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# Socioeconomic Background, Preschool Attendance, and Mathematics Achievement in Serbia: Evidence from TIMSS 2023[1]

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This study examined the associations between preschool attendance, socioeconomic status (SES), gender, and early academic skills, and fourth-grade mathematics achievement in Serbia using data from a nationally representative TIMSS 2023 sample. **Method:** Mathematics achievement was analyzed using plausible values, and regression models were estimated in the IEA International Database Analyzer while accounting for sampling weights. Predictors were entered in four successive regression models, with socioeconomic background entered first, followed by gender and preschool attendance, and finally early literacy and numeracy skills. **Results:** Socioeconomic background emerged as the strongest predictor of achievement, while gender and preschool attendance showed smaller but still statistically significant effects. Early literacy and numeracy did not account for additional variance once these factors were considered. Supplementary analyses indicated that longer preschool attendance was particularly beneficial for students from socioeconomically disadvantaged backgrounds, whereas differences were minimal among high-SES students, suggesting a compensatory effect of early childhood education. **Conclusion:** The results suggest that, while longer preschool attendance can partially compensate for disadvantaged socioeconomic status and contribute to better mathematics achievement, it alone cannot fully offset the strong influence of socioeconomic background, highlighting the need for broader policies that enhance educational quality and reduce educational inequalities.

**Keywords:** TIMSS, mathematics achievement, preschool education, SES, elementary school

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## Introduction

The Trends in International Mathematics and Science Study (TIMSS) is the largest international comparative assessment of student achievement in mathematics and science for elementary/primary education, conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). TIMSS evaluates students' performance at Grades 4 and 8. In addition to mathematics and science achievement data, the study collects extensive contextual information through background questionnaires administered to students, teachers, principals, and parents, focusing on instructional practices, educational resources, attitudes toward learning, and the home environment (Ibralić et al., 2025; Mullis et al., 2021; Thomson et al., 2020). Large-scale international assessments have considerable potential for informing curriculum development, instructional practices, and educational reforms, while also enabling the identification of student-level factors that influence educational outcomes (Heyneman, 2004; Mutawah et al., 2019). In this regard, TIMSS provides rich contextual data and high psychometric item quality (Martin & Mullis, 2019).

So far, TIMSS data in Serbia have been used for a variety of research purposes, ranging from describing national achievement levels to analyzing individual and contextual factors in learning. According to TIMSS 2011 data, fourth-grade students in Serbia performed above the international average in mathematics and science (Martin et al., 2012; Mullis et al., 2012). Subsequent national analyses explored differences across gender and content domains, offering insights to inform educational policy and support the planning of educational system development (Gašić-Pavišić & Stanković, 2012).

While earlier analyses focused on achievement outcomes, later studies using TIMSS 2015 and 2019 data in Serbia turned to affective and motivational dimensions, including intrinsic motivation, academic self-concept, and student profiles in science. The findings showed that higher levels of motivation and self-efficacy were consistently associated with better achievement (Lalić-Vučetić & Mirkov, 2023; Ševkušić et al., 2023). In addition to individual factors, the role of the school context was also examined, including school climate and its relationship with student achievement. The findings indicated that students attending schools with a highly positive climate achieved better results (Vujačić et al., 2020). However, despite the extensive amount of available data and the variety of research approaches, there are relatively few studies in Serbia that have systematically examined the factors predicting student achievement within the TIMSS framework (Gašić-Pavišić & Stanković, 2012; Vujačić et al., 2020; Lalić-Vučetić & Mirkov, 2023).

On the other hand, in international studies as well as regional analyses (Koršňáková et al., 2022; Matković et al., 2019) based on TIMSS data, many

factors have been identified as important predictors of children's academic achievement. Importantly, across the studies and cultural contexts, the most important predictor of school success has been the socioeconomic status (SES) of children (Broer et al., 2019; Coşkun & Özyer, 2023; Ersan & Rodriguez, 2020). Thus, a key challenge for educational researchers is to identify factors that can mitigate or modify the effects of SES on academic achievement. From a practical perspective, this involves identifying protective factors that may help students from socioeconomically disadvantaged backgrounds achieve outcomes comparable to those of their more advantaged peers. In this context, we believe that early interventions in development and education, including targeting cognitive, social, and emotional skills at an early age, can significantly mitigate the negative effects of low SES. These programs provide early support and enable children to develop foundational competencies that later contribute to success in school.

Several factors have been identified as potential targets for intervention, among which early childhood education stands out as a particularly promising approach for narrowing achievement gaps (Starkey et al., 2022). Accessible and high-quality preschool education has been shown to reduce the negative effects of low SES by fostering foundational cognitive and learning-related skills that support children's development across their academic trajectories. Research suggests that children who attend preschool enter formal schooling better equipped with essential skills that contribute to later academic success. Early participation in structured preschool programs may initiate developmental advantages that strengthen learning processes over time, rather than producing only short-term gains (Bikić et al., 2024).

The duration of attendance in early childhood education (ECE) is positively associated with later cognitive and academic outcomes, including intelligence, reading comprehension, mathematical reasoning, and overall school ability up to the age of 13. These associations remain significant even after controlling for confounding factors, such as SES, indicating that longer ECE participation is linked to persistent benefits in school achievement (Melhuish et al., 2015; van Huizen & Plantenga, 2018). Overall, the evidence from meta-analysis suggests that preschool education can function as a long-term developmental investment, with effects extending across multiple domains of functioning into adolescence (OECD, 2021).

There are several mechanisms through which ECE might impact later academic achievement in mathematics. First, ECE can have a positive effect on executive functions such as working memory, cognitive flexibility and inhibitory control, which in turn support mathematical learning (Bukva & Memisevic, 2025; Kang et al., 2019). Second, ECE may influence mathematics achievement through the quality and structure of early mathematics instruction. Research-based curricula that systematically target number,

mathematical concepts, and learning progression produce larger immediate gains in early mathematics skills than business-as-usual approaches (Watts et al., 2018). Next, longitudinal evidence supports a latent foundation perspective, whereby early conceptual knowledge in mathematics serves as a scaffold that facilitates subsequent learning as students encounter increasingly complex mathematical content. From this perspective, preschool mathematics abilities are significant for future academic achievement (Lehrl et al., 2017; Nguyen et al., 2016).

In addition to preschool experiences, early academic skills are also related to later school achievement. A substantial body of research has shown that early numeracy and early literacy are among the strongest predictors of later academic performance, as they reflect children's readiness to engage with formal instruction and to acquire more complex academic skills (Davis-Kean et al., 2021; Mercugliano et al., 2024). These early competencies provide the foundation upon which subsequent learning builds and may therefore influence later mathematics achievement independently of, or in conjunction with, preschool attendance. Accordingly, including measures of early numeracy and early literacy allows for a more precise estimation of the unique and conditional contribution of preschool attendance to later mathematics outcomes.

The role of preschool attendance is particularly relevant in the context of Serbia, where early childhood education has undergone substantial reforms over the past two decades, moving from a more traditional, school-like model toward a child-centred and project-based approach that emphasizes wellbeing, inclusion, and holistic development. Early childhood education in Serbia covers children from six months to 6.5 years of age, with the final year, the preparatory preschool program, being compulsory and free of charge, with the aim of promoting school readiness and reducing initial educational inequalities, particularly among disadvantaged children (Macura-Milovanović, 2013). However, it should be noted that the TIMSS 2023 fourth-grade cohort may not have been fully exposed to the most recent early childhood education reforms, as their preschool attendance largely predates full implementation of the new curriculum framework.

In recent years, some local authorities in Serbia have begun implementing a new model of early intervention in preschool institutions, which involves a transdisciplinary team of professionals from the education, social welfare, and health sectors. The team provides individualized support to parents and their children who face developmental, biological, social, or socioeconomic risks, delivered within the child's natural environment, including the preschool setting. In this context, development is fostered through play, daily routines, and everyday interactions with peers and adults (Velišek-Braško & Svilar, 2019).

Despite these policy advances, access to early childhood education remains uneven. Participation in early childhood education remains lower in Serbia compared to many EU countries. As noted by Marković (2022), these disparities negatively affect broader indicators of educational quality. For example, enrolment among children aged 3–5.5 years is approximately 66% in Serbia, compared to around 90–95% across EU countries (UNICEF Serbia, 2021; OECD, 2023), while coverage in the year before school reaches about 96% due to the compulsory preschool programme (Statistical Office of the Republic of Serbia, 2026). Structural disparities are especially evident among vulnerable groups. Findings from the Multiple Indicator Cluster Surveys (MICS) (Statistical Office of the Republic of Serbia & UNICEF, 2020) in Serbia show substantial inequalities in preschool participation for Roma children, who are significantly less likely to attend early childhood education compared to non-Roma peers, primarily due to poverty, residential segregation, and limited access to local preschool services. These patterns are consistent with international evidence showing that socioeconomic disadvantage is strongly associated with lower preschool participation rates (e.g., Suna & Özer, 2022).

Community-based programmes have been proposed as one possible way to bridge these gaps.

In addition to disparities in access, research has pointed to implementation challenges, including insufficient infrastructure, limited professional support for educators, and the need for more coherent strategies for inclusive practice. Although policy frameworks and curricular reforms are relatively advanced, the translation of these reforms into consistent classroom practice remains uneven, partly because preschool education is centrally regulated but locally governed, resulting in substantial variation across municipalities (Bogovac, 2018; Kravarusić, 2021). Recent statistical data further illustrate the scope of the system. According to the Statistical Office of the Republic of Serbia (2025), a total of 235,344 children attended preschool education and care in the 2024/25 school year, of whom 25.4% were under the age of three, while 74.6% were aged three years to school entry. Taken together, these characteristics suggest that early childhood education in Serbia operates within a context of ongoing reform, expanding access, and persistent socioeconomic disparities in participation and quality. This context is particularly relevant when examining the role of preschool attendance in later academic achievement, as differences in access, duration, and early learning opportunities may contribute to inequalities observed in large-scale assessments such as TIMSS.

Despite robust evidence that early childhood education is associated with later academic achievement (van Huizen & Plantenga, 2018; OECD, 2021),

less is known about whether the benefits of preschool attendance are equally distributed across socioeconomic groups, particularly in contexts where access to early childhood education and its duration vary across the population. Given the central role of socioeconomic background in shaping educational outcomes, it is important to examine whether preschool attendance functions as a compensatory mechanism that disproportionately benefits students from socioeconomically disadvantaged backgrounds, or whether its effects are relatively uniform across SES levels.

Taken together, prior research indicates that early childhood education contributes to later mathematics achievement through the development of foundational cognitive and academic skills, with evidence suggesting potentially stronger effects for children from socioeconomically disadvantaged backgrounds. However, it remains unclear to what extent these benefits are differentially distributed across socioeconomic groups in the Serbian context. Accordingly, this study examines the association between preschool attendance and fourth-grade mathematics achievement, and whether this association is moderated by socioeconomic background, controlling for gender and early academic skills. It is hypothesized that longer preschool attendance will be positively associated with mathematics achievement and that this association will be stronger among students from lower socioeconomic backgrounds.

## Methods

### *Participants*

This study used data from the TIMSS 2023 assessment, an international large-scale study coordinated by the IEA in collaboration with national research centers. In Serbia, the study was implemented by the Institute for the Evaluation of Quality of Education and Training. TIMSS 2023 in Serbia included fourth-grade students in primary education (typically 9–10 years of age), who participated in standardized mathematics and contextual assessments administered during regular school hours. In addition to student data, the study collected information from parents through a home questionnaire, which provides background information on early learning experiences and home educational resources.

TIMSS applies a two-stage stratified cluster sampling design, in which schools are selected first, followed by intact classrooms within selected schools. The analytic sample comprised 4,349 fourth-grade students from 213 classrooms across 158 schools, forming a nationally representative sample of students in Serbia. Sampling weights provided in the TIMSS database were applied in all primary analyses to ensure population-representative estimates, as detailed in the TIMSS 2023 Technical Report (IEA, 2024; https://www.iea.nl/publications/technical-reports/timss-2023-technical-report).

*Procedure*

Data were collected as part of the standard TIMSS 2023 assessment procedures. Students completed the mathematics achievement test and a background questionnaire during regular school hours, following standardized administration protocols. Parents completed a home questionnaire that included items related to early literacy and numeracy activities, and home learning resources. All instruments and procedures were administered (via paper-and-pencil method) by trained school coordinators in accordance with IEA guidelines, and data were centrally processed and quality-checked by the TIMSS international study center.

*Instruments*

Mathematics achievement was measured using the TIMSS mathematics assessment, which covers key content domains such as number, measurement and geometry, and data and probability. In line with IEA methodology, student performance was represented using five plausible values (IEA, 2024), which are multiple imputed estimates of students' underlying proficiency that allow unbiased population-level inferences while accounting for measurement error.

Socioeconomic background was operationalized using the Home Learning Resources scale, which includes indicators such as the number of books at home, availability of educational materials, and parental education. Higher scores indicate more favorable learning conditions in the home environment.

Preschool attendance was measured using a student questionnaire item indicating the duration of participation in early childhood education prior to entering primary school. Responses were coded to reflect increasing years of preschool attendance.

Early literacy and numeracy were measured using parent questionnaire items reflecting children's skills and activities at the beginning of primary school, such as recognizing letters, reading simple words, counting, and basic number recognition. These variables were included to examine whether early academic skills explain additional variance in later mathematics achievement beyond background and early educational factors.

*Data Analysis*

Primary analyses were conducted using the IEA International Database Analyzer (IDB Analyzer) in combination with SPSS (IBM, 2020). Mathematics achievement plausible values and total student sampling weights were applied in all regression models, and variance estimation procedures appropriate for complex survey data were used in accordance with IEA technical guidelines.

Predictors were entered in four successive regression models. Socioeconomic background was entered in the first model, followed by gender in the second model, preschool attendance in the third model, and early literacy and numeracy indicators in the final model. This stepwise modeling strategy was used to examine the incremental contribution of each set of predictors to mathematics achievement. To explore whether the association between preschool attendance and mathematics achievement differed across levels of socioeconomic background, supplementary analyses were conducted using interaction terms and graphical inspection of predicted values. For graphical presentation and ease of interpretation, preschool attendance was additionally recoded into three broader categories (no or very short attendance, 1–2 years, and 3 or more years), while all regression analyses were conducted using the original categorical variable. These analyses were performed for exploratory purposes, and the same interaction pattern was observed across all five mathematics achievement plausible values.

## Results

Prior to the regression analyses, bivariate associations among home learning resources, preschool attendance duration, early literacy skills, early numeracy skills, and mathematics achievement were examined using Pearson correlation coefficients. As shown in Table 1, all variables were positively associated with mathematics achievement. Home learning resources showed the strongest correlation with mathematics achievement, followed by preschool attendance duration. Early literacy and early numeracy skills were moderately associated with mathematics achievement and exhibited a strong intercorrelation, indicating substantial overlap between these two domains of school readiness.

**Table 1**

*Correlations among home learning resources, preschool attendance, early literacy, early numeracy, and mathematics achievement (TIMSS 2023 Serbia)*

| Variable | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Home learning resources | — | | | | |
| 2. Preschool attendance duration | .35 | — | | | |
| 3. Early literacy skills | .24 | .12 | — | | |
| 4. Early numeracy skills | .15 | .08 | .72 | — | |
| 5. Mathematics achievement | .43 | .23 | .13 | .08 | — |

Note. Values are Pearson correlation coefficients. Mathematics achievement is represented by TIMSS plausible values. All coefficients are statistically significant ($p < .05$).

We next present the four successive regression models examining the contribution of socioeconomic background, gender, preschool attendance, and early academic skills to fourth-grade mathematics achievement (Table 2).

**Table 2**

*Regression models predicting mathematics achievement (TIMSS 2023, Serbia)*

| Predictor | Model 1<br>B (SE) | Model 2<br>B (SE) | Model 3<br>B (SE) | Model 4<br>**B (SE)** |
|---|---|---|---|---|
| Home learning resources | 24.5 (1.7)*** | 24.5 (1.7)*** | 22.3 (1.6)*** | 21.9 (1.6)*** |
| Gender | – | 11.1 (3.3)** | 11.1 (3.4)** | 11.1 (3.5)** |
| Preschool attendance | – | – | 5.2 (1.3)*** | 4.7 (1.3)*** |
| Early literacy | – | – | – | 1.5 (1.2) |
| Early numeracy | – | – | – | −0.4 (1.4) |
| Constant | 275.4 (18.3) | 270.4 (18.1) | 268.9 (18.6) | 264.1 (21.8) |
| $R^2$ | .19 | .19 | .20 | .20 |

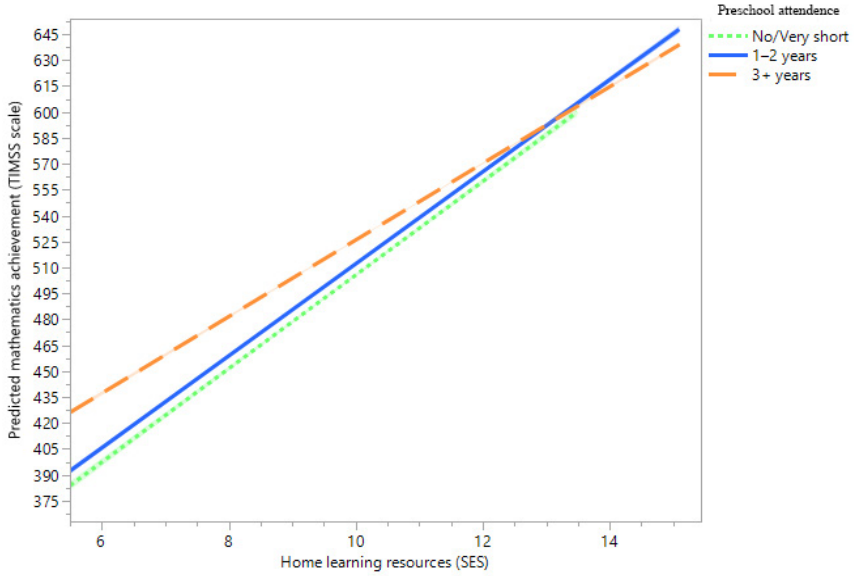
Note. $B$ = unstandardized coefficient, $SE$ = standard error; ** $p$ <.01, *** $p$ <.001; $R^2$ values were taken from the IDB Model Statistics tables.

In Model 1, home learning resources were a strong and statistically significant predictor of mathematics achievement ($B$ = 24.49, $SE$ = 1.66, $p$ <.001), explaining approximately 19% of the variance in achievement scores. This indicates that students with more favorable home learning environments achieved substantially higher mathematics scores. In Model 2, gender was added and showed a small but statistically significant association with achievement ($B$ = 11.11, $SE$ = 3.32, $p$ <.01), while the effect of home learning resources remained stable in both magnitude and significance. The proportion of explained variance remained unchanged ($R^2$ = .19). In Model 3, preschool attendance was entered and emerged as a statistically significant predictor of mathematics achievement ($B$ = 5.21, $SE$ = 1.28, $p$ <.001). Home learning resources and gender remained significant, and the explained variance increased slightly to 20%. In Model 4, early literacy and numeracy indicators were added to the model. Neither early literacy ($B$ = 1.46, $SE$ = 1.15, $p$> .05) nor early numeracy ($B$ = −0.38, $SE$ = 1.29, $p$> .05) contributed significantly to mathematics achievement once socioeconomic background, gender, and preschool attendance were taken into account. The effects of home learning resources, gender, and preschool attendance remained statistically significant and largely unchanged. Overall, socioeconomic background was the strongest and most consistent predictor across all models, while gender and preschool attendance showed smaller but stable associations with mathematics achievement. Early literacy and numeracy did not explain additional variance beyond previously entered predictors.

We also conducted additional analyses using a general linear model to examine whether the association between preschool attendance and mathematics achievement differed across socioeconomic backgrounds. Significant main effects were again found for socioeconomic background, $F$ = 64.24, $p$ <.001, preschool attendance, $F$ = 8.49, $p$ <.001, and gender, $F$ = 26.40, $p$ <.001. Additionally, a significant interaction was observed between preschool

attendance and socioeconomic background, $F = 3.74$, $p = .002$, indicating that the effect of preschool attendance on mathematics achievement varied across SES levels. Inspection of predicted values showed that differences between preschool attendance groups were largest among students from socioeconomically disadvantaged backgrounds, whereas differences were minimal among students from high-SES backgrounds (Figure 1). The same interaction pattern was observed across all five plausible values, indicating that the result was not driven by a single imputed achievement estimate but reflects a robust and consistent association.

*Figure 1*. Predicted mathematics achievement by socioeconomic background and preschool attendance duration (TIMSS 2023, Serbia).




*Note.* Differences between preschool attendance groups are largest at low levels of home learning resources and become smaller as SES increases. This pattern suggests that preschool attendance may be particularly relevant for students from less advantaged backgrounds, although SES remains the strongest predictor of achievement.

## Discussion

The goal of the present study was to examine the association between preschool attendance and fourth-grade mathematics achievement in Serbia using TIMSS 2023 data, and to assess whether this association varies as a function of students' socioeconomic background, while controlling for early academic skills and gender. The results indicated that students' socioeconomic background had the strongest association with mathematics achievement.

A significant gender effect was also observed, with boys achieving slightly higher scores than girls, which is consistent with findings from TIMSS cycles, both at the international level and in national reports for Serbia (IEA, 2024).

Preschool attendance duration emerged as a significant predictor in the model, with longer preschool attendance associated with higher mathematics achievement. This finding highlights the potential role of extended participation in early childhood education in supporting later academic outcomes.

The main finding of the present study concerns the interaction between preschool attendance duration and SES, indicating that the benefits of longer preschool participation are not uniform across SES levels. While students from lower socioeconomic backgrounds appeared to benefit more from extended preschool attendance, differences in mathematics achievement among students from the highest SES levels were small and practically negligible. At these higher SES levels, mathematics achievement did not systematically increase with longer preschool attendance, suggesting diminishing or null returns of extended preschool participation for more advantaged students.

A possible explanation for this pattern is that children from socioeconomically advantaged backgrounds are more likely to experience rich cognitive stimulation and learning support in their home environments, including numeracy-related activities, educational materials, and high levels of parental involvement. As a result, additional years of preschool may provide limited incremental benefits for these children. In contrast, extended preschool participation may play a more substantial compensatory role for children from less advantaged backgrounds by offering structured learning opportunities that are less consistently available in their home environments. This interpretation is consistent with a substantial body of research showing that the effects of schooling and early educational interventions tend to be stronger for children from lower socioeconomic backgrounds (Dinh & Robinson, 2023; Perou et al., 2019).

Although the association between preschool attendance duration and mathematics achievement was positive and statistically significant, the magnitude of this effect was modest. In practical terms, children who attended preschool for four years scored approximately 20 points higher on the TIMSS mathematics scale than children who did not attend preschool at all, corresponding to roughly one-fifth of a standard deviation. Such effects should not be dismissed, as even small differences may have meaningful implications at the population level when applied to large cohorts of children. However, the findings also suggest that preschool attendance alone is insufficient to substantially counterbalance the strong influence of socioeconomic background, which emerged as a far more substantial predictor of mathematics achievement than either preschool duration or gender.

In the present study, early numeracy and early literacy activities / skills did not make a statistically significant contribution to the explained variance in mathematics achievement once other predictors were taken into account. This finding contrasts with a substantial body of research showing that early academic skills are important predictors of later achievement (Lonigan et al., 2000; Paul et al., 2019; Raghubar & Barnes, 2017; Wackerle-Hollman et al., 2024). One possible explanation is that by Grade 4, the direct influence of early skills may diminish as subsequent schooling experiences and more proximal learning factors play a larger role in shaping mathematics performance. In addition, early skills were measured using parent reports, which may have limited precision and variability, thereby reducing their detectable unique contribution in multivariable analyses.

This study is not without limitations. First, the cross-sectional nature of the TIMSS data precludes causal inferences regarding the effects of preschool attendance on later mathematics achievement. Second, information on preschool attendance and early academic skills was based on parent reports, which may be subject to recall bias and limited measurement precision. In addition, the study focused on preschool attendance duration rather than the quality of early childhood education, which may play a crucial role in shaping later academic outcomes. Finally, although the analyses accounted for key background characteristics, unmeasured family, school, and classroom factors may have influenced the observed associations.

Taken together, these findings suggest that while expanding access to preschool education represents an important and worthwhile policy goal, further reductions in educational inequality are likely to require the identification of additional protective factors and interaction effects that operate beyond SES. Future research should therefore move beyond single-factor explanations and examine more complex combinations of early experiences, educational quality, and school-level characteristics that may further reduce differences between high and low SES students.

From a policy perspective, these findings support efforts to expand equitable access to early childhood education, particularly for children from socioeconomically disadvantaged backgrounds. The results suggest that preschool may play a compensatory role in reducing early achievement gaps, highlighting the importance of not only increasing enrolment but also strengthening the quality of preschool provision in Serbia.

Future research should further investigate the mechanisms underlying these effects, with a particular focus on the role of preschool quality and other contextual factors. Longitudinal designs would be especially useful for clarifying causal pathways and disentangling selection effects from the developmental impact of early childhood education.

## Conclusion

This study examined the association between preschool attendance duration and fourth-grade mathematics achievement in Serbia using TIMSS 2023 data, with particular attention to whether this association varies across levels of socioeconomic background, while accounting for early academic skills and gender.

Consistent with previous findings from TIMSS international cycles, socioeconomic background has repeatedly emerged as one of the strongest predictors of mathematics achievement across countries and grade levels (Mullis et al., 2016; Mullis et al., 2020).

Small gender differences were also observed, with boys achieving slightly higher scores than girls. Preschool attendance duration was positively associated with later mathematics achievement, indicating that longer participation in early childhood education is related to better academic outcomes. Importantly, this association varied across socioeconomic groups. Longer preschool attendance was more strongly related to mathematics achievement among children from socioeconomically disadvantaged backgrounds, whereas differences across preschool duration were minimal among students from the highest SES levels. This pattern supports a compensatory interpretation, suggesting that early childhood education may partially offset limited home resources by providing cognitive stimulation, structured routines, and early instruction for disadvantaged children, while offering limited additional benefits for more advantaged students. Despite its statistical significance, the magnitude of the preschool attendance effect was modest. Four years of preschool attendance were associated with approximately one-fifth of a standard deviation increase in mathematics achievement compared to no preschool attendance. While such effects should not be dismissed, they suggest that preschool attendance is only one of several factors contributing to later mathematics achievement, with socioeconomic background remaining a dominant influence.

The findings suggest that expanding access to preschool education in Serbia represents an important policy goal, particularly for disadvantaged children. However, reducing educational inequalities will likely require attention to the quality of early childhood education and broader family– and school-related factors across the educational trajectory.

## References

Bikić, N., Buzađija, N., & Hrnjičić, A. (2024). The impact of early childhood education and mathematical abilities on student achievement: Analysis of TIMSS 2019. *International Electronic Journal of Mathematics Education*, *19*(3), em0779. https://doi.org/10.29333/iejme/14599

Bogovac, T. (2018). Early childhood education and care in Serbia: Current challenges and policies. In *International Perspectives on Early Childhood Education and Care* (pp. 163–174). Routledge.

Broer, M., Bai, Y., & Fonseca, F. (2019). Socioeconomic inequality and educational outcomes: An introduction. 1–6. https://doi.org/10.1007/978-3-030-11991-1_1

Bukva, A., & Memisevic, H. (2025). The relationship between executive functions and mathematics achievements in early-grade elementary students. *Child Neuropsychology*, *31*(4), 635–648. https://doi.org/10.1080/09297049.2024.2421222

Coşkun, B., & Özyer, K. K. (2023). The effect of student characteristics and socioeconomic status on mathematics achievement in Türkiye: Insights from TIMSS 2011–2019. *International Journal of Assessment Tools in Education*. https://doi.org/10.21449/ijate.1272517

Davis-Kean, P., Domina, T., Kuhfeld, M., Ellis, A., & Gershoff, E. (2021). It matters how you start: Early numeracy mastery predicts high school math course-taking and college attendance.. *Infant and Child Development*, 31 2. https://doi.org/10.31234/osf.io/wdvth.

Dinh, P. T. T., & Robinson, J. A. (2023). Persistence and fading of the cognitive and socio-emotional benefits of preschool education in a low-resource setting: Group differences and dose-dependent associations in longitudinal data from Vietnam [Original Research]. *Frontiers in Psychology*, *Volume 14 – 2023*. https://doi.org/10.3389/fpsyg.2023.1065572

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). *Cross-national patterns of gender differences in mathematics: A meta-analysis* [doi:10.1037/a0018053]. American Psychological Association.

Ersan, O., & Rodriguez, M. (2020). Socioeconomic status and beyond: A multilevel analysis of TIMSS mathematics achievement given student and school context in Turkey. *Large-scale Assessments in Education*, *8*, 1–32. https://doi.org/10.1186/s40536-020-00093-y

Gašić-Pavišić, S., & Stanković, D. (2012). Educational achievement of Serbian students in TIMSS 2011. *Zbornik Instituta za pedagoska istrazivanja*, *44*(2), 243–265. https://doi.org/ 10.2298/ZIPI1202243G

Han, S. W., Son, J.-W., & Kang, C. (2017). What do TIMSS studies show about math achievement inequality? A sociological perspective. In J.-W. Son, T. Watanabe, & J.-J. Lo (Eds.), *What Matters? Research Trends in International Comparative Studies in Mathematics Education* (pp. 289–314). Springer International Publishing. https://doi.org/10.1007/978-3-319-51187-0_16

Heyneman, S. P. (2004). The use of cross-national comparisons for local education policy. *Curriculum Inquiry*, *34*(3), 345–352. https://doi.org/10.1111/j.1467-873X.2004.00299.x

IBM. (2020). *IBM SPSS statistics for Windows*. In IBM corp.

Ibralić, I., Kuduzovic, A., & Hadzic, S. (2025). Home environment matters: Predicting TIMSS math success in Bosnia and Herzegovina. *Multidisciplinarni Pristupi u Edukaciji i Rehabilitaciji*. https://doi.org/10.59519/mper7104

International Association for the Evaluation of Educational Achievement. (2024). *TIMSS 2023 international technical report: Methods and procedures*. https://www.iea.nl/publications/technical-reports/timss-2023-technical-report

Kang, C. Y., Duncan, G. J., Clements, D. H., Sarama, J., & Bailey, D. H. (2019). The roles of transfer of learning and forgetting in the persistence and fadeout of early childhood mathematics interventions. *Journal of Educational Psychology*, *111*(4), 590–603. https://doi.org/10.1037/edu0000297

Koršňáková, P., Meinck, S., & Japelj Pavešić, B. (Eds.). (2022). *Dinaric perspectives on TIMSS 2019: Teaching and learning mathematics and science in South-Eastern Europe*. Springer. https://doi.org/10.1007/978-3-030-85802-5

Kravarusić, V. (2021). Factors of professional activity of educators in pedagogical practice. *International Journal of Cognitive Research in Science, Engineering and Education (IJCRSEE)*. https://doi.org/10.23947/2334-8496-2021-9-3-385-398

Lalić-Vučetić, N., & Mirkov, S. (2023). Motivation for learning science and mathematics: TIMSS research in Serbia. *Inovacije u nastavi-časopis za savremenu nastavu*, *36*(3), 1–19. https://doi.org/10.5937/inovacije2303001L

Lehrl, S., Kluczniok, K., Rossbach, H.-G., & Anders, Y. (2017). Longer-term effects of a high-quality preschool intervention on childrens mathematical development through age 12: Results from the German model project Kindergarten of the Future in Bavaria. *Global Education Review*, *4*(3).

Lonigan, C., Burgess, S., & Anthony, J. (2000). Development of emergent literacy and early reading skills in preschool children: evidence from a latent-variable longitudinal study. *Developmental Psychology*, *36 5*, 596–613. https://doi.org/10.1037/0012-1649.36.5.596

Macura-Milovanović, S. (2013). Pre-primary education of Roma children in Serbia: Barriers and possibilities. *Center for Educational Policy Studies Journal*. https://doi.org/10.26529/cepsj.237

Marković, M. (2022). Has Serbia reached the quality of education of EU countries? Multi-criteria evaluation. *Oradea Journal of Business and Economics*. https://doi.org/10.47535/1991ojbe153

Martin, M., & Mullis, I. (2019). TIMSS 2015: Illustrating Advancements in Large-Scale International Assessments. *Journal of Educational and Behavioral Statistics*, *44*, 752–781. https://doi.org/10.3102/1076998619882030

Martin, M. O., Mullis, I. V. S., Foy, P., & Stanco, G. M. (2012). *TIMSS 2011 international results in science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2011/international-results-science.htmlTIMSS 2011 International Results in Science

Matković, T., Dobrotić, I., & Baran, J. (2019). Što vrtić ima s tim? Pristup ranom i predškolskom odgoju i obrazovanju i reprodukcija društvenih nejednakosti u redovnom školovanju: analiza podataka PISA i TIMSS istraživanja. *Revija za sociologiju, 49*(1), 7–35. https://doi.org/10.5613/rzs.49.1.1

Mercugliano, A., Bigozzi, L., De Cunto, A., Graziani, D., Pecini, C., Usai, M., Vecchi, S., & Ruffini, C. (2024). Which childhood predictive indices forecast reading and writing skills in school-age children: A systematic review. *Child Neuropsychology*, 31, 161–196. https://doi.org/10.1080/09297049.2024.2347381.

Melhuish, E., et al. (2015). *A review of research on the effects of early childhood education and care (ECEC) on child development*. In T. Smith (Ed.), Effective Pre-school, Primary and Secondary Education (EPPSE) longitudinal study reports. Institute of Education, University of London.

Mullis, I. V. S., Martin, M. O., & von Davier, M. (Eds.). (2021). *TIMSS 2023 Assessment Frameworks*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2023/frameworks/

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2011/international-results-mathematics.html

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 international results in mathematics*. Boston College, TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2015/international-results/

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. Boston College, TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2019/international-results/

Mutawah, M. A. A., Thomas, R., Al-Hattami, A., Preji, N., & Enizi, M. A. (2019). Initiatives for accomplishing the TIMSS 500 centerpoint through curricula, teachers' development and instructional strategies. *International Journal of Education and Practice*, *7*(3), 200–215. https://doi.org/10.18488/journal.61.2019.73.200.215

Nelson, G., Westhues, A., & MacLeod, J. (2003). A meta-analysis of longitudinal research on preschool prevention programs for children. *Prevention & Treatment*, *6*(1), https://doi.org/10.1037/1522-3736.6.1.631a

Nguyen, T., Watts, T. W., Duncan, G. J., Clements, D. H., Sarama, J. S., Wolfe, C., & Spitler, M. E. (2016). Which preschool mathematics competencies are most predictive of fifth grade achievement? *Early Childhood Research Quarterly*, *36*, 550–560. https://doi.org/https://doi.org/10.1016/j.ecresq.2016.02.003

Organisation for Economic Co-operation and Development (OECD). (2021). *Starting strong VI: Supporting meaningful interactions in early childhood education and care*. Paris: OECD Publishing. https://doi.org/10.1787/f47a06ae-en

Organisation for Economic Co-operation and Development. (2023). *PF3.2: Enrolment in childcare and pre-school*. OECD Family Database. https://www.oecd.org/els/family/database.htm

Paul, J. M., Gray, S. A., Butterworth, B. L., & Reeve, R. A. (2019). Reading and math tests differentially predict number transcoding and number fact speed longitudinally: A random intercept cross-lagged panel approach. In (Vol. 111, pp. 299–313). US: American Psychological Association.

Perou, R., Robinson, L. R., Danielson, M. L., Claussen, A. H., Visser, S. N., Scott, K. G., Beckwith, L., Katz, L., & Smith, D. C. (2019). The Legacy for Children™ randomized control trial: Effects on cognition through third grade for young children experiencing poverty. *Journal of Developmental & Behavioral Pediatrics*, *40*(4), 275–284. https://doi.org/10.1097/dbp.0000000000000656

Raghubar, K., & Barnes, M. (2017). Early numeracy skills in preschool-aged children: A review of neurocognitive findings and implications for assessment and intervention. *The Clinical Neuropsychologist*, *31*, 329–351. https://doi.org/10.1080/13854046.2016.1259387

Republički zavod za statistiku (2025). Predškolsko vaspitanje i obrazovanje u Republici Srbiji u školskoj 2024/2025. godini.

Starkey, P., Klein, A., Clarke, B., Baker, S., & Thomas, J. (2022). Effects of early mathematics intervention for low-SES pre-kindergarten and kindergarten students: A replication study. *Educational Research and Evaluation*, *27*(1-2), 61–82. https://doi.org/10.1080/13803611.2021.2022316

Statistical Office of the Republic of Serbia. (2026). *Preschool education, 2021* (Statistical release). https://www.stat.gov.rs/en-us/vesti/20220420-predskolsko-vaspitanje-i-obrazovanje-2022/

Statistical Office of the Republic of Serbia, & UNICEF. (2020). *Serbia Roma settlements multiple indicator cluster survey 2019 (MICS 6), survey findings report*. UNICEF Serbia. https://www.unicef.org/serbia/media/16726/file/MICS%206%20Multiple%20Indicator%20Cluster%20Survey%20for%202019.pdf

Suna, E., & Özer, M. (2022). *The relationship of preschool attendance with academic achievement and socioeconomic status in Turkey*. Journal of Measurement and Evaluation in Education and Psychology, 13(1), 54–68. https://doi.org/10.21031/epod.1060460

Ševkušić, S., Mirkov, S., & Lalić-Vučetić, N. (2022). Student motivational profiles in science: TIMSS 2019 in Serbia. *Zbornik Instituta za pedagoska istrazivanja*, *54*(2), 117–142. https://doi.org/10.2298/ZIPI2202117S

Thomson, S., Wernert, N., Rodrigues, S., & O'Grady, E. (2020). *TIMSS 2019 Australia. Volume I: Student performance*. Australian Council for Educational Research https://doi.org/10.37517/978-1-74286-614-7

UNICEF Serbia. (2021). *Quality inclusive early childhood education*. UNICEF Serbia. https://www.unicef.org/serbia/en/quality-inclusive-early-childhood-education

van Huizen, T. M., & Plantenga, J. (2018). *Do children benefit from universal early childhood education and care? A meta-analysis of evidence from natural experiments*. Economics of Education Review, 66, 206–222. https://doi.org/10.1016/j.econedurev.2018.08.001

Velišek-Braško, O., & Svilar, M. (2019). Aktuelni koncept rane intervencije u idejama komenskog. *Pedagoška stvarnost*, *66*, 59–70. https://doi.org/10.19090/ps.2019.0.59-70

Vujačić, M., Đević, R., & Jošić, S. (2020). School climate as factor of educational effectiveness of schools: Secondary data analysis from TIMSS 2015 study. *Inovacije u nastavi-časopis za savremenu nastavu*, *33*(2), 15–28. https://doi.org/10.5937/inovacije2002015V

Wackerle-Hollman, A., Hojnoski, R., Missall, K., Abuela, M., & Running, K. (2024). Using Empirical Information to Prioritize Early Literacy Assessment and Instruction in Preschool and Kindergarten. *Assessment for Effective Intervention*, *49*, 190–201. https://doi.org/10.1177/15345084241247059

Watts, T. W., Duncan, G. J., Clements, D. H., & Sarama, J. (2018). What is the long-run impact of learning mathematics during preschool? *Child Development*, *89*(2), 539–555.

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# Važnost socioekonomskog statusa i pohađanja predškolske ustanove za postignuće iz matematike u Srbiji: dokazi iz istraživanja TIMSS 2023

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**Cilj:** Ova studija ispitivala je povezanost između pohađanja predškolskog obrazovanja, socioekonomskog statusa (SES), pola i ranih akademskih veština, i matematičkog postignuća učenika četvrtog razreda u Srbiji, koristeći podatke iz nacionalno reprezentativnog uzorka TIMSS 2023 istraživanja. **Metod:** Postignuće iz matematike analizirano je korišćenjem pretpostavljenih vrednosti, a regresioni modeli su procenjeni u IEA (*International Database Analyzer*) uz uzimanje u obzir težinskih faktora uzorka. Prediktori su uneti u četiri sukcesivna regresiona modela: prvo socioekonomski status, zatim pol i pohađanje predškolske ustanove, i konačno rane veštine pismenosti i numeričke sposobnosti. **Rezultati:** Socioekonomski status se pokazao kao najsnažniji prediktor postignuća, dok su pol i pohađanje predškolske ustanove imali manje, ali i dalje statistički značajne efekte. Rane veštine pismenosti i numeričke sposobnosti nisu doprinosile dodatnoj varijansi kada su ovi faktori uzeti u obzir. Dodatne analize pokazale su da je duže pohađanje predškolske ustanove posebno korisno za učenike iz socioekonomski nepovoljnih sredina, dok su razlike bile minimalne među učenicima iz viših socioekonomskih grupa, što sugeriše kompenzatorni efekat ranog obrazovanja. **Zaključak:** Rezultati ukazuju na to da, iako duže pohađanje predškolske ustanove može delimično kompenzovati nepovoljan socioekonomski status i doprineti boljem postignuću iz matematike, samo po sebi ne može u potpunosti neutralisati snažan uticaj socioekonomskog statusa, naglašavajući potrebu za širim politikama koje unapređuju kvalitet obrazovanja i smanjuju obrazovne nejednakosti.

**Ključne reči:** TIMSS, postignuće iz matematike, predškolsko obrazovanje