Informatics in Education, 2021, Vol. 20, No. 3, 439–462

DOI: 10.15388/infedu.2021.18

Centralised Mathematics Assessments of Lithuanian Secondary School Students: Population Analysis

Audronė JAKAITIENĖ[1], Rimantas ŽELVYS[1,2],
Jogaila VAITEKAITIS[1,2], Saulė RAIŽIENĖ[1,3], Rita DUKYNAITĖ[1]
[1]*Institute of Data Science and Digital Technologies, Vilnius University, Vilnius, Lithuania*
[2]*Institute of Educational Sciences, Vilnius University, Vilnius, Lithuania*
[3]*Institute of Psychology, Vilnius University, Vilnius, Lithuania*
e-mail: audrone.jakaitiene@mf.vu.lt, rimantas.zelvys@fsf.vu.lt, jogaila.vaitekaitis@fsf.vu.lt, saule.raiziene@fsf.vu.lt, rita.dukynaite@mif.vu.lt

Abstract. We focus on two types of centralised national examinations (the 10th grade tests and Matura examination) that are being carried out in Lithuania for two decades. The aim of the paper is to analyse assessments of mathematics for the entire Lithuanian secondary school population that have no sampling errors while considering the factors of location, school ownership and gender as important indicators when judging about educational effectiveness in terms of quality and equity. We analyse the results of the 10th grade tests for the 2011–2015 period and the results of the same cohorts participating in the Matura examination. We observe that the distribution of the assessments of both exams is asymmetric with a positive skew. The median often is below the middle of the grade scale indicating poor performance or mismatch between knowledge and examination tasks. There are limited differences in assessments with respect to gender and school location, although we detect a tendency to have better mathematics achievement in private schools. The conclusions drawn from national assessment data is somewhat different from international data thus one cannot neglect national information for the development of educational policy. The variables analysed in the analysis has limited predictive power for achievements in mathematics and further analysis is called-for.

Keywords: mathematics achievements, population data, 10th grade test, national Matura examination.

1. Introduction

Present-day life dictates the necessity to have good numeracy skills. Mathematical knowledge is essential for practical everyday functioning as well as for individual development. This exact science has an effect on student's educational achievements not only in the subject of math, but in all fields of STEM (science, technology, engineering, math). It is fundamental for understanding nature, architecture, machinery, finances, cartography, technology etc. Moreover, mathematics is crucial beyond utilitarian endeavours. In Ancient Greece, expertise in mathematics was considered a precursory for the study of philosophy. Modern era western tradition philosophers, such as Immanuel Kant, Baruch Spinoza, and Ludwig Wittgenstein, all have used mathematics to grasp epistemology and human reasoning processes (Chesky and Wolfmeyer, 2015). From Computational Thinking that develops student's cognitive processes of abstraction, decomposition or problem-solving skills, to onto-epistemological-ethical life meaning-making, mathematics is here to stay. To no surprise, mathematics examination is obligatory for school exit or "maturity diploma" world-wide. Before delving into the results of national centralised mathematics examinations, we will outline the historical particularities of school leaving examinations in Lithuania, focusing on mathematics.

Lithuania was one of the first former socialist countries to introduce the system of external secondary school leaving, or Matura, examinations. The Lithuanian National Examinations Centre (NEC) was established in 1997 and centralized secondary school examinations were run for the first time in 1999 (Bethel and Zabulionis, 2000). The 10th grade tests were introduced in 2000, and, differently from Matura examinations, students‘ participation in assessment was voluntary. However, in 2011 the 10th grade test (also known as basic education achievement test (Lith. PUPP)) in mathematics and Lithuanian language were made compulsory (OECD, 2017). The examination tasks are developed by NEC, but, unlike the Matura examinations, they are marked by local teachers.

School leaving examinations eventually replaced the entrance examinations to universities. State level Matura examination (Lith. VBE) is intended to assess the achieved level of competences proving students' maturity and is used as an instrument for higher education institutions in selecting potential candidates to be enrolled. 10th grade achievement tests intention is to provide students and their schools with information about learning outcomes and continuity. Matura examinations, 10th grade tests, as well as international studies and other assessments of the education performance have different purposes and goals. Thus, in spite of the fact that different types and forms of assessments have their own goals, information obtained by all of them can serve for increasing the effectiveness of the education system.

Experts suggest alternative models where Matura examinations are combined with other forms of assessment. One of the possible options is the use of the 10th grade test results as a component of higher education admission process – in conjunction with the Matura examinations (OECD, 2017). However, it remains unclear to what extent these two types of examinations can supplement each other, as they rely on different methodological principles and use different marking systems (marking systems are described in Section 3).

Educational quality and equity are one of the key priorities indicated in policy documents of national governments as well as international organizations. Educational effectiveness is one of the measurable facets of educational quality and equity. In the most general sense school effectiveness refers to the level of goal attainment (Scheerens, 2016). One of the commonly used indicators of educational effectiveness are student achievements in international large-scale student assessment (further in the text referred to as ILSA) studies and national school leaving examinations (Somerset, 2011; Kyriakides and Creemers, 2011; Engel and Rutkowski, 2014). For example, in countries where regional differences prevail, schools in villages and small settlements are often undersupplied with human and material resources when compared with schools in large towns and cities. Australian researchers conducted a series of studies with the use of TIMSS and WASES (Western Australia School Effectiveness Study) data which showed that rural and remote location students were disadvantaged in terms of their achievement and the difference was statistically significant. Students were found to achieve significantly lower science and mathematics results irrespective of grade and socioeconomic and cultural (further in the text referred to as SEC) status or other background variables (Young, 1998; Webster and Fisher, 2000; Young, 2000; Panizzon, 2015). Williams (2005) examined cross-national variation by using PISA 2000 data in rural mathematics achievement among 15-yearolds in 24 industrialized nations. Rural mathematics scores were significantly lower than scores in urban and medium-sized communities in 14 of 24 countries. In some countries, however, students in medium-size communities scored highest, followed by urban and then rural locales. In some countries, such as the USA, students in urban communities scored lowest. Once SEC was controlled, rural locale predicted mathematic scores in only 4 of 24 countries. Kryst *et al.* (2015) examined eight grade TIMSS data from five post-socialist countries: Lithuania, Russia, Romania, Hungary and Slovenia. The authors conclude that the fall of communism have not had a positive impact on the educational outcomes of rural students in the area of science. In 2011, rural students in Lithuania scored on average over 23 points lower than urban students even after controlling for gender and family SEC. However, family SEC explains away the rural deficit in Russia, Romania and Slovenia. Therefore, educational research does not provide clear evidence that rural schools are inferior to urban schools (Reeves and Bylund, 2005), so there is a need for more research on urban-rural differences in other school quality factors (Othman and Muijs, 2013).

General public and policy makers voice a continuous concern about the educational quality of Lithuanian rural schools. A decade ago the Ministry of Education and Science in a policy paper on urban and rural differences stated that in rural regions teachers were less qualified, schools were undersupplied with ICT, offered less extra-curricular activities and support services, school infrastructure was less developed and required renovation. The paper noted differences of student achievement in urban and rural schools during the 2003, 2005 and 2007 national testing of 8th grade students. However, since 2003 the results of students in cities and regional centres remained more or less at the same level while the results of students in small towns and villages improved (MoES, 2011). Differences in quality of urban and rural schools were also indicated in State education strategy for 2013–2022 (MoES, 2014). Aside from school location, another frequently discussed factor affecting educational quality and equity is school choice and type.

A great number of scholarly debates concerns educational policies on school choice and competition focusing on public *vs* private sector (Adamson *et al.* 2016; Chakrabarti, and Peterson, 2009; Koinzer *et al.*, 2017). One of the main reasons for offering school choice is a neoliberal one. It is believed, that it creates competition between schools, which, in turn, improves the quality of education. Opponents of this idea highlight, that not all parents are able to exercise this choice to the same extent, since government independent private schools usually charge additional fees (Burgess and Briggs, 2010). While international organizations classify private education institutions into government-dependent institutions (ones that receive at least 50 percent of funding from government) or government-independent institutions (ones that receive less than 50 percent of funding from government) (UNESCO-OECD-Eurostat, 2019), in Lithuania, due to specific funding peculiarities it is hard to distinguish between these two types (Eurydice, 2018). Nonetheless it is noteworthy, that private schools in Lithuania usually receive state funding and collect additional fees. Fee amounts are set by each private school and can reach from 60 to 16 929 Eur a year (Migonytė, 2018). While only 3.6% of lower secondary and 2.2% of higher secondary pupils were in private education institutions in Lithuania (2017 data) (Eurydice, 2020), it is worth mentioning, that, as stated by the Lithuanian Department of Statistics, in the period of 2010 to 2020 the number of private general education institutions has more than doubled (from 30 to 74) increasing student numbers from 5 438 to 14 889.

It is argued, that private schools can cream off socio-economically advantaged and high-ability students which could increase social and academic segregation, and consequently, decrease educational equity (Ammermüller, 2005; Bodovski *et al.*, 2017; Eurydice, 2020). Zabulionis (2020) notes, that on average achievements of Lithuanian students in private schools in reading, mathematics, sciences are significantly higher (about 60 points on the PISA scale) than their peers from public schools. However, pupils in private schools also stand out for their significantly higher SEC status (around 65 points on the relevant SEC status scale), thus, the educational value added of non-state (private schools) is not evident in ILSA. Concerning the social cohesion effects of school choice, Phillips *et al.*, (2015) stresses, that student stratification across educational institutions could add to the private benefits at the price of social objectives. In other words, isolating and segregating low SEC status students from higher ones using pay-wall may adversely affect both the efficiency and the equity of the education system (OECD, 2019a). The section below describes another important factor affecting educational effectiveness – gender achievement differences.

Analysing the effectiveness of the education system in terms of equity, we investigate differences in academic achievement between gender. In effective education systems, one seeks to maximize the cognitive potential of both genders – boys and girls (Miller and Halpern, 2014). Gender disparities in mathematics performance vary across countries (OECD, 2019; Mullis *et al.*, 2016). ILSA studies conducted using the same methodology across different countries over the past few decades reveal a trend of gender gap favouring boys in mathematics decrease and emergence of the difference favouring girls (see Mullis *et al.*, 2016; OECD, 2019). In particularly, the largest difference between boys and girls are recently observed not at the average mathematics performance, but at the top and the bottom of the distribution of mathematics performance, meaning that among the highest and the lowest performers boys are over-represented in comparison with girls. Results of TIMSS 2015 (Mullis *et al.*, 2016) and PISA 2018 (OECD, 2019) have revealed no gender disparities in average mathematics performance among the 4th grade, the 8th grade and 15 years-old Lithuanian students. However, there were more girls than boys among the highest, when there were more boys than girls among the lowest 15 years-old mathematics performers. The under-representation among the top performers and the over-representation among the bottom performers of boys indicates that there could be some gender gap favouring girls in mathematics in Lithuanian high-schools, therefore the future analyses on gender differences in mathematics achievement using national examination data is necessary to validate possible "boys' crises" in Lithuanian educational system.

We aim answering the following research questions: *whether the results of 10th grade national testing and Matura examinations reflect differences between rural and urban schools, state, municipality and private schools, boys and girls, and to what extent they correspond with trends observed from ILSA studies?*

We consider factors of location, school ownership and gender as important indicators when judging about educational effectiveness in terms of quality and equity. ILSA studies are based on the results of a representative sample, which one summarizes for the entire population. In this article, we analyse the national examination data for the entire Lithuanian secondary school population that have no sampling errors.

2. Methodology

2.1. *Data*

In this study, we use individual level data for the entire Lithuanian secondary school student population, who have taken Matura examinations for the 2014–2018 period[1]. We do not analyse the examination data of vocational schools. We analyse the results of mathematics Matura examinations and the achievements of the respective 10th grade test. The data was provided by the Education Management Information System (EMIS, Lith. ŠVIS) of the Ministry of Education, Science and Sports. We analyse the distribution of student's achievements for the 10th grade tests and Matura examinations, respectively, according to the year of taking the exam, as well as gender, school location, and type (state, municipal and private). Differences in achievements of urban and rural schools were compared according to school location in the five groups: Vilnius (capital of Lithuania), large cities (Kaunas, Klaipėda, Šiauliai, Panevėžys), cities (15–100 thous. inhabitants), small cities (3–15 thous. inhabitants), rural area (<3 thous. inhabitants).

2.2. *Methods*

In this article, we analyse population data where the number of records varies from 15,000 to 36,000 depending on the type of exam and academic year (Table 1). For the

[1] The data for the implementation purposes of project EFECTAS (`https://www.efectas.projektas.vu.lt`) were obtained in 2019 and does not examine the most recent data.

normality check when there are more than 5,000 records, the frequently used Shapiro-Wilk criterion is not applicable. Therefore, the Anderson-Darling Goodness of Fit Test, which is used for large data and has sufficient power for asymmetric distributions, was chosen to check the normality (Wijekularathna *et al.* 2019). To answer the research question, we start from simple linear dummy (factor variables coded 0/1) regression models for each factor: gender, school location and ownership. From the latter analysis, the coefficients of determination will be calculated, which will allow us to quantify the importance of each factor for mathematical achievements. Next, we will combine these factors with additional student-level context factors (age, social support indicator, special needs indicator and foreigner status) into a multiple linear regression models. Student-level context factors are described in Subsection 3.4. From these models, we will judge about the suitability of the selected variables for predicting mathematical achievement for each school year. Beyond this ICC intra-school variation coefficient is calculated to estimate the proportion of variance explained by school differences in achievement. We present following descriptive statistics according to selected factors: mean, standard deviation (SD), interquartile range (IQR), minimum, first quartile (Q1), median (Q2), third quartile (Q3), and maximum. We report results for population data, therefore all calculated parameters are population parameters for which standardized errors (SE) are presented. All statistical analysis was performed using R version 3.6.3 and RStudio version 1.2.5033.

3. Analysis of Achievements with Respect to Quality and Equity

Before delving into the factors explaining student achievements we will briefly discuss important features of both 10th grade test and Matura exam regarding purpose, design, and score presentation. The 10th grade tests are supposed to serve as a tool of quality assurance in order to monitor the student achievements and to set the standards for self-evaluation and school improvement. The State Matura examinations, in addition to monitoring proposes are used for student selection to universities and colleges. It is of high importance what model of grading is used in both of them. Analysing the 10th grade tests and Matura exams two grading models are relevant: criterion-referenced assessment and norm-referenced assessment. 10th grade tests used criterion-referenced assessment from the start, while Lithuanian Matura examination system switched from norm-referenced assessment to criterion-referenced in 2013. These two sets of assessments are fundamentally different in terms of purpose, design, and score presentation. As noted by Lok *et al.*, (2016) norm-referenced assessment ranks a student relative to a group (class, school, cohort) effectively showing a relative position of the student in the queue of all students, the criterion-referenced assessment avoids judging student against his or her peers and measures the degree of achievement based on standard learning objective, this way reflecting the progress of development of individual student. The goals of both exams are suitable for criterion-referenced assessment. The important difference is score presentation. Criterion-referenced assessment presents the score as grades linked to criteria, while norm-referenced grades, are derived from raw scores, usually presented in a "bell curve" or normal distribution (Lok *et al.*, 2016). Royal and Guskey (2015) stress, that while normal distribution is appropriate for norm-referenced assessments it is inappropriate to force it into criterion-referenced assessment grading in a post-hoc manner, since educational process is considered "intervention" into normal distribution with the goal to alter the shape of the distribution so that it would be negatively skewed (p. 252).

In the article, we analyse the achievements in mathematics in five cycles (Table 1), i.e. students who took the 10th grade test from 2011–2012 to 2015–2016 academic year, and the results of the same cohort after two years participating in Matura examination. Due to the declining population, we observe the decreasing trend[2] of participants. About 3% do not attend or are exempted from the 10th grade test and, respectively, about 5% from the state Matura examination.

Different assessment scales are used for 10th grade tests and Matura exams. 10th grade test is evaluated on a 10-point scale, while Matura exam is assessed firstly on a 60-point scale, then, converted to 100-point scale. We note that on a 100-point scale there are no observations between 1 point and 15 points of the Matura exam (it is considered, that if student gets 1 to 15 points – he or she fails the exam). Thus we are left with a data gap. We think, that this practice is not transparent or fair to students, nor

Table 1

Student population of analysed secondary schools in Lithuania

	1 cycle	2 cycle	3 cycle	4 cycle	5 cycle
	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016
10th grade test	**37549**	**36581**	**33050**	**32043**	**31180**
Participated, N	36325	35268	31901	31082	30459
Participated, %	96.7	96.4	96.5	97	97.7
Annual growth, %		-2.6	-9.7	-3	-2.7
Absence, N	1224	1313	1149	961	721
Absence, %	3.3	3.6	3.5	3	2.3
	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018
Matura examination	**15619**	**14427**	**17710**	**17346**	**17080**
Participated, N	14937	13786	16820	16516	16236
Participated, %	95.6	95.6	95	95.2	95.1
Annual growth, %		-7.6	22.8	-2.1	-1.5
Absence, N	682	641	890	830	844
Absence, %	4.4	4.4	5	4.8	4.9

[2] The increase in participants observed in 2015–2016 is related to the new requirement - entrants to state-funded places in Lithuanian higher education institutions (except for specialties in the field of arts) must have passed the state Matura examination in mathematics.

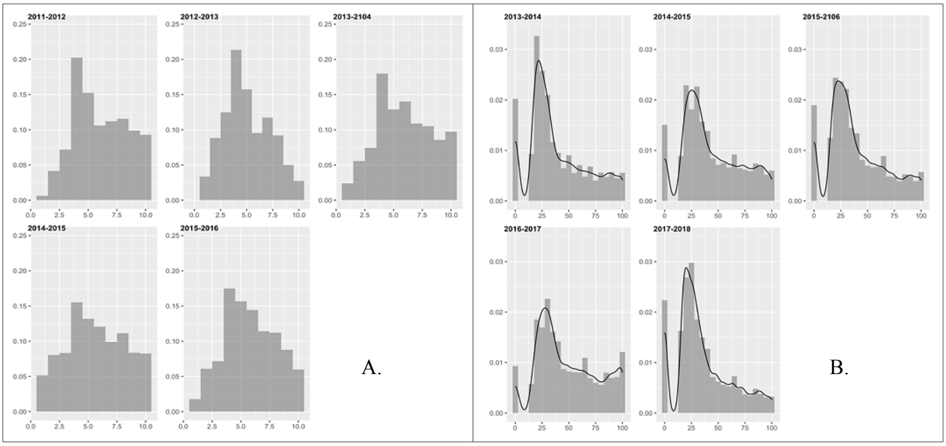

Fig. 1. The distributions of grades for: A. – 10th grade test; B. – Matura examination.

appropriate from the perspective of modern educational sciences. Also distinct scales complicate comparison between exams. Additionally, an analysis of discontinued distribution is complicated.

As described above, in our analysis all examinations have used criterion-referenced assessment systems and achievement distribution supposed to be negatively skewed, i.e. a mean should be smaller than the median. As expected, the results of both 10th grade test and Matura examination do not follow the normal distribution. Graphical inspection of distribution (Fig. 1) and Anderson-Darling test confirm the finding. Instead of negative skewness of achievement distribution, we observe a positive skew for both examinations, which is opposite to expectations. The shape of Matura examination distribution is in line with the calculations of National examination centre[3].

We observe the mode equal to 4 for 10th grade test. The histograms of Matura examination have a peak between 20–30 points. Around half of the students receive grades below 42 points in the Matura examination (Fig. 1 and Table 3). The average score of 10th grade test is always higher than the average score of Matura examination (divided by 10): the difference is between 50% and 200% depending on the year of examination (see Fig. 2). The average score of Matura examination has some upward bias compared to the median, indicating that high grades lift it up. Around half of the grades of Matura examination are below 28–42 points on a 100-point scale. Up and down pattern in the annual chart is not typical, indicating possible structural changes each second year.

Since the distributions of achievement do not correspond to the normal distribution, one should analyse the median as a characteristic of the centre instead of the mean. As a result, we will present both characteristics, but the analysis will be based on the median comparison in a further analysis.

[3] Overall distribution of achievements could be found following the `https://www.nec.lt/714/`

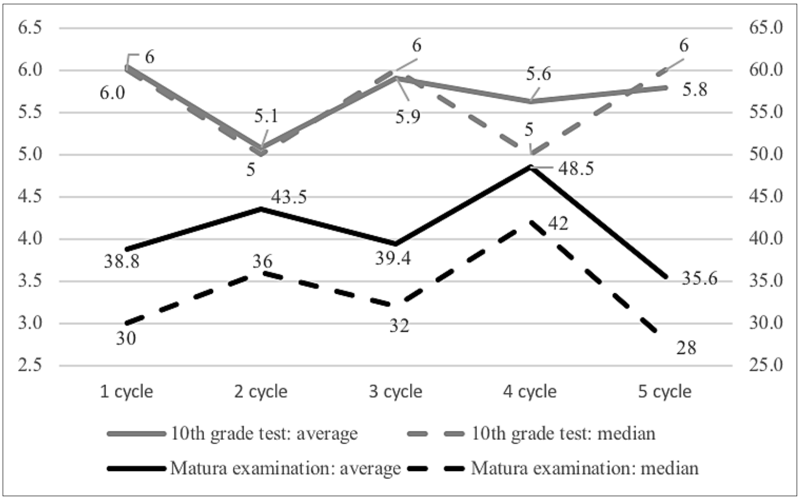

Fig. 2. Average and median dynamics of the achievements for 10th grade test and Matura exams.

3.1. *Gender Differences*

Analysing differences with respect to gender, we observe minor differences, if any. The distributions of achievements are overlapping for each academic year (see Fig. 3).

With respect to the 10th grade test, the median of girls is one unit larger than or equal to the median of boys (see Table 2). About half of the students obtained less than 5 or 6, indicating poor knowledge of math in grade 10. We observe that girls are more likely to receive scores 6 or higher, while boys are more likely to obtain score 5 or smaller. Similar pattern of achievements distribution is observed in PISA 2018 (OECD,

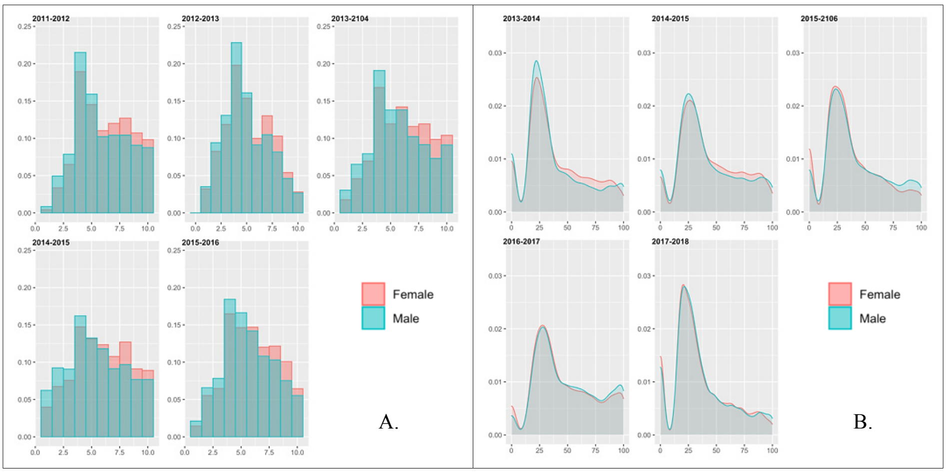

Fig. 3. The distributions of grades with respect to gender for:
A. – 10th grade test; B. – Matura examination.

Table 2
Descriptive summary of 10th grade test achievements according gender

	Mean	SD	IQR	Min	Q1	Q2	Q3	Max	N	R^2, %
2011–2012										
Total	6	2.3	4	1	4	6	8	10	36325	
Female	6.2	2.3	4	1	4	6	8	10	17911	0.55
Male	5.9	2.3	4	1	4	5	8	10	18414	
2012–2013										
Total	5.1	2.2	3	0	4	5	7	10	35268	
Female	5.2	2.2	3	1	4	5	7	10	17378	0.36
Male	5	2.2	4	0	3	5	7	10	17890	
2013–2014										
Total	5.9	2.4	4	1	4	6	8	10	31901	
Female	6.1	2.4	4	1	4	6	8	10	15664	0.81
Male	5.7	2.4	4	1	4	5	8	10	16237	
2014–2015										
Total	5.6	2.6	4	1	4	5	8	10	31082	
Female	5.9	2.5	4	1	4	6	8	10	14964	0.8
Male	5.4	2.6	4	1	4	5	8	10	16118	
2015–2016										
Total	5.8	2.3	4	1	4	6	8	10	30459	
Female	6	2.3	4	1	4	6	8	10	14922	0.55
Male	5.6	2.3	3	1	4	5	7	10	15537	

R^2 – coefficient of determination from simple linear dummy regression.

2019). The proportion of boys and girls participating in 10th grade test is almost equal and stable in every academic year analysed. The gender variable explains 0.4%%–0.8% of the variation in achievement in the 10th grade test.

Regarding the Matura examination, the gender gap in achievement is not persistent over the period under review. In the first two academic years, the median of girls is larger than boys (see Table 3). As from 2015–2016, the median of boys overtakes the median of girls and the gap diminishes in 2017–2018. The variable gender explains 0.03% –0.46% of the variation in achievement in the Matura examination. Interestingly, in 2017–2018, the highest grades became an outlier for both genders. In addition, we observe that after the math exam became mandatory in order to obtain a state-funded place at university, the proportion of girls increased to 54% in taking the mathematics as secondary school Matura examination. Until then, an equal proportion of participation between the genders was observed. This suggests that some boys choose not to attend or delay math Matura exams, which can later lead to disparities in favour of girls in higher education and may have long-term consequences for boys' professional future.

In summary, we observed limited gender gap in 10th grade test results that could be expected based on the results of the PISA 2018 survey (OECD, 2019). However, the results from Matura examination do not confirm the "boys' crises" in the Lithuanian

Table 3

Descriptive summary of Matura grade achievements according gender

	Mean	SD	IQR	Min	Q1	Q2	Q3	Max	N	R^2, %
2013–2014										
Total	38.8	26.9	35	0	21	30	56	100	14937	
Female	39.9	26.8	37	0	21	32	58	100	7557	0.16
Male	37.8	27	34	0	20	29	54	100	7380	
2014–2015										
Total	43.5	27	39	0	24	36	63	100	13786	
Female	44.4	26.6	40	0	25	38	65	100	7016	0.11
Male	42.6	27.4	41	0	22	34	63	100	6770	
2015–2016										
Total	39.4	26.2	34	0	22	32	56	100	16820	
Female	37.8	25.5	33	0	21	32	54	100	9199	0.46
Male	41.4	27	39	0	22	33	61	100	7621	
2016–2017										
Total	48.5	27.5	44	0	26	42	70	100	16516	
Female	47.3	27.4	44	0	26	40	70	100	8857	0.22
Male	49.9	27.6	44	0	28	45	72	100	7659	
2017–2018										
Total	35.6	25	29	0	20	28	49	100	16236	
Female	35.2	24.9	29	0	20	28	49	100	8801	0.03
Male	36	25.2	29	0	20	28	49	100	7435	

R^2 – coefficient of determination from simple linear dummy regression.

educational system, asserting this area of educational equity as unimpaired. An analysis of the results of both the 10th grade test and the Matura exam reveals that the differences in mathematics achievement between the genders are smaller than the dispersion of the mathematics results for each gender.

3.2. *Urban vs Rural*

Analysing student achievement with respect to school location, we observe overlapping distributions, similarly to gender, signalising about no differences between urban and rural areas. Even though results from ILSA studies indicate the existing differences between urban and rural student samples in Lithuania. Zabulionis (2020) notes that average results of rural students in all PISA cycles in which Lithuania participated (2006–2018) were the lowest when compared with other areas and the trends didn't change over time. Average results in large cities remained the highest and eventually slightly improved. Average differences between large cities and cities increased between 2015 and 2018, and differences between middle-sized cities and small towns in 2018 diminished. In 2018 differences between average achievements of urban and rural students exceeded 60 points. Zabulionis (2020) concludes that differences between average achievements of urban and rural students are increasing over time. One must note that ILSA studies are designed so that the distribution of achievements corresponds to the normal distribution and the comparison of means as a centre characteristic is appropriate. Meanwhile, as shown earlier, the distribution of achievement in national exams does not correspond to the normal distribution and therefore the median is analysed as a centre characteristic of the distribution instead of a mean.

From the analysis of national 10th grade test achievements, we can observe similar tendency of medians. Median of achievements are larger in Vilnius and large cities compared to other locations (Table 4). Students from Vilnius and large cities make up 40 percent of all secondary school students' population in 10th grade test. Also the higher proportion of 8–10 evaluations is observed in Vilnius and large cities (Fig. 4). However, except Vilnius (15.2%–16.1% of total population in 10th grade test), in all other locations, 25% of students fail the 10th grade test and median is varying between 5 and 6. This indicates that in Lithuania around 50% of students have poor knowledge of mathematics at 10th class. The school location explains from 2.4% to 4.7% of the variation in the achievement of the 10th grade test.

Considering the results of the Matura examination, we note that the smallest median of the achievements is in the rural areas and the highest one is in Vilnius (Table 5). The difference in medians between Vilnius and large cities varies between 5 to 9 points. The differences in medians between cities, small cities and rural area are even smaller. Students more often obtain 75 points or higher in Vilnius and large cities (Table 5 and Fig. 4, panel B). However, when examining the distributions of achievement, we observe a strong positive skewness regardless the location of the school. Median is more often below 50, which might indicate poor performance or mismatch between knowl-

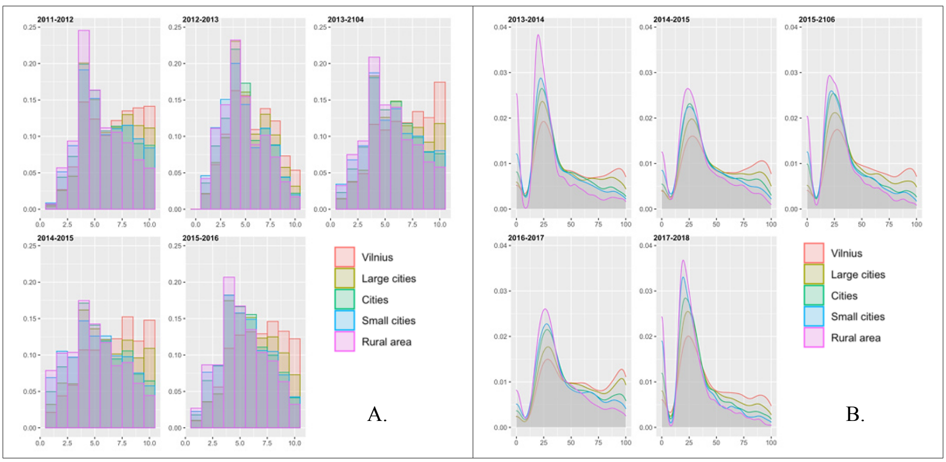

Fig. 4. The distributions of grades with respect to school location for: A. – 10th grade test; B. – Matura examination. Vilnius (capital of Lithuania), large cities (Kaunas, Klaipėda, Šiauliai, Panevėžys), cities (15–100 thous. inhabitants), small cities (3–15 thous. inhabitants), rural area (<3 thous. inhabitants).

edge and examination task difficulty. The school location explains from 4.8% to 6.4% of the variation in the achievement of the Matura examination.

Consequently, if one would base its decisions on the analysis of the central parameter (say median) only, one could conclude that the achievements of students in rural areas

Table 4

Descriptive summary of 10th grade test achievements according school location

	Mean	SD	IQR	Min	Q1	Q2	Q3	Max	N	R^2, %
2011–2012										
Total	6	2.3	4	1	4	6	8	10	36325	
Vilnius	6.6	2.4	4	1	5	7	9	10	5526	2.9
Large cities	6.4	2.3	4	1	4	6	8	10	8801	
Cities	6	2.3	4	1	4	6	8	10	6001	
Small cities	5.9	2.4	4	1	4	6	8	10	6461	
Rural area	5.5	2.2	3	1	4	5	7	10	9536	
2012–2013										
Total	5.1	2.2	3	0	4	5	7	10	35268	
Vilnius	5.7	2.3	3	0	4	5	7	10	5355	2.4
Large cities	5.4	2.2	3	1	4	5	7	10	8474	
Cities	5	2.2	3	1	4	5	7	10	5841	
Small cities	4.8	2.2	4	1	3	4	7	10	6494	
Rural area	4.7	2.1	3	1	3	4	6	10	9104	
2013–2014										
Total	5.9	2.4	4	1	4	6	8	10	31901	
Vilnius	6.8	2.4	4	1	5	7	9	10	4883	3.6
Large cities	6.2	2.4	4	1	4	6	8	10	7781	
Cities	5.8	2.3	4	1	4	6	8	10	5244	
Small cities	5.7	2.4	4	1	4	6	8	10	5898	
Rural area	5.4	2.3	3	1	4	5	7	10	8095	
2014–2015										
Total	5.6	2.6	4	1	4	5	8	10	31082	
Vilnius	6.6	2.5	4	1	5	7	9	10	5012	4.7
Large cities	6	2.5	4	1	4	6	8	10	7659	
Cities	5.4	2.5	3	1	4	5	7	10	5055	
Small cities	5.3	2.6	4	1	3	5	7	10	5582	
Rural area	5	2.5	4	1	3	5	7	10	7774	
2015–2016										
Total	5.8	2.3	4	1	4	6	8	10	30459	
Vilnius	6.6	2.3	4	1	5	7	9	10	4908	4.3
Large cities	6.1	2.2	4	1	4	6	8	10	7302	
Cities	5.6	2.2	3	1	4	5	7	10	5084	
Small cities	5.5	2.3	3	1	4	5	7	10	5502	
Rural area	5.3	2.2	3	1	4	5	7	10	7663	

R^2 – coefficient of determination from simple linear dummy regression. Vilnius (capital of Lithuania), large cities (Kaunas, Klaipėda, Šiauliai, Panevėžys), cities (15–100 thous. inhabitants), small cities (3–15 thous. inhabitants), rural area (<3 thous. inhabitants).

are lower than in cities. However, analysing the whole distribution of achievements, we cannot say that the situation in the countryside is worse than in the cities. Consequently, we claim that quality is equally unsatisfactory regardless of the location.

Table 5
Descriptive summary of Matura grade achievements according school location

	Mean	SD	IQR	Min	Q1	Q2	Q3	Max	N	R^2, %
2013–2014										
Total	38.8	26.9	35	0	21	30	56	100	14937	
Vilnius	47.6	29.5	50	0	24	40	74	100	2696	5.2
Large cities	43	27.5	44	0	22	33	66	100	3746	
Cities	38.2	25.5	33	0	21	30	54	100	2849	
Small cities	35.1	25	30	0	20	28	50	100	2994	
Rural area	29.2	22.5	18	0	18	24	36	100	2652	
2014–2015										
Total	43.5	27	39	0	24	36	63	100	13786	
Vilnius	52.2	29	51	0	28	47	79	100	2587	4.8
Large cities	47.4	27.1	44	0	26	40	70	100	3436	
Cities	42.5	26	37	0	24	34	61	100	2642	
Small cities	39	25.4	34	0	22	33	56	100	2788	
Rural area	34.7	23.6	27	0	20	29	47	100	2333	
2015–2016										
Total	39.4	26.2	34	0	22	32	56	100	16820	
Vilnius	49.6	28.2	45	0	27	45	72	100	3077	6.4
Large cities	43.8	26.7	39	0	24	36	63	100	4176	
Cities	37.2	24.8	30	0	21	31	51	100	3338	
Small cities	34.7	24.3	30	0	19	29	49	100	3485	
Rural area	29.9	21.7	22	0	18	27	40	100	2744	
2016–2017										
Total	48.5	27.5	44	0	26	42	70	100	16516	
Vilnius	56.5	28.3	51	0	32	54	83	100	3328	5.0
Large cities	53	27.9	47	0	29	49	76	100	4254	
Cities	47	26.7	41	0	26	40	67	100	3086	
Small cities	43.7	26.1	38	0	25	36	63	100	3275	
Rural area	38.7	24.2	30	0	24	32	54	100	2573	
2017–2018										
Total	35.6	25	29	0	20	28	49	100	16236	
Vilnius	44.3	27.8	44	0	23	38	67	100	3268	5.4
Large cities	38.8	25.5	33	0	21	31	54	100	4094	
Cities	34.1	23.7	27	0	20	28	47	100	3037	
Small cities	30.2	22.4	23	0	17	26	40	100	3269	
Rural area	27.7	20.5	19	0	17	24	36	100	2568	

R^2 – coefficient of determination from simple linear dummy regression. Vilnius (capital of Lithuania), large cities (Kaunas, Klaipėda, Šiauliai, Panevėžys), cities (15–100 thous. inhabitants), small cities (3–15 thous. inhabitants), rural area (<3 thous. inhabitants).

3.3. *State, Municipality or Private?*

In terms of equity, an effective education system should provide equal educational opportunities for all students, irrespectively not only of gender or school location, but also of the type of school they attend. Exploring the achievements by school type, one should note, that there are three types of schools in Lithuania: State (where the founder is the state), municipal (where the founder is the municipality) and non-state (where founder and partner is neither the state nor the municipality; we will refer to non-state schools as private). According to Education management information system (EMIS, Lith. ŠVIS) in 2018–2019 of the total 1076 general education schools in Lithuania, 91.4% were municipal, 2.6% were state, and 5.9% were non-state (private). Out of 28 state founded schools 15 are intended for students with special educational needs (exceptional artistic / musical talents; and for pupils with severe or very high special educational needs). It is important not to equate these schools with regular municipal schools that integrate pupils recognised as having special education needs. We observe U-shaped distribution in state schools for both 10th grade test and Matura examinations (Fig. 5).

We observe a moderately increasing proportion of students studying in private schools (from 1.6% in 2011–2012 to 2.5% in 2015–2016, Table 6). In the last two years of 10th grade tests, students received more 8–10 grades in private schools compared to other schools (Fig. 5). All quartiles are higher by minimum 1 point in private schools for each academic year (Table 6). This confirms previously discussed ILSA studies highlighting, that segregated students in private schools tend to show higher achievements. This might not be due to methodological or educational innovations in these schools, but, rather, because of the higher SEC status of these students. Results from international student assessment PISA 2018 demonstrate, that on average across all countries after accounting

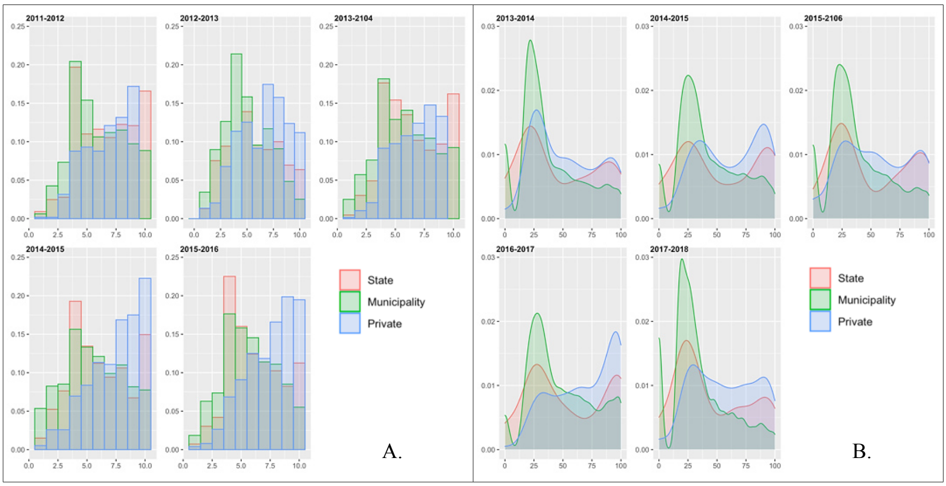

Fig. 5. The distributions of grades with respect to school type for:
A. – 10th grade test; B. – Matura examination.

Table 6
Descriptive summary of 10th grade test achievements according school type

	Mean	SD	IQR	Min	Q1	Q2	Q3	Max	N	R^2, %
2011–2012										
Total	6	2.3	4	1	4	6	8	10	36325	
Municipality	6	2.3	4	1	4	6	8	10	35110	0.9
State	6.6	2.4	5	1	4	7	9	10	645	
Private	7.6	2.2	4	1	6	8	10	10	570	
2012–2013										
Total	5.1	2.2	3	0	4	5	7	10	35268	
Municipality	5	2.2	4	0	3	5	7	10	33988	0.9
State	5.4	2.3	3	1	4	5	7	10	690	
Private	6.6	2.3	3	1	5	7	8	10	590	
2013–2014										
Total	5.9	2.4	4	1	4	6	8	10	31901	
Municipality	5.9	2.4	4	1	4	6	8	10	30595	1.0
State	6.4	2.4	5	1	4	6	9	10	629	
Private	7.5	2.2	4	1	6	8	10	10	677	
2014–2015										
Total	5.6	2.6	4	1	4	5	8	10	31082	
Municipality	5.6	2.6	4	1	4	5	8	10	29636	1.3
State	6.1	2.5	4	1	4	6	8	10	669	
Private	7.4	2.2	3	1	6	8	9	10	777	
2015–2016										
Total	5.8	2.3	4	1	4	6	8	10	30459	1.5
Municipality	5.7	2.3	4	1	4	6	8	10	29006	
State	6.1	2.3	4	1	4	6	8	10	693	
Private	7.5	2.1	3	1	6	8	9	10	760	

R^2 – coefficient of determination from simple linear dummy regression.

for students' and schools' socio-economic profile and per capita GDP students in public schools, actually, score higher in reading, mathematics and science than students in private schools (OECD, 2020). The type of school explains 0.9%–1.5% of the variation in the 10th grade test achievement.

Analysing the results of the Matura exams, unlike 10th grade test, we observe somewhat different situation between school types. The median of private schools is the highest compared to other types of schools in the whole period analysed. However, in the first three years, the third quartile was higher in state schools, while in the fourth year, 3 quartiles were equal, and in the last year, a larger 3 quartile was observed in private schools (Table 7). Proportion of students at private schools is gradually increasing from 2.6% in 2013–3014 to 3.1% in 2017–2018. The type of school explains 0.8%–2.5% of the variation in the achievement of Matura examination.

The previous section has shown differences in achievements based on school type. State schools in both 10th grade test and Matura exams demonstrate U-shaped distribu-

Table 7
Descriptive summary of Matura grade achievements according school type

	Mean	SD	IQR	Min	Q1	Q2	Q3	Max	N	R^2, %
2013–2014										
Total	38.8	27	35	0	21	30	56	100	14937	
Municipality	38.4	27	36	0	20	30	56	100	14371	0.8
State	46.4	33	62	0	20	34	82	100	185	
Private	52.3	28	50	0	28	48	78	100	381	
2014–2015										
Total	43.5	27	39	0	24	36	63	100	13786	
Municipality	42.9	27	39	0	24	34	63	100	13210	1.3
State	52.3	35	66	0	24	45	90	100	179	
Private	60.6	28	51	0	36	63	87	100	397	
2015–2016										
Total	39.4	26	34	0	22	32	56	100	16820	
Municipality	38.8	26	35	0	21	32	56	100	16128	1.2
State	50.5	34	64	0	22	38	86	100	212	
Private	54.6	30	54	0	29	54	83	100	480	
2016–2017										
Total	48.5	28	44	0	26	42	70	100	16516	
Municipality	47.8	27	44	0	26	40	70	100	15724	1.8
State	54.1	34	68	0	25	48	93	100	262	
Private	68.2	27	48	0	46	72	93	100	530	
2017–2018										
Total	35.6	25	29	0	20	28	49	100	16236	
Municipality	34.7	25	27	0	20	28	47	100	15447	2.5
State	45.4	31	52	0	21	34	73	100	288	
Private	56.3	27	48	0	33	54	81	100	501	

R^2 – coefficient of determination from simple linear dummy regression.

tion, this could be explained by "double" purpose these schools serve (some for exceptionally talented and others for students with severe special needs). Private schools compared to other types of schools exhibit highest median achievements in the whole period in the Matura examinations, as well as highest grades in 10th grade test. This confirms previously discussed ILSA studies, and raises concerns regarding educational equity.

3.4. *Predicting Achievements*

In sections above we analysed the factors of location, school ownership and gender as important indicators using single variable regression models. The descriptive power of the individual factors was low. For the understanding the driving factors of mathematics achievement, one should develop models that explain the variation in achievement. The latter models could also be used for the prediction of mathematics achievements.

Therefore we will combine analysed factors with additional student-level context variables (age, social support indicator, special needs indicator and foreigner status) into a multiple linear regression models to assess the suitability of the variables for predicting mathematical achievement for each school year.

We observe the negative association between the age of students and the achievements in mathematics (Table 8 and Table 9). The median of age of students is equal to 16 years (min 13, max 70) for the 10th grade test and, respectively, the median is equal to 18 years (min 15, max 46) for the Matura examination. Postponing the examination time irrespectively 10th grade test or Matura examination on average diminished the achievements in mathematics.

As discussed in Subsection 3.1, the gender gap is very small in favour for females in the results of the 10th grade test controlling for other independent variables. As for the performance in Matura test, two years unfavourable effect for males changes into favourable and fades out for the last academic year.

Mathematics achievement for learners is slightly higher in urban areas than in rural areas than other independent variables do not change. We obtained the largest positive effect for the students from Vilnius schools compared to other locations. Attendance to private school leads to higher achievements in mathematics.

Table 8

Result from multivariable linear regression for 10th grade test achievements (1–10 grade scale)

Independent variable	Category	2011–2012		2012–2013		2013–2014		2014–2015		2015–2016	
		β	SE	β	SE	β	SE	β	SE	β	SE
Age		-0.17	0.01	-0.08	0.01	-0.14	0.01	-0.10	0.01	-0.10	0.01
Gender	Female	Reference category									
	Male	-0.24	0.02	-0.19	0.02	-0.32	0.03	-0.35	0.03	-0.22	0.02
School location	Rural area	Reference category									
	Vilnius	0.91	0.04	0.74	0.04	1.11	0.04	1.22	0.04	1.03	0.04
	Large cities	0.68	0.03	0.48	0.03	0.66	0.04	0.75	0.04	0.65	0.04
	Cities	0.40	0.04	0.19	0.04	0.27	0.04	0.19	0.04	0.16	0.04
	Small cities	0.30	0.04	0.003	0.03	0.15	0.04	0.10	0.04	0.10	0.04
School type	Municipal	Reference category									
	State	0.47	0.09	0.22	0.08	0.27	0.09	0.12	0.09	0.09	0.08
	Private	1.26	0.09	1.28	0.09	1.21	0.09	1.40	0.09	1.28	0.08
Social support indicator		-0.71	0.03	-0.70	0.03	-0.80	0.04	-0.82	0.04	-0.69	0.04
Foreigner status		0.19	0.23	0.10	0.19	-0.34	0.21	0.06	0.2	-0.01	0.16
Special needs indicator		-2.25	0.06	-1.99	0.06	-2.28	0.06	-1.93	0.05	-2.12	0.05
Adjusted R^2, %		10.9		8.3		12.1		12.1		13.2	
ICC, %		25.3		25.4		25.6		27.2		27.3	

SE – standard error of β.

School location: Vilnius (capital of Lithuania), large cities (Kaunas, Klaipėda, Šiauliai, Panevėžys), cities (15–100 thous. inhabitants), small cities (3–15 thous. inhabitants), rural area (<3 thous. inhabitants).

Table 9

Result from multivariable linear regression for Matura achievements (1–100 grade scale)

Independent variable	Category	2013–2014		2014–2015		2015–2016		2016–2017		2017–2018	
		β	SE	β	SE	β	SE	β	SE	β	SE
Age		-2.94	0.34	-3.14	0.33	-3.43	0.36	-3.77	0.41	-3.00	0.37
Gender	Female	Reference category									
	Male	-2.40	0.43	-1.94	0.45	3.32	0.39	2.51	0.42	0.63	0.38
School location	Rural area	Reference category									
	Vilnius	17.48	0.72	16.22	0.76	18.58	0.67	16.45	0.71	15.39	0.64
	Large cities	13.12	0.67	11.68	0.71	12.89	0.62	13.06	0.67	9.83	0.61
	Cities	8.40	0.71	7.04	0.75	6.67	0.65	7.40	0.72	5.76	0.65
	Small cities	5.85	0.69	3.96	0.74	4.73	0.64	4.85	0.7	2.52	0.64
School type	Municipal	Reference category									
	State	7.38	1.95	8.96	1.98	11.37	1.76	4.21	1.68	9.40	1.46
	Private	9.17	1.36	13.20	1.34	11.41	1.17	16.29	1.18	17.77	1.10
Social support indicator		-6.14	0.79	-6.76	0.88	-5.81	0.82	-6.48	0.94	-4.51	0.94
Foreigner status		-1.20	4.31	-0.62	3.95	-13.99	3.85	-4.48	3.3	-4.92	2.56
Special needs indicator		-15.26	2.83	-4.68	1.84	-16.16	2.49	-8.80	2.93	-8.89	2.61
Adjusted R^2, %		6.7		6.8		8.4		7.1		7.6	
ICC, %		20.4		19.7		20.6		19.7		21.1	

SE – standard error of β.

School location: Vilnius (capital of Lithuania), large cities (Kaunas, Klaipėda, Šiauliai, Panevėžys), cities (15–100 thous. inhabitants), small cities (3–15 thous. inhabitants), rural area (<3 thous. inhabitants).

Special needs indicator is an independent variable which represents students with special needs that are provided with complete or partial integration (in regular classes or special classes of mainstream municipal schools). We obtain the strongest negative association between the achievements and special needs variable for 10th grade test which is less pronounced for Matura examination. This suggests, that integration policies have still space for further improvement.

The achievements are on average marginally lower for the students that need social support. The social support indicator according to the Law on Social Assistance to Pupils distinguishes two forms of social support for learners: the provision of free school meals (breakfast, lunch, dinner and meals in summer camps organised by schools); and the provision of basic school supplies. Pupils have the right to free school meals and support for purchase basic school supplies if the average income for family members is less than 1.5 of the state-supported income. Other cases (related to sickness, accident, loss of the breadwinner, provision of assistance to a pupil of disabled parents or from a family with three or more children, etc.) are subject to the decision of council of a municipality (Eurydice, 2020). We had no possibility to discern between these two forms of social support.

Some researchers propose, that social support to pupils, specifically, the free school meals could be understood as a viable indicator of low SEC status (Gorard, 2012). In the USA, eligibility for free lunches has been used as a measure of student SEC background for a long time (Sirin, 2005), nonetheless, there is a growing number of educational researchers that disagree and point out, that free school meals as a variable is a poor measure of SEC status due to its narrow conceptualization of SEC status (focus on economic dimension while ignoring the social and cultural ones) (Harwell and LeBeau, 2010).

Mathematical achievements of students with Lithuanian citizenship and students with foreign citizenship are almost the same in the 10th grade. However, the results of Matura exam are on average somewhat lower for students with foreign citizenship controlling for other independent variables.

Overall all selected explanatory variables explain 8.3%–13.2% of the variation for the 10th grade test achievements, and, respectively, 6.7%–8.4% of the variation for the Matura achievements. This indicates that the developed models, although embed important variables, lacks precision for the prediction of mathematics achievements for both examinations. Thus we need more student-level variables (such as cognitive abilities, motivational aspects, variables reflecting social, economical and cultural status) to explain the variation in achievement. However, we also calculated intra-school variation coefficient (ICC) to estimate what proportion of achievements' variance is explained by school differences. The differences between schools explain 23–27% of the variation in the 10th grade test achievements and up to 21 percent of the variation in the Matura examination achievements. This reveals that students' achievements in mathematics is at least partially related to the school in which students are enrolled which is in line with results from PISA studies (Brunner *et al.*, 2018). This between-school variance can reflect the school differences in students' composition based on their socioeconomic background and/or can be attributed to the institutional characteristics and policies of schools (OECD, 2006). Consequently, the development of more accurate models for prediction of achievements requires not only additional student-level variables, but also should take into account the hierarchical structure of educational data while the students are nested in classes and the classes in schools.

4. Conclusions and Policy Implications

This study set out to analyse the results of centralised assessments of mathematics in secondary schools in Lithuania while considered the factors of location, school ownership and gender as an important indicators when judging about educational effectiveness in terms of quality and equity. We deduce that conclusions drawn from national assessment data is somewhat different from international data and propose that one cannot neglect national information for the development of educational policy. There are small differences in assessments with respect to gender and school location, although we detect the trend to have better mathematics achievements in private schools. As suggested by ILSA, this could be attributed to their higher SEC status, rather than pedagogical or methodological strides of these schools. However, to confirm this for national exams data, we need additional student-level context indicators concerning SEC status. U-shape distribution of achievements in state schools explain the double purpose these schools serve (half of state schools are intended for students with severe or very high special educational needs, while the rest are for students with exceptional artistic / musical talents). We notice that pupils with special needs struggle to achieve highest scores in municipal schools. Students having these personal uncontrolled circumstances fall behind in terms of both, 10th grade test and Matura exams. This might signify an insufficient inclusiveness and fairness of the system, which is not compatible with a goal of a welfare state. Decision makers should ensure that all obstacles preventing equity in education, regardless of the level of the disorders, are removed. The differences between schools explain about 20 percent of the variation in the achievements of the 10th grade test and, respectively, about 25 percent of the variation in the achievements of Matura examination. It seems that some Lithuanian secondary school students, regardless of gender or school location, find it difficult to master the mathematics curriculum. The median often is below the middle of the grade scale, which might indicate poor performance or mismatch between knowledge and examination tasks. Therefore, development of national education policy should rely more on national examination data rather than on ILSA studies.

In this article, we analyse the national assessment data for the entire Lithuanian population of secondary schools that have no sampling errors. ILSA studies are based on the results of a representative sample, where some less favourable groups tentatively are under-represented in the studies. Unlike ILSA achievement scores, which are symmetrical and normally distributed, we observe that the distribution of the assessments of both national exams is asymmetric with a positive skew. We urge to analyse not only the characteristics of the centre (median/average) when formulating national education policy, but monitor the whole distribution of observations. One should recall that a mean is a valid centre characteristic when data follows normal distribution which, apparently, is not a target distribution. Thus, a strategy and an implementation plan is needed to gradually move towards a negative skewness in the distribution of mathematics achievements.

In the article, we examine the results of the 10th grade test and Matura exams without analysing the quality of the exam tasks, which, according to the NEC and the fact that the tasks are prepared each year by another team of researchers hired in a public competition, is somewhat different each year. We encourage to produce exam tasks of comparable quality each year so that the exam results are determined by the student's competencies without additional external success factors.

Both types of examinations serve different purposes, rely on different methodological principles and use different marking systems. Subsequently, the examinations reveal different aspects of student performance in secondary schools. However, in order to follow the OECD recommendations about the use of the 10th grade test results as a component of higher education admission process – in conjunction with the Matura examination – both types of examination should be made compatible. Therefore, we advise to introduce a unified marking system for all national exams.

Acknowledgments

This research is funded by the European Social Fund according to the activity Improvement of researchers' qualification by implementing world-class R&D projects of Measure No.09.3.3-LMT-K-712. The project No. DOTSUT-39 (09.3.3-LMT-K-712-01-0018) / LSS-250000-57.

References

Adamson, F., Astrand, B., Darling-Hammond, L. (Eds.) (2016). *Global Education Reform: How Privatization and Public Investment Influence Education Outcomes.* Routledge.

Ammermüller, A. (2005). Educational opportunities and the role of institutions. *ZEW-Centre for European Economic Research Discussion Paper*. (05–044).

Bethell, G., Zabulionis, A. (2000). *Examination Reform in Lithuania.* Vilnius, National Examination Centre.

Bethell, G., Zabulionis, A. (2012). The Evolution of High-Stakes Testing at the School-University Interface in the Former Republics of the USSR. *Assessment in Education: Principles, Policy & Practice,* 19(1), 7–25.

Bloxham, S., Boyd, P., Orr, S. (2011). Mark my words: the role of assessment criteria in UK higher education grading practices. *Studies in Higher Education,* 36(6), 655–670. https://doi.org/10.1080/03075071003777716

Bodovski, K., Byun, S.Y., Chykina, V., Chung, H.J. (2017). Searching for the golden model of education: Cross-national analysis of math achievement. *Compare: A Journal of Comparative and International Education,* 47(5), 722–741.

Brunner, M., Keller, U., Wenger, M., Fischbach, A., & Lüdtke, O. (2018). Between-school variation in students' achievement, motivation, affect, and learning strategies: Results from 81 countries for planning group-randomized trials in education. *Journal of Research on Educational Effectiveness*, 11(3), 452–478.

Burgess, S., Briggs, A. (2010). School Assignment, school choice and social mobility. *Economics of Education Review, 29,* pp. 619–649. https://doi.org/10.1016/j.econedurev.2009.10.011

Chesky, N.Z., & Wolfmeyer, M.R. (2015). Philosophy of STEM education a critical investigation (Vol. 44). https://doi.org/10.1057/9781137535467.0001

Chakrabarti, R., Peterson, P.E. (2008). *School Choice International: Exploring Public-Private Partnerships.* MIT Press. 55 Hayward Street, Cambridge, MA 02142.

Creemers, B.P.M., Kyriakides, L. (2008). *The dynamics of educational effectiveness: A contribution to policy, practice and theory in contemporary schools.* London, UK: Routledge.

Engel, L.C., Rutkowski, D. (2014). Global Influences on National Definitions of Quality Education: Examples from Spain and Italy. *Policy Futures in Education,* 12(6), 769–783.

ESP (2006). *Education in a Hidden Marketplace: Monitoring of Private Tutoring*. Budapest: Education Support Program (ESP) of the Open Society Institute.

Eurydice (2018). *Organisation of Private Education, Lithuania.* [Accessed 2020-12-09] Available at: https://eacea.ec.europa.eu/national-policies/eurydice/content/organisation-private-education-44_en

Eurydice (2020). *Equity in school education in Europe: Structures, policies and student performance.* Eurydice report. Luxembourg: Publications Office of the European Union.

Glaser, R., Klaus, D.J. (1962). Proficiency Measurement: Assessing Human Performance. *Psychological Principles in System Development*, edited by R. M. Gagne, 419–474. New York, NY: Holt, Rinehart & Winston.

Gorard, S. (2012). Who is eligible for free school meals? Characterising free school meals as a measure of disadvantage in England. *British Educational Research Journal, 38*(6), 1003–1017. https://doi.org/10.1080/01411926.2011.608118

Harwell, M., LeBeau, B. (2010). Student Eligibility for a Free Lunch as an SES Measure in Education Research. *Educational Researcher*, 39(2), 120–131. https://doi.org/10.3102/0013189X10362578

Koinzer, T., R. Nikolai and F. Waldow (2017). *Private schools and school choice in compulsory education: Global change and national challenge*, Springer Fachmedien Wiesbaden. http://dx.doi.org/10.1007/978-3-658-17104-9

Kryst, E.L., Kotok, S., Bodovski, K. (2015) Rural/Urban Disparities in Science Achievement in Post-Socialist Countries: The Evolving Influence of Socioeconomic Status. *Global Education Review*, 2(4), 60–77.

Kyriakides, L., Creemers, B. P. (2011). Can schools achieve both quality and equity? Investigating the two dimensions of educational effectiveness. *Journal of Education for Students Placed at Risk (JESPAR),* 16(4), 237–254.

Lok, B., McNaught, C., Young, K. (2016). Criterion-referenced and norm-referenced assessments: compatibility and complementarity. *Assessment & Evaluation in Higher Education,* 41(3), 450–465. `https://doi.org/10.1080/02602938.2015.1022136`

Migonytė S. (2018). Brangiausios privačios mokyklos: kiek kainuoja mokslo metai. Verslo žinios. Available at [Accessed 2020-12-09]: `https://www.vz.lt/paslaugos/2018/10/05/brangiausios-privacios-mokyklos-kiek-kainuoja-mokslo-metai`

Miller D., Halpern D. (2014) The new science of cognitive sex differences. *Trends in Cognitive Science.* 18(1), 37–45.

MoES (2011). What are the differences in education between rural and urban schools? Analysis of the educational problem (Lith. Kokie ugdymo skirtumai kaimo ir miesto mokyklose?) *Švietimo problemos analizė*. Vilnius: Švietimo aprūpinimo centras.

MoES (2014). *State Education Strategy for 2013–2022* (Lith. Valstybinė švietimo 2013–2022 metų strategija). Vilnius: Švietimo aprūpinimo centras.

Mullis, I.V.S., Martin, M.O., Loveless, T. (2016). 20 Years of TIMSS: International trends in mathematics and science achievement, curriculum, and instruction. Chestnut Hill: TIMSS & PIRLS International Study Center, Boston College. Retrieved from: `http://timss2015.org/timss2015/wp-content/uploads/2016/T15-20-years-of-TIMSS.pdf`

NEC (2017). 2017 metų nacionalinio mokinių pasiekimų patikrinimo ataskaita. Vilnius, Nacionalinis egzaminų centras.

NEC (2018). 2018 metų nacionalinio mokinių pasiekimų patikrinimo ataskaita. Vilnius, Nacionalinis egzaminų centras.

OECD (2006), "Between- and within-school Variation in the Mathematics Performance of 15-year-olds", in Education at a Glance 2006: OECD Indicators, OECD Publishing, Paris. `https://doi.org/10.1787/eag-2006-6-en`

OECD (2017). Education in Lithuania. Highlights 2017. [Accessed 2020-12-17] Retrieved from: `https://www.oecd.org/education/school/Education-in-Lithuania-2017-highlights.pdf`

OECD (2017). *Reviews of National Policies for Education. Education in Lithuania.* Paris: OECD Publishing. `https://doi.org/10.1787/19900198`

OECD (2019). *PISA 2018 Results (Volume II): Where All Students Can Succeed, PISA*, OECD Publishing, Paris. `https://doi.org/10.1787/b5fd1b8f-en`

OECD (2019a). *Balancing School Choice and Equity. An International Perspective Based on PISA*. PISA, Paris: OECD Publishing. `https://doi.org/10.1787/2592c974-en`

OECD (2020). *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, PISA, OECD Publishing, Paris. `https://doi.org/10.1787/ca768d40-en`

Othman, M., Muijs, D. (2013). Educational quality differences in a middle-income country: the urban-rural gap in Malaysian primary schools. *School Effectiveness and School Improvement,* 24(1), 1–18.

Panizzon, D. (2015). Impact of geographical location on student achievement: Unpacking the complexity of diversity. In: *Diversity in Mathematics Education.* Springer, Cham. pp. 41–61.

Philips, K., Larsen, E., Hausman, C. (2015). School choice & school stratification: How intra-district transfers shift the racial/ethnic and economic composition of schools. *Social Science Research,* 51 (May), pp. 30–50. `https://doi.org/10.1016/j.ssresearch.2014.12.005`

Phillips, K.J., Larsen, E.S., Hausman, C. (2015). School choice & social stratification: How intra-district transfers shift the racial/ethnic and economic composition of schools. *Social Science Research, 51*, 30–50.

Prince, R. (2017). The relationship between school-leaving examinations and university entrance assessments: The case of the South African system. *Journal of Education (University of KwaZulu-Natal),* (70), 133–160.

Reeves, E.B., Bylund, R.A. (2005) Are rural schools inferior to urban schools? A multilevel analysis of school accountability trends in Kentucky. *Rural Sociology,* 70(3), 360–386.

Royal, K.D., Guskey, T.R. (2015). On the Appropriateness of Norm- and Criterion-referenced Assessments in Medical Education. *Ear, Nose & Throat Journal*, 94(7), 252–254. `https://doi.org/10.1177/014556131509400701`

Scheerens, J. (2016) *Educational Effectiveness and Ineffectiveness. A Critical Review of the Knowledge Base.* Dordrecht: Springer.

Sirin, S.R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research,* 75, 417–453.
Somerset, A. (2011). Strengthening educational quality in developing countries: the role of national examinations and international assessment systems. *Compare,* 41(1), 141–144.
Stein, M.L., Berends, M., Fuchs, D., McMaster, K., Sáenz, L., Yen, L., ... & Compton, D.L. (2008). Scaling up an early reading program: Relationships among teacher support, fidelity of implementation, and student performance across different sites and years. *Educational Evaluation and Policy Analysis*, 30(4), 368–388.
Tampayeva, G.Y. (2015). Importing Education: Europeanisation and the Bologna Process in Europe's Backyard – The Case of Kazakhstan. *European Educational Research Journal*, 14(1), 74–85.
UNESCO-OECD-Eurostat (2019). *UOE data collection on formal education: Manual on concepts, definitions and classifications.* [Accessed 2020-12-09] `http://uis.unesco.org/sites/default/files/documents/uoe-data-collection-manual-2019-en.pdf`
Webster, B.J., Fisher, D.L. (2000). Accounting for variation in science and mathematics achievement: A multilevel analysis of Australian data Third International Mathematics and Science Study (TIMSS). *School Effectiveness and School Improvement,* 11(3), 339–360.
West, R., Crighton, J. (1999). Examination Reform in Central and Eastern Europe: issues and trends. *Assessment in Education: principles, policy & practice,* 6(2), 271–289.
Williams, J.H. (2005) Cross-National Variations in Rural Mathematics Achievement: A Descriptive Overview. *Journal of Research in Rural Education*, 20(5).
Wijekularathna, D.K., Manage, A.B., Scariano, S.M. (2019). Power analysis of several normality tests: A Monte Carlo simulation study. Communications in Statistics-Simulation and Computation, 1–17.
Young, D.J. (2000) Rural Differences in School Achievement: The Effect of Student Perceptions. *Educational Research and Evaluation*, 6(3), 207–228.
Young, D.J. (1998) Rural and Urban Differences in Student Achievement in Science and Mathematics: A Multilevel Analysis. *School Effectiveness and School Improvement*, 9(4), 386–418.
Zabulionis, A. (2020) *Tarptautinio švietimo tyrimo OECD PISA Lietuvos ir kaimyninių šalių tikslinė antrinė analizė*. Vilnius, Nacionalinė švietimo agentūra.

A. Jakaitienė – PhD in physical sciences (informatics), chief researcher at the Institute of Data Science and Digital Technologies, Faculty of Mathematics and Informatics Vilnius university. Research interests: analytics of social, physical and biomedical data.

R. Želvys is a chief researcher at Vilnius University, Institute of Data Science and Digital Technologies, and professor, Institute of Educational Sciences. Research interests: Education management and Policy, Education reforms, International assessments.

J. Vaitekaitis is a junior researcher at Vilnius University, Institute of Data Science and Digital Technologies, PhD Researcher at Institute of Educational Sciences. His scientific interests include: Politics and philosophy of education, Curriculum development, STEM sciences, International assessments, Education for sustainable development.

S. Raižienė is a senior researcher at Vilnius University, Institute of Data Science and Digital Technologies, and a professor at the Institute of Psychology, Vilnius University. Her major research interests include adolescents' positive development and academic motivation.

R. Dukynaitė is a chief researcher at Vilnius University, Institute of Data Science and Digital Technologies. Research interests: International assessment, Education management, Education Policy, Leadership.