
Differences in Mathematics Achievement Between Students from European Public Schools and Students Following the Luxembourgish Curriculum: A Cross-Sectional Analysis at Primary and Secondary School Level (Integral version)

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This document appears as supplementary material in connection with the Luxembourg National Education Report 2024 – specifically as an integral version of the following article:

Unterschiede zwischen Öffentlichen Europaschulen und Schulen, die dem luxemburgischen Lehrplan folgen: Eine Querschnittsanalyse von Mathematikleistungen in der Grund- und Sekundarschule

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Suggested citation for this document:

Colling, J., Grund, A., Keller, U., Esch, P., Fischbach, A. & Ugen, S. (2024). *Differences in Mathematics Achievement Between Students from European Public Schools and Students Following the Luxembourgish Curriculum: A Cross-Sectional Analysis at Primary and Secondary School Level (Integral version)*. Luxembourg Centre for Educational Testing (LUCET) & Service de la Recherche et de l'Innovation pédagogiques (SCRIPT). <https://doi.org/10.48746/bb2024lu-en-33>

The "Luxembourg National Education Report 2024" is published in German and French and can be accessed at the following link:

www.bildungsbericht.lu

1. Introduction

Luxembourg is a highly diverse country regarding the socioeconomic, cultural, and linguistic composition of its population. This diversity is reflected in its education system, where 68.4 % of primary and 66.3 % of secondary school students are speaking another language than Luxembourgish at home (SCRIPT, 2024).

Large-scale educational assessment studies (e.g., OECD's PISA studies) have shown that many education systems struggle with an adequate handling of increasingly diverse student populations (Schleicher, 2019). When it comes to Luxembourg, findings from national and international studies indicate that students with a low socioeconomic status (SES) and/or students speaking another language than Luxembourgish and/or German at home are especially at risk to struggle academically (e.g., Boehm et al., 2016; Sonnleitner et al., 2021).

To deal more adequately with the increasing language diversity of the student population and to counter the identified educational inequalities that are assumed to result (at least in part) from a curriculum with high language demands, the Luxembourgish government has broadened the educational offer by introducing European Public Schools (EPS) that are following the European curriculum (Eurydice, 2022). In contrast to schools following the Luxembourgish curriculum, EPS offer language sections (i.e., German, French, and English) in which students mainly pursue their education in a selected language of instruction.

Through the opportunity to choose a main language of instruction, EPS might provide a learning environment which is more adapted to the highly diverse student population and might in turn reduce educational inequalities that have persistently been identified in schools following the Luxembourgish curriculum.

Preliminary results from the *Épreuves Standardisées* (ÉpStan; LUCET & SCRIPT, 2023) indicate that EPS students perform better in mathematics than students following the Luxembourgish curriculum at primary school level, and than their peers from the *Enseignement secondaire général - voie d'orientation* (ESG) and the *Enseignement secondaire général - voie de préparation* (ESG-VP) at secondary school level. In addition, low SES students and students speaking another language than Luxembourgish and/or German at home (e.g., Portuguese) attending EPS were on average performing better in mathematics than students with the same background characteristic in schools following the Luxembourgish curriculum.

The present chapter aims at understanding whether these initial findings can be confirmed using the full-cohort data from the ÉpStan 2023/24, focusing on the following two research questions:

- (a) How do EPS students at primary and secondary school level perform in mathematics compared to their peers in schools following the Luxembourgish curriculum?
- (b) How do specific student groups (e.g., students with a low SES, students speaking another language than Luxembourgish/German at home) in EPS perform in mathematics compared to students with the same background characteristics in schools following the Luxembourgish curriculum?

Although facing the same methodological limitations as described for the 2022/23 ÉpStan cohort (LUCET & SCRIPT, 2023), investigating whether the same pattern of results can be found in another ÉpStan cohort constitutes an important step in scientifically evaluating which impact the establishment of EPS has on reducing the observed educational inequalities in Luxembourg's education system.

2. Methodology and Measures

The ÉpStan are a well-established national school monitoring tool and consist of standardized academic achievement tests, which assess achievement of primary and secondary school students in selected key areas of education (Martin et al., 2015). Administered in autumn at the beginning of each new learning cycle in Luxembourg's schools, the ÉpStan systematically monitor whether the educational standards of the previous learning cycle (as defined by the Ministry of Education, Children and Youth) have been achieved by all students of the respective grade (MENFP, 2011a).

In the school year 2022/23, **key competences in mathematics** were assessed for the first time in all five grade levels in EPS (P1, P3, P5, S1 and S3), which are considered equivalent to the grade levels in which the ÉpStan are administered in schools following the Luxembourgish curriculum (C2.1, C3.1, C4.1, 7^e and 5^e). Detailed information on the domains assessed in the respective grades can be found in the European Public School Report (LUCET & SCRIPT, 2023). In line with international large-scale assessments (e.g., PISA; OECD, 2018), one global score is computed for mathematics achievement, which is normed in such a way that the mean ÉpStan score for all students in Luxembourg lies at 500 points, with a standard deviation of 100 points in a reference school year.

In addition, the ÉpStan gather data on **individual student background characteristics** via student and parent (only at primary school level) questionnaires. Based on the *International Socio-Economic Index of Occupational Status* (ISEI; Ganzeboom, 2010), the highest available ISEI value (HISEI) of either the father or the mother (or a respective legal representative) is considered for the classification of a student's SES. The lowest 25% of the distribution are defined as having a low SES and the highest 25% as having a high SES. Regarding migration background, students are considered as natives when the students and at least one of their parents were born in Luxembourg. To compare students based on their languages, students are considered to have a specific language background (i.e., Luxembourgish/German, French, Portuguese, or English) when they speak the respective language with at least one of their parents at home. This means that the language groups are not exclusive (e.g., a student speaking Luxembourgish with his/her mother and Portuguese with his/her father is allocated to the two language background groups of Luxembourgish and Portuguese). With regard to gender, we used a binary (male/female) indicator provided by the student administrative database of the Ministry of Education, Children and Youth.

3. Results

3.1. Sample descriptives

The results presented in the present chapter are based on representative data from approximately 29,100 students from five different grade levels (C2.1, C3.1, C4.1, 7^e and 5^e in schools following the Luxembourgish curriculum, as well as P1, P3, P5, S1, and S3 in EPS) of primary and secondary education. The sociodemographic characteristics of the two student populations (i.e., EPS in green and schools following the Luxembourgish curriculum in yellow) can be found in *Table 1*.

At primary school level, 977 students attended EPS, which equals to 5.4% of the full ÉpStan cohort of primary school students. Regarding secondary education, 1249 students attended EPS, which equals to 11.4% of secondary school students. Compared to the ÉpStan cohort of the previous school year (2022/23), the percentage of students attending EPS increased by 0.6% at primary school level and by 1.8% at secondary school level. Looking at student background characteristics, it does however become apparent, that the student population in EPS continued to be distinct in its composition compared to schools following the Luxembourgish curriculum. In line with the results for the previous ÉpStan cohort, the EPS student population was characterized by a higher SES and a lower share of natives than the student population in schools following the Luxembourgish curriculum. In addition, French was the language primarily spoken at home by EPS students compared to Luxembourgish/German in schools following the Luxembourgish curriculum.

Tab. 1: Detailed Sample Description of the ÉpStan Cohort for the School Year 2023/24

			<i>N</i>	HISEI (<i>M</i>)	% female	% natives	Language background			
							% Lux/German	% French	% Portuguese	% English
Luxembourgish curriculum	EF	C2.1	5823	51	48 %	40 %	43 %	21 %	23 %	6 %
		C3.1	5775	51	49 %	39 %	40 %	20 %	22 %	5 %
		C4.1	5546	49	49 %	38 %	43 %	21 %	22 %	3 %
	ES – 7 ^e	ESC	978	54	52 %	58 %	60 %	19 %	12 %	3 %
		ESG	1881	39	48 %	32 %	33 %	17 %	37 %	1 %
		ESG-VP	457	36	38 %	25 %	26 %	11 %	45 %	4 %
	ES – 5 ^e	ESC	1905	57	55 %	56 %	60 %	21 %	11 %	3 %
		ESG	3845	40	46 %	31 %	33 %	14 %	36 %	1 %
		ESG-VP	640	35	38 %	20 %	21 %	14 %	44 %	2 %
EPS	EF	P1	346	59	49 %	11 %	14 %	41 %	10 %	24 %
		P3	331	58	52 %	10 %	12 %	41 %	9 %	24 %
		P5	300	59	45 %	9 %	9 %	36 %	10 %	19 %
	ES	S1	669	52	48 %	19 %	21 %	34 %	15 %	13 %
	ES	S3	580	57	46 %	17 %	20 %	34 %	17 %	11 %

Note: *N* = Number of students. HISEI (*M*) = Mean of the highest available *Index of Socio-Economic Index of Occupational Status* value. EF = *Enseignement fondamental* (primary school level). ES = *Enseignement secondaire* (secondary school level). ESC = *Enseignement secondaire classique*. ESG = *Enseignement secondaire général - voie d'orientation*. ESG-VP = *Enseignement secondaire général - voie de préparation*. For details on the operationalization of student background variables, see Section 2. Due to methodological differences in the composition of the HISEI variable, means cannot be compared between EF and ES.

3.2. Mathematics achievement at primary school level

Figure 1 illustrates the distribution of academic achievement in mathematics for all three primary school grades split by curriculum. Each student's ÉpStan score is represented by an individual dot and the density of the dots reflects the size of each group. The mean values are depicted in the centre of each distribution. In mathematics, regular fluctuations of ± 10 ÉpStan points can be observed from one year to another at both primary and secondary school level and these small changes should generally not be interpreted as considerable differences in academic achievement.

Fig. 1: Distribution of Achievement in Mathematics Split by Curriculum at Primary School Level in the ÉpStan Cohort 2023/24

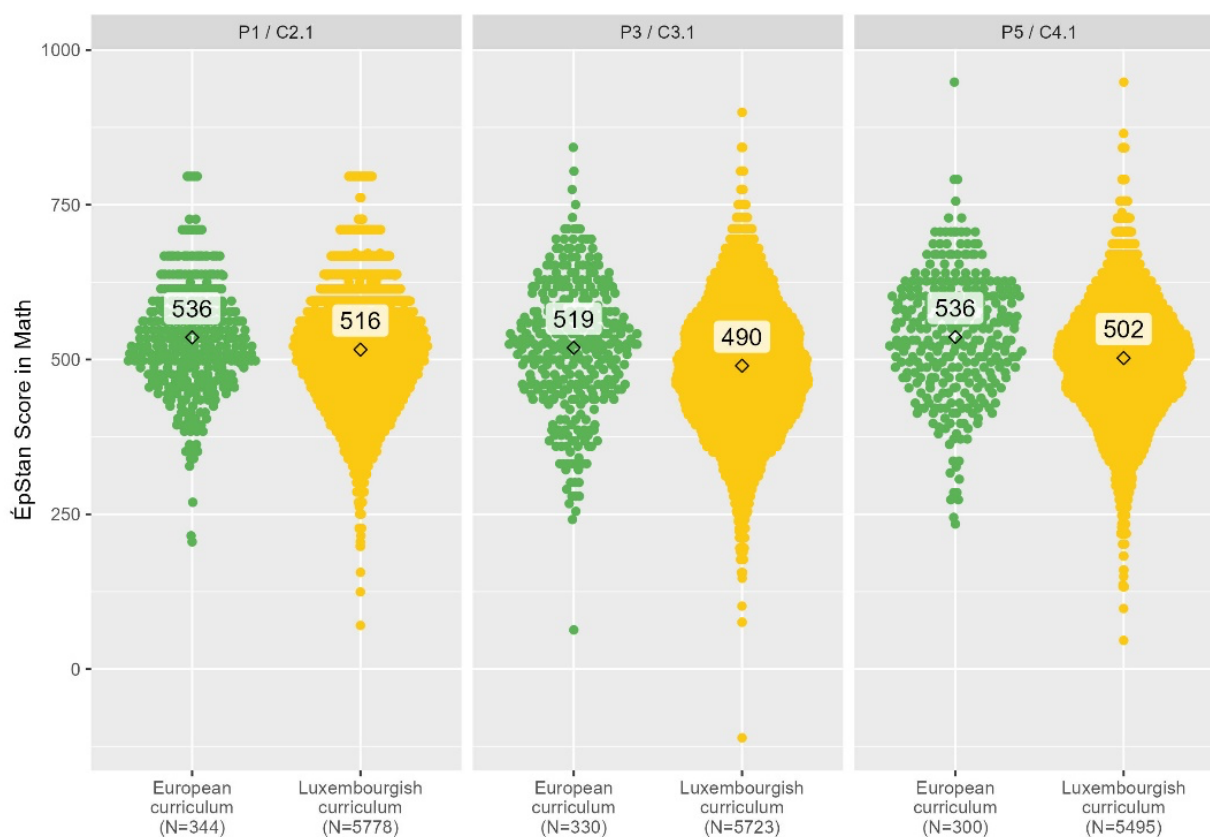


Figure 1 indicates that EPS students displayed higher mean values than their peers attending schools following the Luxembourgish curriculum across all three grade levels. With group differences of 20 ÉpStan points in C2.1/P1, 29 ÉpStan points in C3.1/P3, and 34 ÉpStan points in C4.1/P5, the observed achievement differences in favour of EPS students exceeded regularly observed fluctuations and thus seem to indicate that EPS students performed better on average in mathematics than their peers in schools following the Luxembourgish curriculum, most prominently so in C4.1/P5. These findings are in line with the pattern observed in the ÉpStan cohort of the previous school year (2022/23).

Exemplary, Figure 2 shows the distribution of academic achievement in mathematics for this grade level, separately by curriculum and by student background variables, considering that specific student groups (e.g., low SES students, students having a migration background, and/or students speaking another language than Luxembourgish/German at home) have repeatedly been found to struggle academically in schools following the Luxembourgish curriculum (see Section 1 for details).

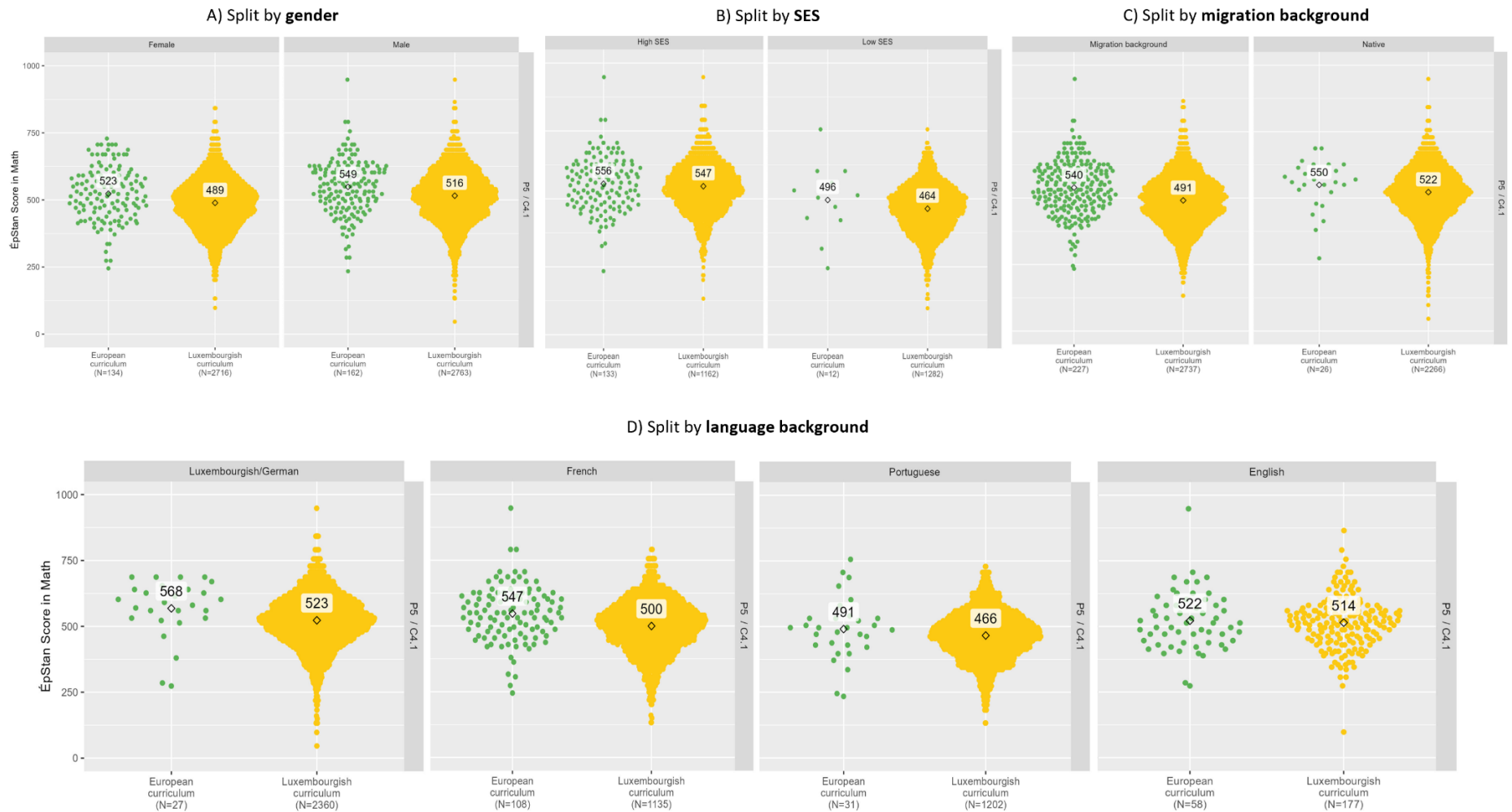
Regarding **gender** (see Figure 2A), both male and female students attending EPS showed higher mean values than their peers in schools following the Luxembourgish curriculum. With a difference of 33 ÉpStan

points for male students and 34 ÉpStan points for female students, these differences exceeded regularly observed fluctuations of ± 10 ÉpStan points and thus indicate that EPS students performed better on average in mathematics than students in schools following the Luxembourgish curriculum, irrespective of their gender. This pattern can also be observed in C2.1/P1 and C3.1/ P3 (see *Online Supplement*) and it is furthermore in line with the findings for the previous ÉpStan cohort (see *Figure IV.2* in LUCET & SCRIPT, 2023).

Figure 2B illustrates the distribution of academic achievement in mathematics split by curriculum and **SES**. Looking at high SES students, a difference of 9 ÉpStan points in favour of EPS students was observed, which fails to differ considerably from previously observed regular fluctuations of ± 10 ÉpStan points. This observation also holds true for students attending C3.1/P3, indicating that high SES students of these two grade levels perform well irrespective of their school's curriculum. Looking at C2.1/P1, an achievement difference of 19 ÉpStan points in favour of students following the Luxembourgish curriculum was however found, which indicates that high SES students in this early school grade performed better than their high SES peers in EPS (see *Online Supplement*). With differences ranging from 32 ÉpStan points in C4.1/P5 to 77 ÉpStan points in C2.1/P1, low SES students attending EPS showed higher mean values in all three grades compared to low SES peers in schools following the Luxembourgish curriculum. By considerably exceeding regularly observed fluctuations of ± 10 ÉpStan points, the differences in favour of low SES students in EPS are a tentative indication that they performed better than their low SES peers in schools following the Luxembourgish curriculum, a finding which is in line with observations for the previous ÉpStan cohort (see *Figure IV.3* in LUCET & SCRIPT, 2023). As visualized by the small number of individual dots in *Figure 2B*, it must however be kept in mind that these results are based on very small *N*s (between 12 and 26 low SES students in EPS only) and should thus be interpreted with notable caution.

Looking at **migration background**, *Figure 2C* indicates that both native EPS students and students with a migration background showed higher mean values than their peers with the same characteristics in schools following the Luxembourgish curriculum. Considering that the group differences in favor of native EPS students (difference of 28 ÉpStan points) and of EPS students with a migration background (difference of 49 ÉpStan points) exceeded regularly observed fluctuations, EPS students performed better on average in mathematics than students in schools following the Luxembourgish curriculum irrespective of their migration background. The pattern of students with a migration background performing better when attending EPS can also be observed in C2.1/P1 and in C3.1/ P3 (see *Online Supplement*). However, the pattern for native students seems less coherent across grades with no significant difference identified in C2.1/P1 and a significant difference in favor of students following the Luxembourgish curriculum in C3.1/P3 (difference of 12 ÉpStan points). This finding differs slightly from the observations made in the previous ÉpStan cohort (2022/23), where native EPS students showed lower mean values in both C2.1/P1 and C3.1/P3 than native students in schools following the Luxembourgish curriculum (see *Figure IV.4* in LUCET & SCRIPT, 2023).

Fig. 2: Distribution of Achievement in Mathematics Split by Curriculum and Student Background Variables in C4.1/P5 (ÉpStan Cohort 2023/24)



Note: This figure illustrates the distribution of achievement in mathematics split by curriculum and student background variables for the students attending C4.1 of schools following the Luxembourgish curriculum and of P5 students in EPS. All the figures for C2.1/P1 and C3.1/P3 can be found in the *Online Supplement* of this chapter, which can be downloaded via the website of the National Education Report (www.bildungsbericht.lu). For more details on the operationalization of the different student background variables, see *Section 2*.

In light of potential differences in the countries of origin between students with a migration background in EPS (e.g., other non-EU countries) and in schools following the Luxembourgish curriculum (e.g., Portugal, see *Figure I.11* in LUCET & SCRIPT, 2023), and given the small students groups (between 26 and 38 native students in EPS only), these findings on achievement differences in mathematics split by migration background must be interpreted with notable caution.

Figure 2D illustrates the distribution of academic achievement in mathematics split by curriculum and by **language background**. EPS students of all four language groups showed higher mean values in mathematics than their peers with the same language background in schools following the Luxembourgish curriculum. With the differences exceeding regularly observed fluctuations of ± 10 ÉpStan points for EPS students with a Luxembourgish/German (difference of 45 ÉpStan points), a French (difference of 47 ÉpStan points), and a Portuguese language background (difference of 25 ÉpStan points), these results indicate that EPS students performed better on average in mathematics than students with the same language background in schools following the Luxembourgish curriculum. This pattern can also be observed in C2.1/P1 and in C3.1/P3 (see *Online Supplement*), but differs from the findings in the previous cohort (2022/23), where students with a Luxembourgish/German (C2.1/P1 and C3.1/P3) and Portuguese (C3.1/P3) language background performed better at schools following the Luxembourgish curriculum (see *Figures IV.5 to IV.7* in LUCET & SCRIPT, 2023). In contrast to the findings for these three language groups, the observed difference of 8 ÉpStan points in favor of EPS students with an English language background did not differ considerably from regularly observed fluctuations. In addition, the English language group is the only one for which no consistent pattern across all three primary school grades could be identified. In C2.1/P1, the observed difference of 7 ÉpStan points in favor of English speaking students attending schools following the Luxembourgish curriculum did not differ from regularly observed fluctuations of ± 10 ÉpStan points, whereas a difference of 14 ÉpStan points in favour of English speaking EPS students was found in C3.1/P3 (see *Online Supplement*). These results stand in contrast to the findings from the previous ÉpStan cohort (2022/23), where EPS students with an English language background showed a consistent pattern of performing better in mathematics than their English speaking peers in schools following the Luxembourgish curriculum across all three primary school grades.

3.3. Mathematics achievement at secondary school level

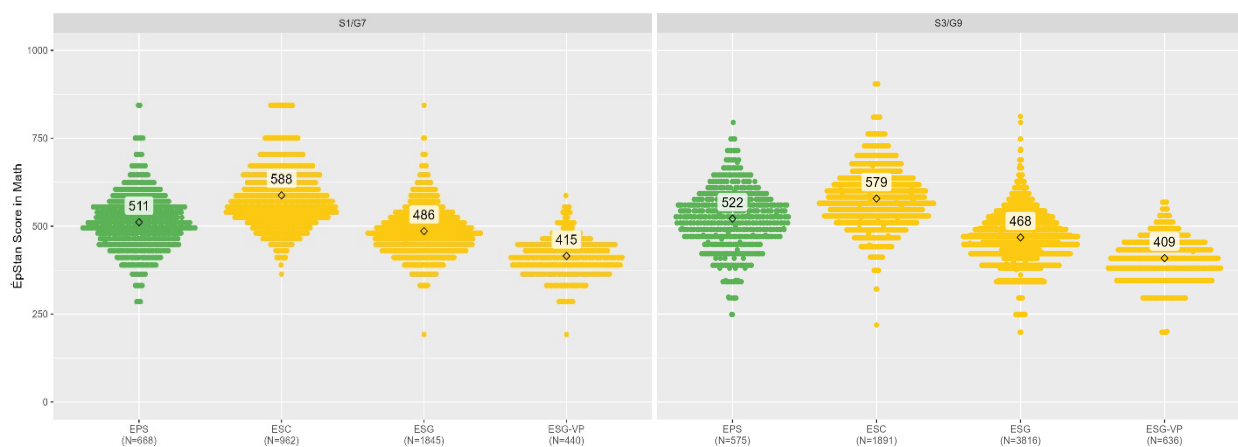
Figure 3 illustrates the distribution of academic achievement in mathematics for the two secondary school grades 7^e/S1 and 5^e/S3 split by curriculum. In secondary schools following the Luxembourgish curriculum, students are allocated to three school tracks based on their abilities (ESC, ESG and ESG-VP represented in yellow). In contrast, EPS follow the principle of allocating all students to one common track until the end of lower secondary education (represented in green). In addition, two thirds of EPS students have only transitioned into the EPS system after having pursued primary education in a school following the Luxembourgish curriculum (see *Online Supplement* of the present chapter). Against the background of

differences between the two curricula (i.e., a shorter duration of primary education and no tracking in secondary education in EPS), the following results on achievement differences in secondary education should be interpreted with additional caution.

As for primary education (see 3.2), *Figure 3* displays the *ÉpStan* score of each secondary school student by an individual dot and the density of all dots reflects the size of each group.

Secondary school students attending EPS displayed higher mean values than their peers allocated to ESG or ESG-VP in both 7^e/S1 and 5^e/S3, with a difference ranging from 25 to 54 *ÉpStan* points in comparison to ESG students and from 96 to 113 *ÉpStan* points in comparison to ESG-VP students. By exceeded regularly observed fluctuations of ± 10 *ÉpStan* points, they indicate that EPS students performed better on average in mathematics than their ESG and ESG-VP peers in schools following the Luxembourgish curriculum, most prominently so in 5^e/S3. In comparison to students attending ESC, EPS students displayed a mean value that is 77 *ÉpStan* points lower in 7^e/S1 and 57 *ÉpStan* points lower in 5^e/S3. These findings are in line with the pattern observed in the *ÉpStan* cohort of the previous school year (2022/23).

Fig. 3: Distribution of Achievement in Mathematics Split by Curriculum at Secondary School Level in the *ÉpStan* Cohort 2023/24



In a second step, results were split by the individual background characteristics of gender, SES, migration, and language background. The pattern of EPS students achieving lower mean scores in mathematics than their peers in ESC and higher scores than ESG and ESG-VP students was found irrespective of the students' background characteristics in both 7^e/S1 (with the exception of low SES students and Portuguese speaking students in ESG, where the differences failed to go beyond the regularly observed fluctuations of ± 10 *ÉpStan* points) and 5^e/S3 (see *Online Supplement*). These results are furthermore in line with the general pattern that was observed in the previous *ÉpStan* cohort (2022/23; with the exception of English speaking students in 7^e/S1, where the achievement difference in favor of EPS students when compared to their ESG peers did not go beyond the regularly observed fluctuations of ± 10 *ÉpStan* points).

4. Methodological Limitations

Although the results of the present chapter seem to indicate that EPS might contribute to encounter existing educational inequalities, they have to be interpreted with caution due to a number of important methodological limitations.

As described in section 3.1, the EPS student population differs considerably from the student population in schools following the Luxembourgish curriculum, which leads to very small student groups with specific characteristics (e.g., low SES or Portuguese-speaking students) in EPS. The results are thus based on small group sizes and should be interpreted with caution. In addition, the small group sizes in EPS did not allow to investigate students based on the language section they attend or on a combination of background variables (e.g., low SES students speaking Portuguese at home).

Considering that the *ÉpStan* achievement tests are developed based on the education standards of the Luxembourgish curriculum, it cannot be excluded that mathematics achievement was underestimated for EPS students. Although a theoretical comparison of the mathematics curricula implemented in the two school offers indicated that they seem to be comparable regarding domains (LUCET & SCRIPT, 2023), a more in-depth analysis of the two curricula would have to be done in future studies.

Furthermore, it has to be noted that the currently available data does not allow to identify which aspect(s) decisively contribute to the observed achievement differences. Whereas the assumed better linguistic fit offered by EPS can be considered as one potential explanation for the observed achievement differences, this linguistic fit was not operationalised in the *ÉpStan* (e.g., via the student questionnaire). The described differences in the student populations and the structural differences that exist between the systems (e.g., institutionalized quality assurance, flexibility in teacher recruitment, provision of primary and secondary education in a single institution for EPS) are alternative explanations which cannot be ruled out.

In addition to these limitations that apply to both primary and secondary school levels, methodological limitations that are specific to the comparison of EPS and schools following the Luxembourgish curriculum at secondary school level further limit the interpretation of the results (e.g., comparison of a tracked to a common core system, six years vs. five years of primary school education). To draw methodologically sounder conclusions, the student population at secondary school level should ideally be split based on trajectories, with students having pursued their whole education in EPS being of special interest. Due to the small number of EPS students at this moment in time, such an analysis is however not yet feasible.

5. Summary and Discussion

Whereas the *ÉpStan* 2022/23 were administered, for the first time, to five grade levels in EPS and allowed to provide initial and tentative answers to the question whether diversifying the school offer through the implementation of EPS can contribute to reducing previously observed academic inequalities, the present

chapter aimed at understanding whether these initial findings can be confirmed using the full-cohort data from the *ÉpStan 2023/24*. In the following, the findings for primary and secondary education will be summarized and discussed in light of important methodological limitations.

Regarding academic achievement in mathematics at primary school level, students in EPS performed on average better than students in schools following the Luxembourgish curriculum across all three grades, and this particularly so in C4.1/P5. In addition, analyses split by specific background characteristics indicate that specific student subgroups (e.g., low SES students, students speaking Portuguese at home), which have previously been found to struggle academically in Luxembourg's education system, performed on average better in mathematics when attending EPS than their peers in schools following the Luxembourgish curriculum. At secondary school level, EPS students performed on average better in mathematics than their peers in ESG and ESG-VP, while they stayed below the performance of ESC students and this irrespective of individual background characteristics. These findings generally follow the same pattern that was observed in the *ÉpStan 2022/23*, thus substantiating the initial conclusion that the diversification of the school offer can contribute to encounter existing educational inequalities in Luxembourg.

One potential explanation for the observed achievement differences in favor of EPS students might be that EPS offer a better linguistic fit to the linguistically diverse student population in Luxembourg. By providing the opportunity to choose a language section, EPS allow students to be educated in the language they speak at home or a related language (e.g., another Romance language). The observation that achievement differences in mathematics appear to be most pronounced in C4.1/P5 seems especially noteworthy. Research in schools following the Luxembourgish curriculum found achievement differences to significantly increase over time (e.g., Sonnleitner et al., 2021) and achievement in mathematics to be partially dependent on language skills in the instruction language (Greisen et al., 2021). Achievement differences in favor of EPS students being most prominent in later school years could thus potentially be explained by the fact that mathematical instruction becomes both increasingly complex and thereby more language-bound in higher grades. The expected better linguistic fit offered by EPS might thus come more strongly into play in C4.1/P5.

Another explanation for the observed achievement differences could lie in structural differences between EPS and schools following the Luxembourgish curriculum (e.g., institutionalized quality assurance, greater flexibility in teacher recruitment, provision of primary and secondary education in one institution, for a detailed explanation on how these aspects might affect achievement see LUCET & SCRIPT, 2023). In addition, the student population in EPS differs from the population in schools following the Luxembourgish curriculum. The composition of the schools' student population is likely to be reflected at classroom level (e.g., lower share of low SES students in EPS classrooms) and has repeatedly been identified to relate to individual student achievement (e.g., Sykes & Kuyper, 2013). Research furthermore showed that teachers might lower their instructional level in classes with a high share of low SES students and that low SES students might generally be more sensitive to contextual classroom effects (e.g., class size, didactical

approaches, instruction quality) than their high SES peers (Hornstra et al., 2015). The different student population found in EPS should therefore be considered as another potential explanation for the observed achievement differences in favor of EPS students.

Although facing important methodological limitations that applied to the analyses of the previous ÉpStan cohort (2022/23), the results of the present chapter using full-cohort data from the ÉpStan 2023/24 were able to confirm the general pattern observed in the European Public School Report 2023 (LUCET & SCRIPT, 2023). This indicates that the observed achievement differences in favor of EPS students are not a one-off finding, but rather a stable result that can be observed across cohorts.

By continuously integrating EPS into a well-established school monitoring tool, the ÉpStan will in the future allow for more in-depth analyses of potential academic achievement differences between EPS and schools following the Luxembourgish curriculum. In this context, the next European Public School Report plans to provide first longitudinal data on how achievement in mathematics develops over two school years when comparing students in EPS to their peers in schools following the Luxembourgish curriculum. In addition, including achievement measures in languages (e.g., German, French), as far as psychometrically possible (e.g., comparability of test versions and language curricula), in a future ÉpStan data collection would allow to analyze whether academic achievement differences in favor of EPS students also exist in other subjects.

Furthermore, an operationalization of the assumed better linguistic fit (e.g., possibility for parents to offer their child academic support) and of the learning environment (e.g., cognitive activation) in the ÉpStan questionnaires are foreseen to investigate which characteristics of the school offer decisively contribute to explaining the observed achievement differences in favor of EPS students.

A better understanding of how the extension of the linguistic offer in EPS helps to counter the existing educational inequalities would provide the involved stakeholders with solid and reliable data for evidence-based policy making in the field of education. In turn, such findings could inform the (ongoing) creation of school offers in which all students can make better use of their academic potential irrespective of their individual background characteristics (e.g., SES, language background).

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