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TESTING THE EFFECT OF PRESCHOOL EDUCATION ON FOURTH GRADE STUDENTS' MATHEMATICS ACHIEVEMENT IN THE TIMSS 2015: THE LITHUANIAN CASE

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Abstract

The Lithuanian education system, along with many others, might address the problem of educational inequality. One of its strategic educational goals is to narrow the achievement gap in terms of socioeconomic status (SES) by ensuring equal opportunities for children from families of different SES backgrounds to optimally develop their competencies during school years. However, the findings suggest that not only did the achievement gap between students not narrow, but it significantly widened between 1995 and 2015 – based on the 20-year Trends in International Mathematics and Science Study (TIMSS). Affordable and high-quality preschool education can be seen as one of the most effective policies to reduce differences in competence between children from different SES backgrounds in the early stages of their development. However, the long-lasting effect of preschool education on academic achievement in elementary school is debated, and these effects might differ depending on the elementary school environment to which children are exposed after preschool education. In this study, using Lithuanian data from the TIMSS 2015, we use 2-level random effects models to examine the links between the length of preschool education of students and their mathematics achievement in fourth grade. We ask the following research questions: 1) Is preschool education associated with students' mathematics achievement in fourth grade in the TIMSS 2015, after controlling for the SES of students' families? 2) What are the compositional and interactional effects, with respect to preschool education, on student achievement? The TIMSS 2015 results indicate a significant positive effect of preschool education on mathematics achievement at the student level. However, the composition of the school based on preschool education strengthens the relationship within the school between the student's SES and achievement. It seems that in Lithuania the problem of educational inequality remains and should be further addressed.

Keywords: preschool education, mathematics achievement, Trends in International Mathematics and Science Study (TIMSS).

Introduction

Many educational systems address the problem of educational inequality. Lithuania is no exception, and one of its strategic educational goals is to narrow the socioeconomic status (SES) achievement gap by ensuring equal opportunities for children from families of different SES backgrounds to optimally develop their competencies during school years. However, findings suggest that students' achievement gap did not narrow, instead significantly widening between 1995 and 2015 based on the 20-year Trends in International Mathematics and Science Study (TIMSS) (Broer, Bai, & Fonseca, 2019). It is critically important to further examine educational inequality in Lithuania.

The association between SES and students' academic achievement has been well documented in the literature; however, research on factors that affect this association is limited. Affordable and high-quality preschool education could be seen as one of the most effective policies to reduce differences between the competence of children of different SES backgrounds in the early stages of development (European Commission/EACEA/

Eurydice, 2019). Studies have shown that child-teacher relationships play an important role in children's cognitive and social development (Yoshikawa et al., 2013). From the attachment perspective, if children have insecure attachment with their parents, they tend to be ambivalent towards the exploration of new situations in order to learn new things about the world. Close, supportive relationships with teachers could provide these children with the opportunity to develop alternative models of relations with the social world, ensuring a safe base for exploration (Davis, 2003). However, the long-lasting effect of preschool education on academic achievement in elementary school is debated (Han, Connor, & McCormick, 2019), and these effects may differ depending on the elementary school environment to which children are exposed after preschool education (Ansari & Pianta, 2018).

In this study, we seek to examine the links between the length of preschool education of students and their mathematics achievement in fourth grade by using 2-level random effects models. We ask the following research questions: 1) Is preschool education associated with students' mathematics achievement in fourth grade in the TIMSS 2015, after controlling for the SES of students' families? 2) What are the compositional and interactional effects, with respect to preschool education, on student achievement?

1. Methodology

Data. This study used Lithuanian data from the international fourth grade TIMSS study of 2015 (data downloaded from the International Association for the Evaluation of Educational Achievement (IEA) website in December, 2020). The sample included 4529 fourth-grade Lithuanian students. For analysis, we used all plausible values of mathematics achievement. The highest level of education of the parent was selected as the indicator of family SES. Parents were asked how long their child had attended preschool. We recoded SES and preschool variables so that higher values indicated a higher level of parental education and a longer preschool attendance. To evaluate the school compositional effect, we calculated the average SES and preschool education in each school, referred to as SchoolSES and SchoolPRE.

Analysis. We ran seven 2-level random effects models with Mplus version 8.3. The dependent variable was mathematics achievement (all plausible values, ASMMAT01 – ASMMAT05). Independent variables at the student level were the preschool education of the individual student (ASDHAPS, further, preschool) and family SES (ASD-HEDUP). Within the school level, independent variables were the school's means of preschool education of the students and SES. The null model allows for the mathematics achievement variance decomposition between the individual level and the context (school) level to be observed. Model 1 is a random intercepts model with individual-level preschool and SES predictors. Model 2 is a random intercepts model with preschool and SES predictors within the individual and school levels. Model 3 is a random slope model for SES with the preschool predictor at the individual and school levels. Model 4 is a random slope model for preschool and SES with school-level predictors (preschool, SES). Model 5 is a random slope model for SES with SES and preschool

predictors at the individual and school levels, and with the effect of the cross-level interaction of school preschool education on the effect of mathematics achievement within the school on the SES. Model 6 is a random slope model for SES with the student and school predictors, and with two (school preschool education and school SES) cross-level interactions. Model 7 is a random slope model for preschool education and SES with the school-level predictors (preschool and SES), and with two (school preschool education and school SES) cross-level interactions. The most suitable model was selected according to the lowest values of the AIC and BIC indices.

We applied grand mean centering in the models, which subtracts the whole sample mean from each observation. Different weights were also used at the student and school levels. Student-level weights were constructed from student and class weighting factors (WGTFAC3, WGTFACT2) and response adjustments (WGTADJ3, WGTADJ2). School-level weights were constructed from the school weighting factor (WGTFAC1) and response adjustment (WGTADJ1).

2. Results

The descriptive statistics of student-level variables in the Lithuanian TIMSS 2015 data are presented in Table 1. The results show that one third of Lithuanian students who participated in the TIMSS 2015 were from families where parents had a university education, and another third of students were from families where parents had post-secondary but not university education. Only 12% of participants came from families where parents had not been involved in education after school. Regarding the preschool education of the students, only 5% of participants had not attended preschool education. Of those who had attended preschool education, the majority (58.2%) had attended for three or more years, with fewer participants attending preschool for two years or one year – 6.8% and 16.6%, respectively.

As not all parents provided information about their highest educational level and the preschool attendance of their child, 15.4% of values were missing for family SES and 13.8% for preschool education. Participants who had missing values were excluded from further analysis.

Table 1. Descriptive statistics of student-level variables in the Lithuanian TIMSS 2015

Sample	4529
Gender	50% girls
Average mathematics achievement	535.34
SES (parents' highest education level)	
University or higher	*1566 (36.7%)*
Post-secondary, but not university	*1679 (35.9%)*
Upper secondary	*356 (7.6%)*
Lower secondary	*155 (3.9%)*
Some primary, lower secondary, or no school	*17 (0.5%)*

		Missing	756 (15.4%)
Students' preschool attendance			
		Did not attend	207 (4.6%)
		1 year or less	753 (16.6%)
		2 years	310 (6.8%)
		3 years or more	2636 (58.2%)
		Missing	623 (13.8%)

The results of the 2-level random effects models are presented in Table 2. The results of the null model indicate that the differences between schools explain 24.6% of the variation in the mathematics achievement of fourth grade students. This reveals that the achievement of students in mathematics is at least partially related to the school in which the students are enrolled, which is in line with the results of PISA studies (Brunner, Keller, Wenger, Fischbach, & Lüdtke, 2018). This between-school variance can reflect schools' differences in student composition based on their socio-economic background or other characteristics, and/or can be attributed to the institutional characteristics and policies of schools (OECD, 2006).

Table 2. *The results of 2-level random effects models in the Lithuanian TIMSS 2015*

	NULL	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Observations	4529	3759	3759	3759	3759	3759	3759	3759
Intercept	520.364*** (3.804)[1]	523.091*** (4.017)	524.498*** (3.022)	524.237*** (2.902)	524.138*** (2.902)	522.212*** (2.962)	521.697*** (2.96)	521.655*** (2.965)
Student-level								
SES	not estimated	21.191*** (2.259)	21.185*** (2.26)	random	random	random	random	random
Preschool	not estimated	3.2* (1.694)	3.256* (1.665)	3.171* (1.678)	random	3.45* (1.668)	3.436* (1.67)	random
Variance / Residual variance	3975.311*** (135.448)	3724.753*** (142.814)	3726.393*** (144.413)	3703.015*** (147.607)	3678.443*** (158.128)	3693.943*** (147.364)	3698.513*** (148.116)	3675.357*** (157.11)
School-level								
SchoolSES	not estimated	not estimated	21.325* (10.096)	21.734* (10.137)	21.519* (10.146)	19.314··· (9.921)	20.484* (9.456)	20.344* (9.463)
SchoolPRE	not estimated	not estimated	19.447* (9.868)	19.758* (9.49)	20.121* (9.345)	24.312** (8.919)	22.948** (8.463)	23.214** (8.412)
SES MEAN SLOPE	not estimated	not estimated	not estimated	21.16*** (2.278)	21.14*** (2.28)	20.734*** (2.254)	21.129*** (2.356)	20.984*** (2.338)
Preschool MEAN SLOPE	not estimated	not estimated	not estimated	fixed	3.243··· (1.727)	fixed	fixed	3.535* (1.726)
SES SLOPE VARIANCE	not estimated	not estimated	not estimated	46.976 (68.392)	41.531 (67.044)	28.978 (46.083)	20.565 (50.813)	14.211 (51.836)
Preschool SLOPE VARIANCE	not estimated	not estimated	not estimated	fixed	33.179 (44.266)	fixed	fixed	32.891 (44.672)

	NULL	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
CROSS-LEVEL INTERAC-TION (SchoolPRE predicts slope of achievement on SES)	not esti-mated	not esti-mated	not esti-mated	not esti-mated	not esti-mated	14.678* (6.63)	12.133 (7.959)	12.07 (7.922)
CROSS-LE-VEL INTE-RACTION (SchoolSES predicts slope of achievement on SES)	not esti-mated	not esti-mated	not esti-mated	not esti-mated	not esti-mated	not esti-mated	3.976 (4.032)	3.868 (4.079)
Variance / Residual variance	1373.799*** (159.794)	1478.418*** (185.292)	605.631*** (123.888)	581.351*** (117.512)	574.92*** (115.293)	564.918*** (110.617)	562.021*** (108.877)	556.082*** (106.525)
AIC	50896.728	42067.637	41893.783	41893.681	41893.835	**41871.896**	41872.519	41872.583
BIC	50915.982	42098.797	41937.406	41943.537	41949.922	**41927.983**	41934.838	41941.134
Number of free parameters	3	5	7	8	9	9	10	11
R2 within	-	0.068	0.095	-	-	-	-	-
R2 between	-	-	0.364	-	-	-	-	-
ICC for math achievement	0.246	0.261	0.180	0.180	0.180	0.180	0.180	0.180

Notes: Standard errors shown in parentheses. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$; •$p < 0.1$; School-SES – school mean of SES; SchoolPRE – school mean of preschool education.

Model comparison based on AIC and BIC values shows that the random slope model for SES with student-level preschool and school-level SES and preschool predictors, and with preschool cross-level interaction (model 5), is best suited to explaining mathematics achievement in the TIMSS 2015. The results show that preschool education is positively associated with mathematics achievement at the student and school level. This means that there are compositional effects based on preschool education on individual mathematics achievement in addition to the individual effects. In addition, we see the positive effect of the school preschool cross-level interaction effect on student SES and the mathematics achievement slope. This reflects the notion that school composition based on preschool education strengthens the within-school relationship between student SES and achievement.

Conclusions

Based on secondary data from the Lithuanian TIMSS 2015 results, we can observe the significant positive effect of preschool education on mathematics achievement at the student and school levels. This allows us to conclude that longer preschool

education could be associated with higher academic achievement in primary school. A significant compositional effect regarding preschool education also shows that the collective school capital that occurs when many children attended longer preschool education contributes to achievement, on top of the individual effect. It seems that it is useful to have a longer preschool education period and to ensure that all children have the opportunity to participate in preschool education because if there were many students at school with a longer preschool education, this would have an additional effect on achievement.

However, contrary to our expectations, the cross-level interaction effect based on preschool education was positive with regards to the individual SES-achievement slope. It seems that if many students at the school have a longer preschool education, a student with low SES benefits less from the joint school capital than other students. Consequently, we can conclude that it is critically important in Lithuania to discuss the policy of compulsory primary education. Besides this, issues of the SES achievement gap should be further addressed.

Acknowledgements

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Summary

The Lithuanian education system, along with many others, might address the problem of educational inequality. One of its strategic educational goals is to narrow the achievement gap in terms of socioeconomic status (SES) by ensuring equal opportunities for children from families of different SES backgrounds to optimally develop their competencies during school years. However, the findings suggest that not only did the achievement gap between students not narrow, but it significantly widened between 1995 and 2015 – based on the 20-year trend in International Mathematics and Science Study (TIMSS) (Broer, Bai, & Fonseca, 2019). Affordable and high-quality preschool education can be seen as one of the most effective policies to reduce differences in competence between children from different SES backgrounds in the early stages of their development (European Commission/EACEA/Eurydice, 2019). However, the long-lasting effect of preschool education on academic achievement in elementary school is debated, and these effects might differ depending on the elementary school environment to which children are exposed after preschool education (Ansari & Pianta, 2018). In this study, using Lithuanian data from the TIMSS 2015, we use 2-level random effects models to examine the links between the length of preschool education of students and their mathematics achievement in fourth grade. We ask the following research questions: 1) Is preschool education associated with students' mathematics achievement in fourth grade in the TIMSS 2015, after controlling for the SES

of students' families? 2) What are the compositional and interactional effects, with respect to preschool education, on student achievement? The sample included 4529 fourth-grade Lithuanian students. For the analysis, we used all plausible values of mathematics achievement. The highest level of education of the parent was selected as the family SES indicator, and parents were asked how long their child had attended preschool. We ran seven 2-level random effects models with Mplus version 8.3. The dependent variable was mathematics achievement (all plausible variables), and independent variables within the student level were the preschool education of the individual student (further, preschool) and their SES. Within the school level, the independent variables were the school's means of preschool education of students and SES. The results of the null model indicate that the differences between schools explain 24.6% of the variation in the mathematics achievement of fourth grade students. Model comparison based on AIC and BIC values shows that the random slope model for SES with student-level preschool and school-level SES and preschool predictors, and with preschool cross-level interaction, (model 5) is the best suited to explaining mathematics achievement in the TIMSS 2015. The results indicate a significant positive effect of preschool education on mathematics achievement at the student and school levels. Longer preschool education is associated with higher academic achievement in primary school. In addition, a significant compositional effect regarding preschool education shows that collective school capital that occurs when many children attend preschool education for a longer time contributes to achievement, on top of its individual effect. However, the composition of the school based on preschool education strengthens the relationship within the school between the SES of students and their achievement level. Contrary to our expectations, it seems that if many students in the school attend preschool education for a longer time, a student with low SES derives less benefit from the joint school capital than other students. Based on these results, we can recommend the introduction of compulsory preschool education in Lithuania, as this policy might ensure the accessibility of preschool education to all children. In addition, our results show that there is a problem of educational inequality in Lithuania. The issue of the SES achievement gap needs to be further addressed in Lithuania, as the 2015 results show that in the cases of certain students and certain school conditions, preschool education not only did not narrow the SES achievement gap, but even strengthened it.

Keywords: *preschool education, mathematics achievement, Trends in International Mathematics and Science Study (TIMSS).*

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