biases. Furthermore, rural students face significant challenges in accessing STEM education, indicating a clear need for targeted interventions to ensure equitable opportunities for all, regardless of geographic location. While the number of siblings was not found to significantly influence STEM interest, this suggests that family size, in isolation, is not a critical determinant.

The insights derived from these results are relevant for educators, career advisors, and policymakers involved in guiding students' academic choices, particularly during the transition from primary to secondary education. By understanding the complex socio-demographic factors shaping students' STEM interests, targeted strategies can be developed to support all students, including those who do not fit the typical STEM profile but demonstrate potential. It is important to offer all students, regardless of their socio-demographic characteristics, out-of-school learning experiences that nurture STEM motivation, such as visits to science centers, research laboratories, and industrial institutions. These activities can provide students with immersive experiences that reinforce their interest in STEM fields. This research contributes to the global dialogue on STEM inclusion, advocating for educational systems that are accessible, equitable, and supportive of all students, regardless of gender, socio-economic background, or geographic location. Finally, the study lays the foundation for future longitudinal research that tracks changes in STEM interest over time, offering valuable insights into the effectiveness of educational policies and interventions aimed at increasing STEM participation globally.

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Limitations and Recommendations

The research has certain inherent limitations. The design and implementation of this research were carried out with an understanding of the limited generalizability of the findings beyond the specific context in which they were gathered. The dominant limitation stems from the chosen research approach and data collection method. Considering that the study was limited to four grammar schools in Serbia, it is suggested that subsequent research include a larger and more diverse sample. Moreover, the questionnaire was custom-designed for this research and focused solely on exploring potential relations between students' STEM interests and specific educational and socio-demographic variables. Consequently, the scope of the instrument is limited in its broader applicability. Further research, based on this topic, could also include other family-related factors, such as socio-economic status and parental involvement, which may play an important role in shaping students' engagement with STEM fields. Additionally, while this study employed a quantitative approach, integrating qualitative methods could provide a more thorough comprehension of the factors influencing students' interest in STEM education and careers.

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Declaration of Interest

The authors declare no competing interest.

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Appendix

Instrument

1. Gender
   a) male
   b) female

2. Department
   a) natural sciences and mathematics department
   b) socio-linguistic department
   c) general stream of studies
   d) bilingual department,
   e) specialized department for sports
   f) specialized department for philology
   g) specialized department for mathematics
   h) specialized department for computer science
   i) specialized department for physics
   j) specialized department for biology and chemistry.

3. I grew up in:
   a) Rural locality
   b) Urban locality

4. Grammar school which I attend is:
   a) First Grammar school in Kragujevac
   b) Second Grammar school in Kragujevac
   c) Grammar school „Svetozar Marković" in Novi Sad
   d) Grammar school „Jovan Jovanović Zmaj" in Novi Sad

5. Mother' s educational level:
   a) Primary education degree
   b) Secondary education degree
   c) Bachelor's degree
   d) Master's degree

6. Father' s educational level:
   a) Primary education degree
   b) Secondary education degree
   c) Bachelor's degree
   d) Master's degree

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7. How many children are there in your family, including yourself? (Enter the number): _____

8. Write down the most frequent end-of-term grade you received in the given subject during your primary school education:

a) Biology____
b) Physics____
c) Chemistry____
d) Mathematics____
e) Computer Science ___
f) Technical education and technology ___

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