Teacher-student assortative matching and student achievement*

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Abstract

This paper investigates the extent of sorting between teacher and student characteristics and its relation to student achievement. Using administrative data on all Dutch primary school teachers between 2008 and 2016, we find strong positive assortative matching on education levels and migrant background, particularly in urbanized areas. The school share of non-western migrant teachers relates positively to test scores of migrant students, with no negative effect found for natives. Further, the share of teachers holding a master's degree is unrelated to test scores of students with university-educated parents. The results suggest teacher sorting along migration background could increase educational effectiveness.

Keywords: Teacher sorting; Teacher quality; Student achievement; Segregation

JEL: I20, I21, I24

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I. Introduction

In the Netherlands, as well as in most other developed countries, there is a large achievement gap between students from different socio-economic and migration backgrounds (Inspectorate of Education, 2018; OECD, 2017). There is some international evidence that school segregation is partly responsible for the size of the gap (Card & Rothstein, 2007). In the Dutch education system, which is characterized by high school autonomy and free school choice, differing parental school preferences along socioeconomic and migration background are leading to an increasingly segregated and fragmented school landscape, especially in the urban areas (Boterman, 2018). This increasing school segregation could have a negative impact on equality of educational opportunities along the lines stated above. One mechanism through which school segregation could harm educational opportunities is through an unequal distribution of teaching resources, as teaching quality has been shown to be strongly related to student achievement (Hanushek & Rivkin, 2006; Hanushek, 2011; Chetty, Friedman, & Rockoff, 2014). When schools serving a disadvantaged student population have more trouble attracting high quality teachers, this could further increase school segregation, as well as its negative impact on the size of the achievement gap.

In this paper, we investigate the extent of positive assortative matching between student and teacher characteristics and its relationship with student achievement. We use administrative data on all primary school students and teacher assignments in the Netherlands over the period 2008 to 2016 to show that there is strong sorting along both educational lines and migration background. Schools serving a larger proportion of children with university-educated parents employ a larger percentage of teachers holding a master's degree, while schools with a high percentage of students from a non-western migration background employ more teachers with a non-western migration background. These patterns are especially pronounced in urban areas, where both parents and teachers have more options to act on their

preferences for school, student, and teacher characteristics. Analyses focusing on early career teachers that graduated in the period 2007 to 2015 show that the sorting patterns of young teachers reinforce the sorting patterns on average.

To investigate the relationship between student educational outcomes and positive assortative matching between student and teacher characteristics, we run OLS and school fixed-effects regressions, relating cohort-to-cohort variation in teacher characteristics at the school level, to individual student performance on the high stakes test at the end of primary school. The results suggest that assortative matching on migration background is beneficial to student performance. Students with a migration background perform slightly better in schools with a larger share of non-western migrant teachers, with no negative effects found for native students. The results are more pronounced for students from a relatively low socio-economic background, and are driven by increased performance on the mathematics part of the test, with no matching effects found for the language part of the test. In contrast, the share of teachers holding a master's degree is unrelated to the performance of students with university-educated parents, nor do students with low educated parents perform worse in schools with a larger percentage of master's degree holding teachers.

This paper contributes to the literature on teacher sorting and student achievement in three ways. First, it adds to the school sorting literature by looking at assortative matching on teacher and student characteristics along educational and migration background for an entire country, allowing us to distinguish between urban and non-urbanized areas. In an early paper, Lankford, Loeb, & Wyckoff (2002) examine the extent of teacher sorting for the state of New York. They find that schools serving disadvantaged students employ teachers with fewer qualifications, consistent with the results of this paper. Other studies on teacher sorting patterns using statewide data (e.g. Clotfelter, Ladd, & Vigdor, 2005; Goldhaber, Choi, & Cramer, 2007) reach similar conclusions. Second, this study adds evidence on a lack of

matching effects between additional teacher certification and students' parental educational background. This finding is consistent with an earlier study by Sass et al. (2012), who show that while the average value added of teachers in high poverty schools is lower than the average value added of teachers in low poverty schools, teacher certification does not explain much of the variation in teacher quality across schools. Finally, we provide supporting evidence in a different institutional context for the significant positive ethnic match effect on student achievement first studied by Dee (2004, 2005), and corroborated more recently by Egalite, Kisida, & Winters (2015), Gershenson et al. (2018), and Yarnell & Bohrnstedt (2018).

While the latter result suggests that segregation along migration background might be beneficial from an educational effectiveness point of view, this does not imply that schools and policy makers should stimulate segregation of their student and teacher force across migration background. One concern is that other important functions of the school system such as socialization and increased societal cohesion may be enhanced more by increased diversity at schools and exposure to teachers and students from different backgrounds. The potential gains in student achievement on standardized tests could be outweighed by the losses in terms of the socialization function of the educational system.

The remainder of this paper is structured as follows. In section II, we discuss the data and show some descriptive statistics. Section III presents the results, and section IV concludes.

II. Data

The main dataset used for constructing school-level average student characteristics is the registration file that is used to finance schools based on student enrollment data, the 'DUO 1cijferPO' registration file. We use the data for the years 2008-2016. The dataset contains information on all students enrolled in primary education in the Netherlands, their background characteristics, and school characteristics. This dataset is combined with information on parental education using data on highest obtained education from Statistics Netherlands, and collapsed at the *school*year* level (BRIN4) to obtain school-by-year averages of student characteristics.[4]

Information on teacher assignments and teacher characteristics come from the Dutch teacher registration file, the 'DUO Functiemix' file. This file is based on national administrative salary data, and contains yearly information on all teacher assignments in primary and secondary school for all schools in the Netherlands between 2008 and 2016. From this file, we select those teachers working in regular primary education, and add information on the highest obtained level of education, and the municipal administration data for teachers' date of birth, gender, and migrant status from Statistics Netherlands. Finally, information about each teacher's wage, monthly hours worked, and tenure status are added from the salary administration data (the 'Polis administration file') of Statistics Netherlands. These data are then similarly collapsed at the *school*year* level (BRIN4) to obtain *school*year* averages of teacher characteristics and student characteristics.

<Table 1>

[4] Ideally, the data would be aggregated at the school-location level (BRIN6), but unfortunately the teacher data are not precise enough to allow identification of teachers at that level of detail. While 98% of primary schools in the dataset have only one location, for the 2% of schools with multiple locations there is some uncertainty with respect to which students are exposed to which group of teachers. The analyses are unaffected by the exclusion of schools for which the exact location of teachers cannot be determined.

Table 1 shows the weighted average student and teacher characteristics at the school level for the entire period studied (2008-2016), separately for the whole of the Netherlands and highly urbanized areas. The reason for making the distinction between strongly urbanized areas and the country as a whole is that positive assortative matching is more likely to occur when both students and teachers have more opportunities to sort on their preferences. In non-urbanized areas, there may be just one or two schools for parents to send their children to (as prior research has shown that parents prefer not to travel too far for primary schools (Borghans, Golsteyn, & Zölitz, 2015)). Likewise, teachers living in these rural areas have fewer schools to apply to than their city-dwelling colleagues. There are 56,808 school*year combinations in the dataset in total, i.e. around 6,200 schools per year. Schools in highly urbanized areas tend to serve more students, have a larger percentage of students with a migrant background, and more students whose parents have either a very high or a very low education level. The average test score at the end of grade 6 is also slightly lower in strongly urbanized areas.

In terms of teacher characteristics, the vast majority of teachers are female (82.9%), and 90% of teachers have no migration background. Around 19% of teachers within each school for whom information on their highest obtained education is available, have completed a master's degree. The average monthly hours worked within each school (120 hours per month) is significantly less than full time (140-160 hours per month), implying that a large share of teachers work on a part-time contract. Around 90% of teachers within each school are tenured, and yearly teacher turnover comprises around 12% of the total teaching force within each school.

Early career teacher individual level data

To identify early career teachers, we use data from national higher education student registration files (the DUO 1cijferHO database). This administrative dataset includes information on all student registrations between 2002 and 2016 in the Dutch (subsidized) higher education system, both for higher vocational and university level programs. This dataset includes information of the full-time or part-time student status, whether a student has graduated or not, the highest obtained educational level before enrolling in higher education and on the students' grades and track in secondary education. From this file, we select those full-time students[5] that graduated from primary teacher training between the academic years 2007/2008 and 2015/2016.[6] The data on the graduates are then linked to the 'DUO Functiemix teacher registration' file. This creates a panel dataset where each graduate's first observation is the year in which (s)he started their first teaching job. Finally, for all graduates working as a teacher we add the *school*year* average student, school, and teacher colleague characteristics from the school-average level dataset described earlier.

Table 2 shows the average characteristics of the early career primary school teacher subsample by graduation year. As in the full teacher population, the large majority of the early career teachers are female (88%) and non-migrants (91%). However, there is a slight increase in the amount of non-western migrants that graduate primary teacher education over time. Most early career teachers attended the middle track (Havo) during secondary school, but the share of graduates from the high secondary school track (Vwo) is steadily increasing. The share of early career teachers holding a master's degree is relatively low at around 8%,

[5] Only full-time students are considered because part-time students are likely to already be employed at a primary school well before their graduation date. By excluding part-time students, it is much more likely that the individual level analyses truly capture the sorting behaviour of early career teachers.

[6] The reason for restricting the sample to those graduating from the academic year 2007/2008 onward is that the aim is to follow teachers from the first year of entering the teaching force, and there is no information available on teacher assignments prior to 2008. Those that graduate in the academic year 2007/2008 will be in the labor market by October 2008, plausibly working their first teaching job.

which suggests that teachers holding a master's degree usually obtain one over the course of their working career.[7] The amount of graduates observed in the data is decreasing over time. This is not only because of dwindling enrolment rates into primary education teacher training, but also because the graduates from later years have had less time in the labor market to find a teaching job. As a result, those that graduated relatively recently have a higher chance of not showing up in the teacher registry database yet.

<Table 2>

Student level data on educational outcomes

The information on student level educational outcomes is derived from the national register on students in primary education (the '1cijferPO registration' files) from 2008-2016. We keep all students that took the most commonly used grade 6 end of primary school test (Cito) during the period studied.[8] Table 3 shows the descriptive statistics of the individual level student data. Pooling all cohorts, there are over 1.1 million students that took the Cito end of primary school standardized test, with an average score of 535.25.[9] Furthermore, there is separate information on students' achievement at the math and language sections of the test. For all students taking the Cito, we calculate the share of students from a certain parental educational background, migrant status, gender composition and average age in their classroom.

<Table 3>

[7] Of the early career teachers that attended the high track in secondary school, 21% hold a master's degree. Of those that attended the middle or low track, the percentages are 9% and 5% respectively. This shows that at least for early career teachers, master degree obtainment is related to teacher cognitive skills.

[8] While alternative tests have become somewhat more popular during the last three years, over the period studied the vast majority of students that took any form of standardized test at the end of primary school, took the Cito test. In the first two years of the dataset (2008 and 2009), test scores are not available for relatively many students. All other years see Cito test-score coverage of around 80%. Some concerns about selectivity of the group for whom test scores are available in 2008 and 2009 may arise. However, all analyses are robust to the exclusion of students who took the Cito test in 2008 and 2009.

[9] In the Cito test, the range of possible test scores is 501-550

III. Results

In order to visualize the extent of assortative matching between student and teacher characteristics at the school level, we divide schools into quartiles based on their share of teachers that obtained a master's degree in addition to their initial teaching qualification, and their share of teachers with a non-western migration background separately. For each quartile, the average percentage of students with a certain parental education level, and the average percentage of students from a migration background are calculated. Results are reported both for the Netherlands as a whole, as well as for strongly urbanized areas separately.

Figures 1A and 1B show the average percentage of students from a certain parental educational background against the quartiles of the share of teachers that obtained a master's degree for the whole of the Netherlands, and strongly urbanized areas respectively.[10] In schools with a large share of teachers with a master's degree, the share of students whose parents completed a university degree is higher: 15% of students for the bottom-, and 22% in the top quartile. The results are more pronounced in strongly urbanized areas, where the share of students whose parents completed a university degree is 31% on average in schools employing the largest share of teachers holding a master's degree (compared to 17% in schools employing the lowest share of teachers holding a master's degree). These results are indicative of assortative matching on educational levels.

<Figure 1A>

<Figure 1B>

Figures 2A and 2B follow the same principle, this time dividing the schools into quartiles based on the share of teachers with a non-western migrant background and the

[10] The average shares of teachers holding a master's degree per quartile for the Netherlands are Q1: .05, Q2: .14, Q3: .22, Q4: .35. The shares for strongly urbanized areas are Q1: .06, Q2: .14, Q3: .21, Q4: .33

average share of students from a certain migrant background. Since there are relatively few non-western migrant teachers in total, the median school in the Netherlands does not employ any teacher with this background. As a result, there is no distinction possible between the first and second quartile. In strongly urbanized areas, there are more teachers with a non-western migration background, and a distinction between the first and the second quartile becomes possible again.[11] Both figures show that schools where the share of teachers with a non-western migrant background is higher tend to serve more students from a non-western migration background. For the whole of the Netherlands, this result is to be expected, since the population of non-western migrants is mostly centered in urban areas. However, zooming in on these particular urban areas, the pattern is even more striking. In these areas, schools that employ the largest share of non-western migrant teachers serve around 75% non-western migrant students, while schools without any teachers from a non-western migrant background serve only 20% non-western migrant students. These results are indicative of strong matching along migration background.

<Figure 2A>

<Figure 2B>

Early career teacher sorting

The previous section showed that there is strong assortative matching between student and teacher characteristics. However, it is unclear whether a particular student composition attracts a particular teacher population, or a certain teacher composition attracts certain students. In this section, we investigate the sorting patterns of early career teachers, relating their characteristics to the characteristics of the student population of the first school they start teaching after graduation. Since parents cannot anticipate the characteristics of teachers

[11] The average shares of teachers from a non-western migration background per quartile for the Netherlands are Q1 & Q2: .00, Q3: .03, Q4: .13. The shares for strongly urbanized areas are Q1: .00, Q2: .04, Q3: .10, Q4: .33

that have yet to be hired, the sorting pattern of early career teachers is more likely to reflect teacher preferences for a certain student population, or a school's preference for a certain type of teacher, than parental preferences for a certain teaching force.

Since the large majority of teachers that obtain master's degrees do so over the course of their career rather than before entering the teaching force, sorting of early career teachers on educational background is investigated through looking at the secondary school track they attended prior to entering teacher training. Since higher secondary school tracks are associated with higher cognitive abilities of students, teacher sorting on this characteristic is analogous to the school-level sorting on the share of teachers holding a master's degree.

Figures 3A and 3B show the share of students from a certain parental educational background against the early career teacher's secondary school track before starting teacher training (for the Netherlands as a whole and urbanized areas respectively). The results show that even though the large majority of early career teachers start with the same level of teaching qualification, there is sorting along teachers' education prior to teacher training. Teachers that graduated from the highest track of secondary school start their careers at schools with a larger percentage of students with highly educated parents. Again, these results are more pronounced in urbanized areas, where teachers from the highest secondary school track start working at schools with a substantially lower percentage of students from low educated households.

<Figure 3A>

<Figure 3B>

Figures 4A and 4B show the sorting of early career teachers on migration background for the whole of the Netherlands and urbanized areas respectively. The results show that sorting on migration background is more pronounced in early career teachers than it is on average. Teachers without a migration background work in schools where on average around

75% of the student population does not have a migrant background, while teachers from a non-western migration background start working at schools where 60% of the student population has a non-western migration background. In urbanized areas, the amount of students from a non-migration background is smaller in total, but the same sorting pattern is apparent.

<Figure 4A>

<Figure 4B>

Teacher characteristics and student achievement

While the preceding section showed that there is strong positive assortative matching of teacher and student characteristics, the impact of this unequal distribution of teachers across schools on student learning outcomes is unclear. If the characteristics on which teachers are sorted are strongly related to teaching quality, these patterns could reinforce educational inequalities. On the other hand, if student learning is enhanced by being taught by a teacher that shares his or her background characteristics, it might be optimal to match teachers and students to each other based on exactly these attributes.

There is some prior evidence supporting both of these arguments. Dee (2004, 2005) finds that a match along ethnic lines between teacher and students has a positive impact on student achievement for both black and white students in the United States, particularly for students of low socioeconomic status. More recent studies, such as Egalite et al. (2015), Gershenson et al. (2018), and Yarnell & Bohrnstedt (2018) have corroborated these results. For higher education, Fairlie et al. (2014) show strong positive ethnic match effects on the probability of dropping out and student GPA. In this case, positive assortative matching along ethnic lines could increase educational effectiveness.

Conversely, while holding a master's degree does not seem to be related to teacher quality in itself (Harris & Sass, 2011; Coenen et al., 2018), there is some evidence that teachers with high cognitive ability achieve better outcomes for their students (Metzler & Woessmann, 2012; Hanushek, Piopiunik, & Wiederhold, 2018). If education beyond the initial teaching qualification is correlated with cognitive ability, teachers holding such additional master's degrees are expected to be of slightly higher cognitive ability, and therefore quality, on average.[12] In this case, positive assortative matching on educational background would increase educational inequalities. It is therefore an empirical question whether these sorting patterns can be held partly responsible for differences in student performance.

In order to investigate the relationship between teacher characteristics and student achievement, we run OLS and school fixed effects regressions on student performance at the end of primary school exam in grade 6. [13] The main explanatory variables of interest are the primary school-average teacher characteristics. In order to investigate matching effects, we interact the educational and migrant background of teachers with the parental education and migrant background of students.

$$(1)\ Y_{icst} = X_i + \overline{T_{st}} + (Mig_i * \overline{Tmig_{st}})\beta_1 + (Educ_i * \overline{Teduc_{st}})\beta_2 + \overline{C_{sct}} + \overline{S_{st}} + M_s + \gamma_{st} + \delta_t + \varepsilon_{icst}$$

Equation 1 shows the standard OLS specification. Citoscore *Y* of student *i* in classroom *c* in school *s* in year *t* is predicted by a vector of individual student characteristics *X*, a vector of school average teacher characteristics $\overline{T}$, and two interaction terms: one

[12] While we do not observe teacher cognitive skills directly, master degree obtainment is higher for teachers coming from the highest secondary school track, at least in early career teachers. This lends some plausibility to the assumption that master degree obtainment is positively related to teacher cognitive ability.
[13] The main regressions are conducted on all schools in the Netherlands. Additional analyses limited to schools in strongly urbanized areas reveal similar results, and are available upon request.

interaction between a student's migrant background and the school level share of teachers from a certain migration background ($Mig* \overline{Tmig}$), and one between a student's parental education background and the share of teachers holding a master's degree at the school level ($Educ * \overline{Teduc}$). Additionally, we control for classroom-average peer characteristics $\bar{C}$, school-average student characteristics $\bar{S}$, municipality dummies *M*, observable school characteristics γ, and year dummies δ.

A potential concern with the OLS specification above is that time-invariant unobservable characteristics at the school level that relate both to increased performance of a certain subset of students and to a propensity to employ a certain type of teacher, could bias the results. For example, some schools may focus on offering enrichment programs for their students with high ability, which may simultaneously attract teachers with a master's degree interested in teaching these particular programs. Any association between teachers holding a master's degree and the achievement of high ability students would then by confounded by the availability of the enrichment program. Therefore, the second specification includes school fixed effects:

$$(2)\ Y_{icst} = X_i + \overline{T_{st}} + (Mig_i * \overline{Tmig_{st}})\beta_1 + (Educ_i * \overline{Teduc_{st}})\beta_2 + \overline{C_{sct}} + \overline{S_{st}} + \gamma_{st} + \varphi_s + \delta_t + \varepsilon_{icst}$$

where φ represents the effect of all school-level time invariant characteristics on students' test scores.

Note that a general limitation of this dataset is that we cannot link individual students to their individual teachers. The standard OLS regression coefficients should therefore be interpreted as the impact of exposure to a certain combination of teachers throughout primary education, while the school fixed effects regressions relate to variation in the composition of teacher characteristics at the school level. An increase in, for example, the share of teachers

from a non-migrant background increases the probability that a student is taught by one, but does not make it certain. It is therefore likely that both specifications underestimate the true association between teacher characteristics and student achievement.

Table 4 shows the results of the OLS regressions explaining grade 6 Cito test scores. Column 1 includes student and school characteristics, as well as year and municipality dummies. Standard errors are clustered at the school level in all specifications. Column 2 adds teacher characteristics, and column 3 adds the interactions between average teacher characteristics and individual student characteristics. The results show that, while there is no overall relationship between the share of teachers from a certain migration background and test scores, there is a significant positive interaction between the share of non-western migrant teachers and migrant status of the students on student achievement, particularly for first generation non-western migrants. However, the share of non-western migrant teachers relates negatively to student achievement for native students. These results are in line with the results of Dee (2004, 2005), who finds positive match effects along ethnic lines for both majority and minority students. In contrast, the interaction between the share of teachers holding additional qualifications and the parental educational background of students is not significant, nor is there an overall relationship between the share of teachers holding a master's degree and student achievement.

Table 5 shows the results of school fixed effects regressions on student performance at the end of primary school. The negative association between the share of non-western migrant teachers and student performance of native students disappears when adding school fixed effects, while the positive interaction effect for migrants stays significant. Again, no significant interaction is found between the share of teachers holding an advanced degree and students' parental educational background. These results corroborate earlier literature on the

lack of association between additional teacher certification and student outcomes (e.g. Harris & Sass, 2011; Hanushek & Rivkin, 2006; Coenen et al., 2018).

In terms of the size of the relationship, a one standard deviation increase in the share of non-western migrant teachers is related to a .01 (.03) standard deviation higher Cito score for second (first) generation non-western migrants. This seems like a relatively small association. However, it has to be interpreted in light of the size of teacher effects in general. For example, Papay & Kraft (2015) find that the difference between a novice teacher and one with 5 years of experience is around .08 standard deviations. Considering that the positive return to early career experience is one of the largest and most well established findings in the teacher effectiveness literature (Coenen et al., 2018), an association of .03 is not unsubstantial. Furthermore, other studies investigating interaction effects between teacher and student ethnicity find relationships in the neighborhood of .05 standard deviations (e.g. Clotfelter, Ladd, & Vigdor, 2010). These prior studies have the benefit of being able to match students to their individual teachers, whereas in our case the association between student and teacher migrant status is likely underestimated because of uncertainty in the extent to which students were exposed to teachers sharing their migration background.

<Table 4>

<Table 5>

Robustness and heterogeneity

A concern with the school fixed effects specification is that variation in the share of teachers from a certain background necessarily coincides with some form of teacher turnover. An increase in the share of migrant teachers implies that either a migrant teacher was hired, or a non-migrant teacher left the school. Since teacher turnover has been shown to negatively affect student outcomes in and of itself (Bryk & Schneider, 2002; Guin, 2004; Bryk, Sebring, Allensworth, Easton, & Luppescu, 2010; Ronfeldt, Loeb, & Wyckoff, 2013), the effects of turnover could confound the associations between the change in average teacher

characteristics at the school level and test scores. Table 6 shows the results of the school fixed effects regressions adding two different measures of teacher turnover to the full model.[14] While teacher turnover does appear to negatively influence student test scores, neither measure of teacher turnover reduces the positive interactions on teacher-student migrant status match.

<Table 6>

Because there is information about student performance on the math and language subscales of the Cito-test, it is interesting to see whether the teacher-student match effects are subject specific. Table 7 shows school fixed effects regressions on achievement in language (column 1) and math (column 2) separately. The results show that the positive interaction between the share of non-western migrant teachers and students' non-western migration background is only significant for the math part of the test. These results contrast with the findings of Dee (2004), which show gains in both the math and reading domains. A plausible explanation for these discrepant results is that non-western migrant teachers have higher math skills relative to their Dutch language skills than their native colleagues as they have usually been brought up bilingual. In America, however, both white and black teachers have most likely been raised to speak English. Unfortunately, since there are no data available on teacher subject knowledge this interpretation cannot be empirically validated.

<Table 7>

Finally, Dee (2004) shows that an ethnic student-teacher match is particularly beneficial for students of low socioeconomic status. Starting from the academic year 2014/2015, Statistics Netherlands calculates a predicted Cito-score based on observable

[14] Teacher turnover is operationalized as the share of new teachers in a certain school in a certain year (column 1), and the share of teachers that did not return to a certain school after the previous year (column 2). Analyses using absolute numbers of teacher turnover instead of shares show similar results.

student characteristics for each student using multiple sources of background information.[15] These predicted Cito-scores are highly contingent on students' socioeconomic background. To see whether an student-teacher match on migration background is associated with higher test scores specifically for students from a low socioeconomic background, we run the main school fixed effects regressions for students with a below average and an above average predicted Cito-score separately.

<Table 8>

Table 8 shows the results. Column 1 shows the results for the subsample of students with a below average predicted Cito-score, while column 2 shows the results for the students whose Cito-scores were predicted to be above average. The tables show that, at least from the academic year 2014/2015 onwards, a student-teacher match on migration background is related to higher student achievement only for the subset of students with a below average predicted Cito-score.

IV. Conclusions

School segregation across migration background and socio-economic lines is a rising cause of concern for policy makers because of its potential to exacerbate inequality of educational opportunities. One channel through which school segregation could lead to increased inequality is through an unequal distribution of teaching resources. In this paper, we investigate the extent of teacher sorting using Dutch registry data and find evidence of strong positive assortative matching of students and teachers across migration background and educational lines. Schools serving students with highly educated parents employ a larger share of teachers holding master's degrees. The same holds for migration background: schools with a higher percentage of non-western migrant students employ a larger percentage

[15] The characteristics used by Statistics Netherlands to predict Cito-scores are maternal and paternal education level, parental countries of origin, maternal years of residence in the Netherlands, parental gross yearly income, and an indicator for whether a student's parents are currently part of an outstanding debt refinancing program ("schuldsanering") (CBS, 2017).

of teachers with a non-western migration background. Positive assortative matching is especially pronounced in urbanized areas, and the sorting patterns of early career teachers magnify, rather than mitigate, the extent of teacher sorting.

In terms of the impact of teacher sorting on student achievement, analyses on the link between teacher characteristics and student outcomes reveal no association between test scores and the share of teachers from a migrant background or the share of teachers holding an advanced degree in general. However, we find a positive interaction between the share of teachers from a non-western migrant background and student migrant background on test scores, providing suggestive evidence of a positive match effect as previously found by Dee (2004, 2005), and more recently by Egalite et al. (2015), Gershenson et al. (2018), and Yarnell & Bohrnstedt (2018). The results are more pronounced for students from a low socio-economic background, and are driven by increased performance in mathematics, but not in language. In contrast, we find no match effect along educational lines.

In conclusion, considering the positive interaction between the share of non-western migrant teachers and non-western migrant student outcomes, positive assortative matching on migration background could be beneficial to student achievement and equality of educational opportunities. However, this does not mean that policy makers should design interventions aimed at stimulating student-teacher matches on migration background, as educational effectiveness is only one of several functions of the school system. Potential gains in student achievement from increased assortative matching on teacher and student characteristics may come at the cost of reducing socialization and citizenship skills outcomes, which could potentially be benefited from exposure to teachers from different backgrounds. Therefore, while the extent of positive assortative matching between student and teacher characteristics is sizable, the consequences of this sorting pattern for educational inequalities of opportunities are not yet fully clear.

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Tables

Table 1: School-level average student and teacher characteristics

	School-level characteristics			
	Netherlands		Urban areas	
Variable	**Mean**	**SD**	**Mean**	**SD**
School characteristics				
Number of schools	56,808		8,621	
Number of students	229.98	138.22	314.20	157.84
Number of teachers	22.77	12.56	31.57	15.66
Student characteristics				
Girls pct.	49.56	3.49	49.72	2.98
Migrant status:				
Non-migrant pct.	76.49	22.28	52.21	27.68
Non-western migrant pct.	16.66	20.67	37.66	28.37
Western migrant pct.	6.83	4.82	10.11	6.40
Parental education:				
University pct.	18.82	15.12	23.93	20.36
HBO pct.	26.49	10.62	19.07	10.29
MBO34 pct.	31.58	9.50	25.58	8.85
Max MBO2 pct.	23.09	17.06	31.41	23.88
Unknown pct.	20.32	9.89	15.39	8.02
Cito-score	535.24	3.81	534.41	4.82
Teacher characteristics				
Female pct.	82.90	7.95	82.74	7.27
Age	43.78	3.80	43.15	3.70
Migrant status:				
Non-migrant pct.	90.97	11.54	80.73	17.51
Non-western migrant pct.	3.73	9.54	11.39	16.56
Western migrant pct.	5.28	5.90	7.86	7.59
Master's degree	19.04	12.01	18.13	10.55
Hourly wage	22.51	2.067	22.19	2.16
Tenured pct.	90.04	11.12	88.04	12.23
Monthly hours worked	120.76	12.42	127.9	11.54
New teacher in school pct.	12.24	11.13	12.12	10.66
Teachers that did not return pct.	12.10	9.05	11.40	7.97

Note: School-level average student (teacher) characteristics are calculated using the number of students (teachers) within a school as analytic weights.
Source: DUO 1cijferPO, DUO Functiemix, Statistics Netherlands POLIS, Statistics Netherlands municipal administration, and Statistics Netherlands highest achieved level of education databases.

Table 2: Individual early career teacher characteristics per year of graduation

	Early career teacher characteristics								
	Graduation year								
Variables	2007	2008	2009	2010	2011	2012	2013	2014	2015
N	3,734	3,216	2,884	2,846	2,592	2,329	2,231	2,046	1,608
Female pct.	88.9	89.6	87.7	89.6	87.7	87.9	86.7	84.8	85.8
Average age	24.4	24.4	24.6	25.0	25.1	24.8	24.6	24.4	24.0
Non-western migrant pct.	4.47	5.6	3.74	3.72	3.78	4.89	4.35	5.33	5.6
Western migrant pct.	4.31	3.54	3.95	3.55	3.74	3.65	3.54	3.52	3.73
Master's degree pct.	10.28	7.62	7.47	9.23	9.13	9.22	10.48	11.98	.
MBO pct.	34.68	34.61	32.87	33.98	33.83	32.33	32.14	30.89	26.06
Havo pct.	53.83	53.79	54.33	53.09	54.4	53.03	54.1	53.76	55.97
Vwo pct.	8.62	9.11	10.26	11.03	10.11	13.44	12.33	14.03	16.79
Mean exam grade VMBO graduates	.	.	.	.	6.38	6.53	6.38	6.35	6.44
Mean exam grade Havo graduates	.	.	.	.	6.19	6.18	6.15	6.16	6.27
Mean exam grade Vwo graduates	.	.	.	.	6.09	6.05	6.01	6.04	6.02

Note: Average exam grades for the cohorts prior to 2011 and information on obtained master's degrees for the 2015 cohort are not available because of data constraints.
Source: DUO 1cijferHO, DUO Functiemix, DUO vakkenanalysebestand, and Statistics Netherlands highest achieved level of education databases.

Table 3: Individual student and average grade 6 student characteristics

Cito student characteristics					
Individual characteristics			**Average grade 6 characteristics**		
Variable	**Mean**	**SD**	**Variable**	**Mean**	**SD**
Number of students	1,117,268		Average number of students	39.05	21.35
Girls pct.	50.22		Girls pct.	50.21	10.01
Age	11.48	0.65	Average age	11.58	0.15
Migrant status			Migrant status		
Non-migrant pct.	77.66		Non-migrant pct.	77.63	23.72
Western migrant pct.	6.2		Western migrant pct.	6.21	5.76
Non-western migrant 2nd gen pct.	14.76		Non-western migrant pct.	16.16	22.44
Non-western migrant 1st gen pct.	1.38				
			Parental education:		
Parental education:			University pct.	17.54	15.62
University pct.	13.82		HBO pct.	25.19	13.18
HBO pct.	19.05		MBO34 pct.	33.49	13.62
MBO34 pct.	25.08		Max MBO2 pct.	23.76	18.72
Max MBO2 pct.	18.32		Unknown pct.	23.72	12.79
Unknown pct.	23.72				
Relative age					
Early pct.	26.06				
Average pct.	48.78				
Late pct.	25.15				
Cito-score	535.25	9.79			
Cito-score language	83.92	18.37			
Cito-score math	49.79	14.37			
Predicted Cito-score	535.32	3.26			

Source: DUO 1cijferPO and Statistics Netherlands "kenmerken van deelnemers aan de Eindtoets Basisonderwijs van Cito" databases.

Table 4: OLS regressions of Cito-scores on student and teacher characteristics

VARIABLES	(1) Standardized Cito	(2) Standardized Cito	(3) Standardized Cito
Gender (1=F)	-0.028**	-0.028**	-0.028**
Age	-0.271**	-0.271**	-0.271**
Relative age			
Early	-0.095**	-0.095**	-0.095**
Late	0.153**	0.153**	0.153**
Migration status:			
Western migrant	0.031**	0.031***	0.032**
2nd gen NW-migrant	-0.117**	-0.117***	-0.117**
1st gen NW-migrant	-0.137**	-0.138***	-0.149**
Parental education:			
Max MBO2	-0.298**	-0.298**	-0.302**
HBO	0.310**	0.310**	0.305**
University	0.575**	0.575**	0.570**
Unknown	0.004	0.004	-0.005
Mean teacher salary		0.003	0.003
Mean monthly hours worked		0.005*	0.005
Tenured teachers pct.		0.004	0.004
Female teachers pct.		-0.011**	-0.011**
Mean teacher age		0.007*	0.007*
NW-migrant teachers pct.		-0.004	-0.018**
W-migrant teachers pct.		0.000	-0.000
Teachers with master's degree pct.		0.000	-0.002
NW-migrant teachers pct. * Western migrant			0.019*
NW-migrant teachers pct. * 2nd gen NW-migrant			0.017**
NW-migrant teachers pct. * 1st gen NW-migrant			0.030**
W-migrant teachers pct. * Western migrant			0.006
W-migrant teachers pct. * 2nd gen NW-migrant			-0.001
W-migrant teachers pct. * 1st gen NW-migrant			0.008
Teachers with master's pct. * Max MBO2			0.004
Teachers with master's pct. * HBO			0.003
Teachers with master's pct. * University			-0.002
Teachers with master's pct. * Unknown			0.006*
Classroom peer characteristics	X	X	X
School peer characteristics	X	X	X
School characteristics	X	X	X
Municipality dummies	X	X	X
Year dummies	X	X	X
Constant	2.146**	4.641**	5.307**
Observations	996,238	994,000	994,000
R-squared	0.174	0.1744	0.1744

Note: school-level teacher characteristics are standardized. The baseline category for relative age is "average". The baseline category for migration status is "non-migrant". The baseline category for parental education is "MBO34".Classroom peer characteristics include share of peers from a certain migration background, share of peers with a certain educational background, share of boys in class, class size, and peer average age. School peer characteristics include school-level share of children from a certain migration background, share of children with a certain educational background, and share of boys. School characteristics include school size, religious denomination, educational philosophy, and school board size. Standard errors are clustered at the school level, and omitted for brevity; the full regression output is available upon request.
** p<0.05; ** p<0.01*

Table 5: School fixed effects regressions of Cito-scores on student and teacher characteristics

VARIABLES		(1) Standardized Cito	(2) Standardized Cito	(3) Standardized Cito
Gender (1=F)		-0.0282**	-0.028**	-0.028**
Age		-0.271**	-0.271**	-0.271**
Relative age				
	Early	-0.096**	-0.096**	-0.0956**
	Late	0.155**	0.155**	0.155**
Migration status:				
	Western migrant	0.0313**	0.031**	0.032**
	2nd gen NW-migrant	-0.117**	-0.117**	-0.115**
	1st gen NW-migrant	-0.132**	-0.132**	-0.146**
Parental education:				
	Max MBO2	-0.298**	-0.298**	-0.302**
	HBO	0.310**	0.310**	0.305**
	University	0. 574**	0.574**	0.568**
	Unknown	0.004	0.004	-0.005
Mean teacher salary			0.000	0.000
Mean monthly hours worked			0.001	0.000
Tenured teachers pct.			0.003	0.0036
Female teachers pct.			-0.000	-0.000
Mean teacher age			-0.001	-0.001
NW-migrant teachers pct.			-0.001	-0.01
W-migrant teachers pct.			-0.003	-0.003
Teachers with master's degree pct.			0.001	-0.001
NW-migrant teachers pct. * Western migrant				0.022**
NW-migrant teachers pct. * 2nd gen NW-migrant				0.012*
NW-migrant teachers pct. * 1st gen NW-migrant				0.030**
W-migrant teachers pct. * Western migrant				0.004
W-migrant teachers pct. * 2nd gen NW-migrant				-0.003
W-migrant teachers pct. * 1st gen NW-migrant				0.011
Teachers with master's pct. * Max MBO2				0.002
Teachers with master's pct. * HBO				0.005
Teachers with master's pct. * University				-0.003
Teachers with master's pct. * Unknown				0.0073*
Classroom peer characteristics		X	X	X
School peer characteristics		X	X	X
Year dummies		X	X	X
School fixed effects		X	X	X
Constant		3.299**	3.300**	3.308**
Observations		998,182	995,919	995,919
R-squared		0.164	0.1642	0.1642

*Note: school-level teacher characteristics are standardized. The baseline category for relative age is "average". The baseline category for migration status is "non-migrant". The baseline category for parental education is "MBO34". Classroom peer characteristics include share of peers from a certain migration background, share of peers with a certain educational background, share of boys in class, class size, and peer average age. School peer characteristics include school-level share of children from a certain migration background, share of children with a certain educational background, and share of boys Standard errors are clustered at the school level, and omitted for brevity; the full regression output is available upon request. * p<0.05; ** p<0.01*

Table 6: School fixed effects regressions of Cito-scores on student and teacher characteristics, and teacher turnover

VARIABLES	(1) Standardized Cito	(2) Standardized Cito
Share of new teachers within a school	-0.0008**	.
Share of teachers that did not return	.	-0.0003
Migration status:		
Western migrant	0.034**	0.034**
2nd gen NW-migrant	-0.112**	-0.112**
1st gen NW-migrant	-0.144**	-0.143**
Parental education:		
Max MBO2	-0.301**	-0.301**
HBO	0.306**	0.307**
University	0.571**	0.571**
Unknown	-0.005	-0.005
NW-migrant teachers pct.	-0.008	-0.008
W-migrant teachers pct.	-0.003	-0.003
Teachers with master's degree pct.	-0.001	-0.001
NW-migrant teachers pct. * Western migrant	0.023**	0.023**
NW-migrant teachers pct. * 2nd gen NW-migrant	0.013*	0.013*
NW-migrant teachers pct. * 1st gen NW-migrant	0.033**	0.032**
W-migrant teachers pct. * Western migrant	0.004	0.004
W-migrant teachers pct. * 2nd gen NW-migrant	-0.002	-0.002
W-migrant teachers pct. * 1st gen NW-migrant	0.013	0.013
Teachers with master's degree pct. * Max MBO2	0.002	0.002
Teachers with master's degree pct. * HBO	0.005	0.005
Teachers with master's degree pct. * University	-0.003	-0.003
Teachers with master's degree pct. * Unknown	0.007*	0.007*
Student characteristics	X	X
Classroom peer characteristics	X	X
Teacher characteristics	X	X
School peer characteristics	X	X
Year dummies	X	X
School fixed effects	X	X
Constant	3.298**	3.301**
Observations	966,375	963,585
R-squared	0.1644	0.1642

Note: school-level teacher turnover variables are in percentages (scale 0-100). School-level teacher characteristics are standardized. The baseline category for migration status is "non-migrant". The baseline category for parental education is "MBO34". Student characteristics include student gender, and absolute and relative age. Classroom peer characteristics include share of peers from a certain migration background, share of peers with a certain educational background, share of boys in class, class size, and peer average age. Teacher characteristics include the school-level average hourly wage, hours worked, and age, and the percentage of female, and tenured teachers. School peer characteristics include school-level share of children from a certain migration background, share of children with a certain educational background, and share of boys. Standard errors are clustered at the school level, and omitted for brevity; the full regression output is available upon request.
** p<0.05; ** p<0.01*

Table 7: School fixed effects regressions of Cito language and math subscale scores on student and teacher characteristics

VARIABLES	(1) Standardized Cito - Language	(2) Standardized Cito - Math
Gender (1=F)	0.157**	-0.245**
Age	-0.132**	-0.153**
Relative age		
Early	-0.067**	-0.064**
Late	0.085**	0.085**
Migration status:		
Western migrant	0.011**	0.034**
2nd gen NW-migrant	-0.092**	-0.034**
1st gen NW-migrant	-0.106**	-0.032**
Parental education:		
Max MBO2	-0.179**	-0.156**
HBO	0.167**	0.180**
University	0.353**	0.369**
Unknown	-0.008**	0.020**
NW-migrant teachers pct.	0.001	-0.007
W-migrant teachers pct.	0.000	-0.001
Teachers with master's degree pct.	-0.000	-0.000
NW-migrant teachers pct. * Western migrant	-0.000	0.023**
NW-migrant teachers pct. * 2nd gen NW-migrant	-0.002	0.021**
NW-migrant teachers pct. * 1st gen NW-migrant	0.004	0.020**
W-migrant teachers pct. * Western migrant	0.001	0.008*
W-migrant teachers pct. * 2nd gen NW-migrant	-0.006	-0.000
W-migrant teachers pct. * 1st gen NW-migrant	0.0024	0.004
Teachers with master's degree pct. * Max MBO2	0.003	0.003
Teachers with master's degree pct. * HBO	0.002	0.002
Teachers with master's degree pct. * University	-0.000	-0.001
Teachers with master's degree pct. * Unknown	0.006**	0.007**
Classroom peer characteristics	X	X
Teacher characteristics	X	X
School peer characteristics	X	X
Year dummies	X	X
School fixed effects	X	X
Constant	1.416**	1.720**
Observations	816,875	816,875
R-squared	0.570	0.469

Note: school-level teacher characteristics are standardized. The baseline category for relative age is "average". The baseline category for migration status is "non-migrant". The baseline category for parental education is "MBO34". Classroom peer characteristics include share of peers from a certain migration background, share of peers with a certain educational background, share of boys in class, class size, and peer average age. School peer characteristics include school-level share of children from a certain migration background, share of children with a certain educational background, and share of boys Standard errors are clustered at the school level, and omitted for brevity; the full regression output is available upon request.
** p<0.05; ** p<0.01*

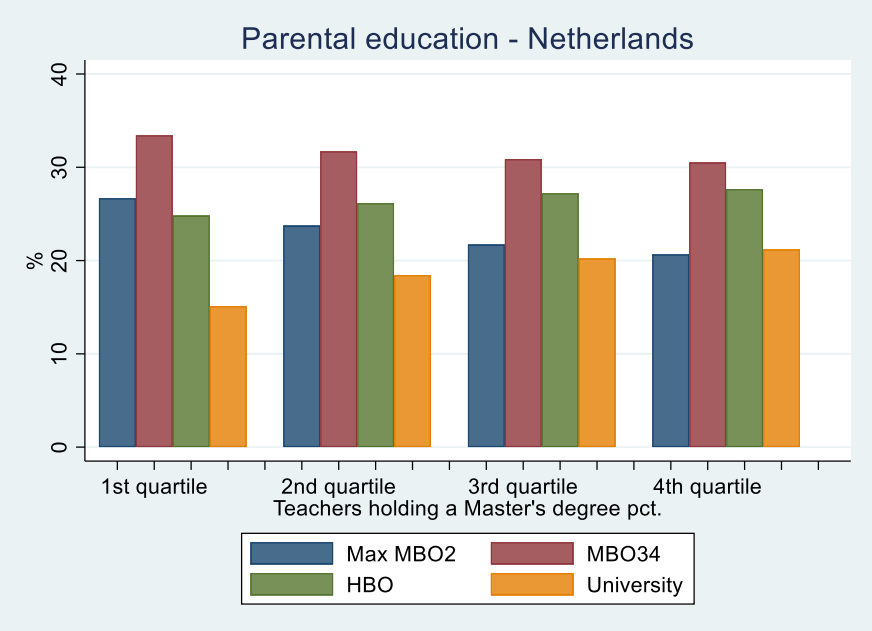
Table 8: School fixed effects regressions of Cito-scores on student and teacher characteristics seperately for students with a below- and above average predicted Cito-score

VARIABLES		(1) Standardized Cito	(2) Standardized Cito
Migration status:			
	Western migrant	0.096**	0.039**
	2nd gen NW-migrant	0.012	-0.046**
	1st gen NW-migrant	0.089**	-0.106**
Parental education:			
	Max MBO2	-0.220**	-0.396**
	HBO	0.179**	0.155**
	University	0.341**	0.401**
	Unknown	0.005	-0.098**
NW-migrant teachers pct.		-0.018	-0.008
W-migrant teachers pct.		-0.007	-0.001
Teachers with master's degree pct.		-0.013	0.018
NW-migrant teachers pct. * Western migrant		0.050**	0.016
NW-migrant teachers pct. * 2nd gen NW-migrant		0.028**	-0.014
NW-migrant teachers pct. * 1st gen NW-migrant		0.047**	0.055
W-migrant teachers pct. * Western migrant		0.012	0.015
W-migrant teachers pct. * 2nd gen NW-migrant		0.013	-0.008
W-migrant teachers pct. * 1st gen NW-migrant		0.017	0.018
Teachers with master's degree pct. * Max MBO2		0.004	0.011
Teachers with master's degree pct. * HBO		0.010	-0.036
Teachers with master's degree pct. * University		0.016	-0.007
Teachers with master's degree pct. * Unknown		-0.013	-0.013
Student characteristics		X	X
Classroom peer characteristics		X	X
Teacher characteristics		X	X
School peer characteristics		X	X
Year dummies		X	X
School fixed effects		X	X
Constant		3.945**	3.481**
Observations		185,068	184,072
R-squared		0.064	0.088

Note: School-level teacher characteristics are standardized. The baseline category for migration status is "non-migrant". The baseline category for parental education is "MBO34". Student characteristics include student gender, and absolute and relative age. Classroom peer characteristics include share of peers from a certain migration background, share of peers with a certain educational background, share of boys in class, class size, and peer average age. Teacher characteristics include the school-level average hourly wage, hours worked, and age, and the percentage of female, and tenured teachers. School peer characteristics include school-level share of children from a certain migration background, share of children with a certain educational background, and share of boys. Standard errors are clustered at the school level, and omitted for brevity; the full regression output is available upon request.
** p<0.05; ** p<0.01*

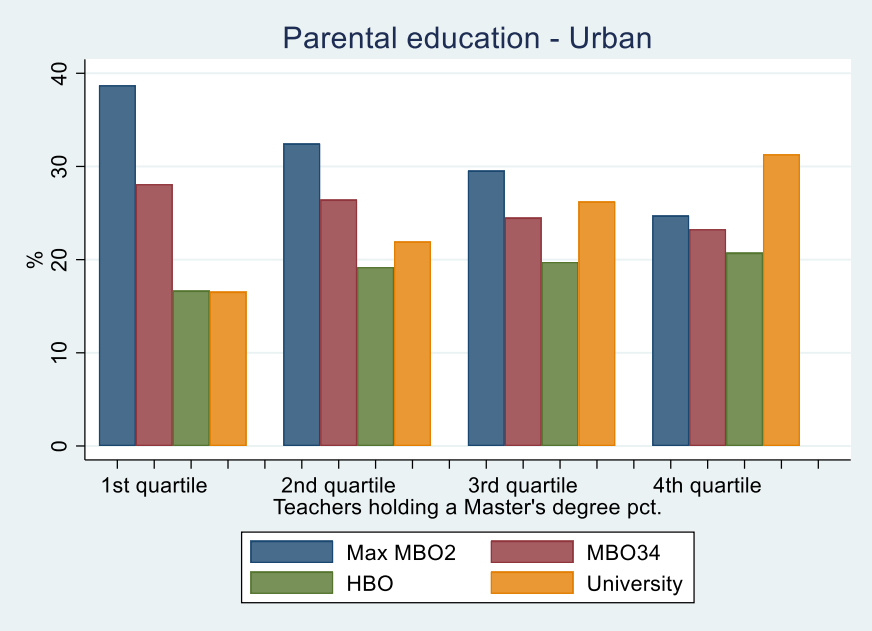
Figures

Figure 1A: Average percentage of students from a certain parental educational background per quartiles of the school-level share of master's degree holding teachers - Netherlands



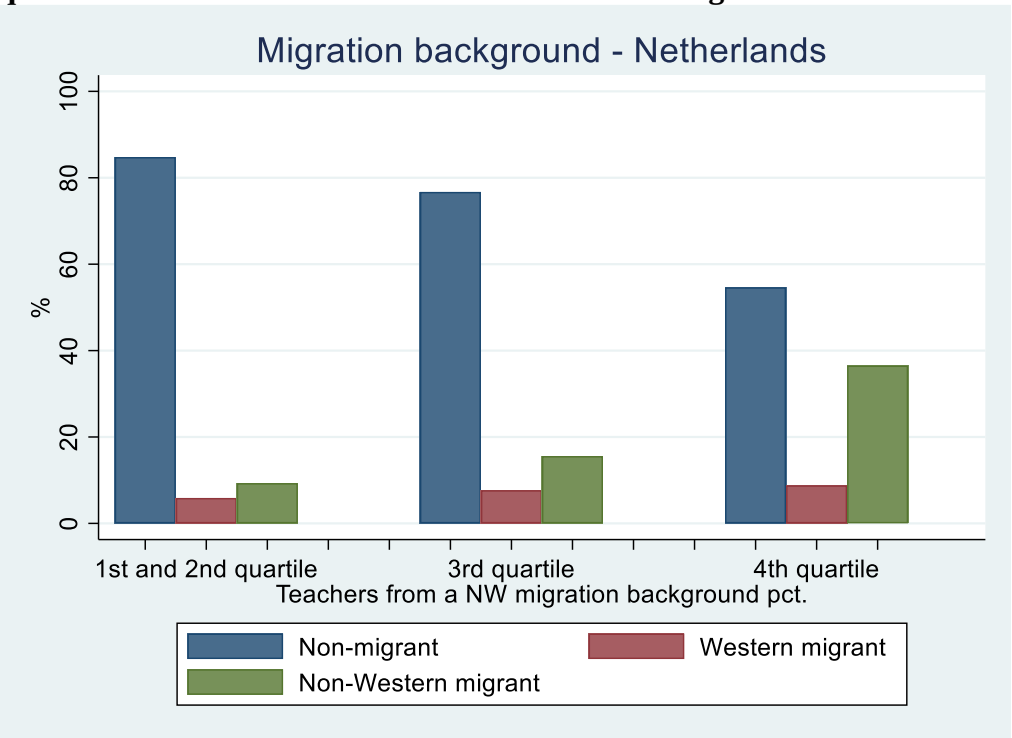
Source: DUO 1cijferPO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.

Figure 1B: Average percentage of students from a certain parental educational background per quartiles of the school-level share of master's degree holding teachers - Urban



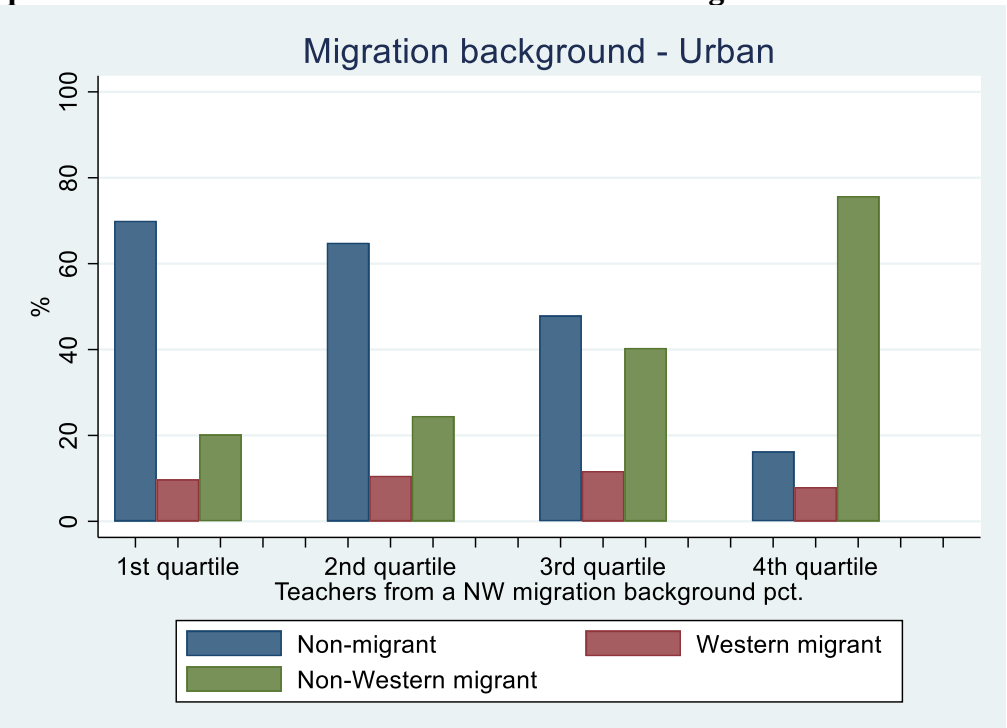
Source: DUO 1cijferPO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.

Figure 2A: Average percentage of students from a certain migration background per quartiles of the school-level share of non-western migrant teachers - Netherlands



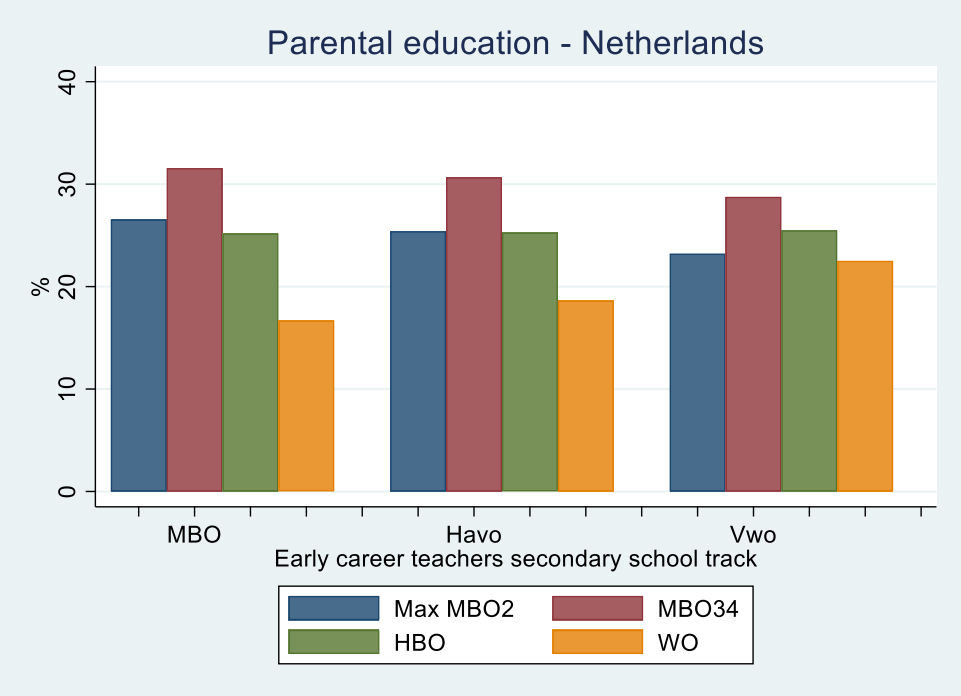
Source: DUO 1cijferPO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.

Figure 2B: Average percentage of students from a certain migration background per quartiles of the school-level share of non-western migrant teachers - Urban



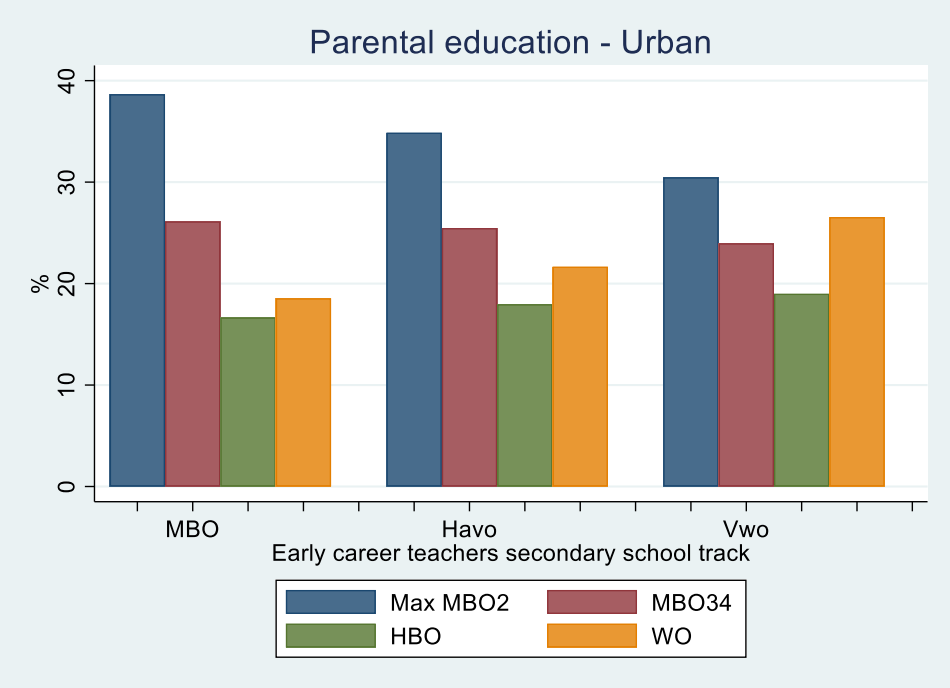
Source: DUO 1cijferPO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.

Figure 3A: Average percentage of students from a certain parental educational background per early career teachers' secondary school track - Netherlands



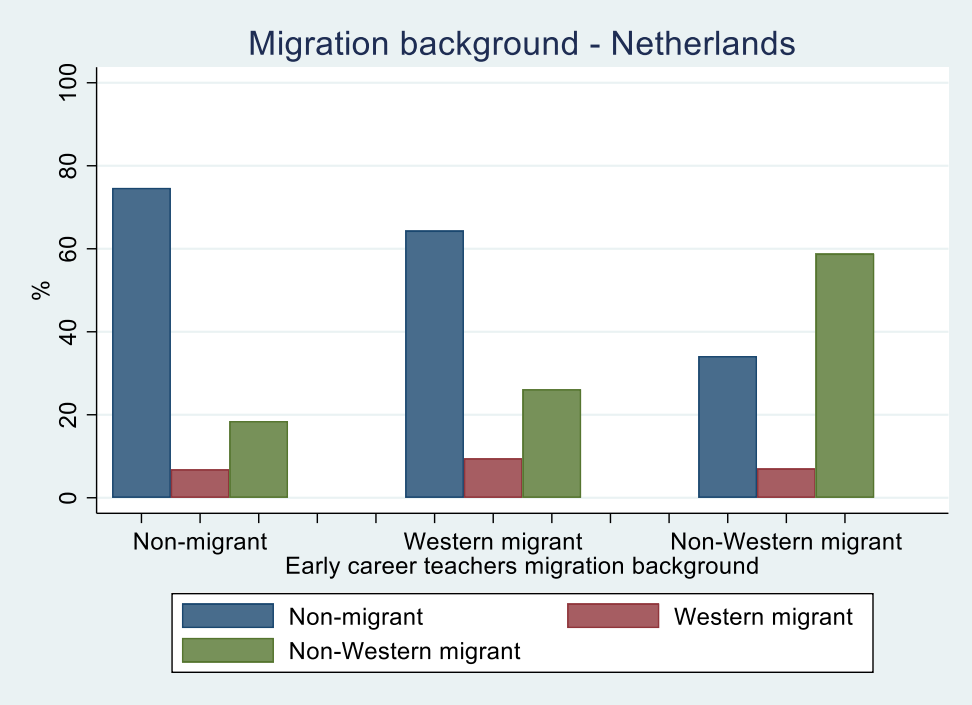
Source: DUO 1cijferPO, DUO 1cijferHO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.

Figure 3B: Average percentage of students from a certain parental educational background per early career teachers' secondary school track - Urban



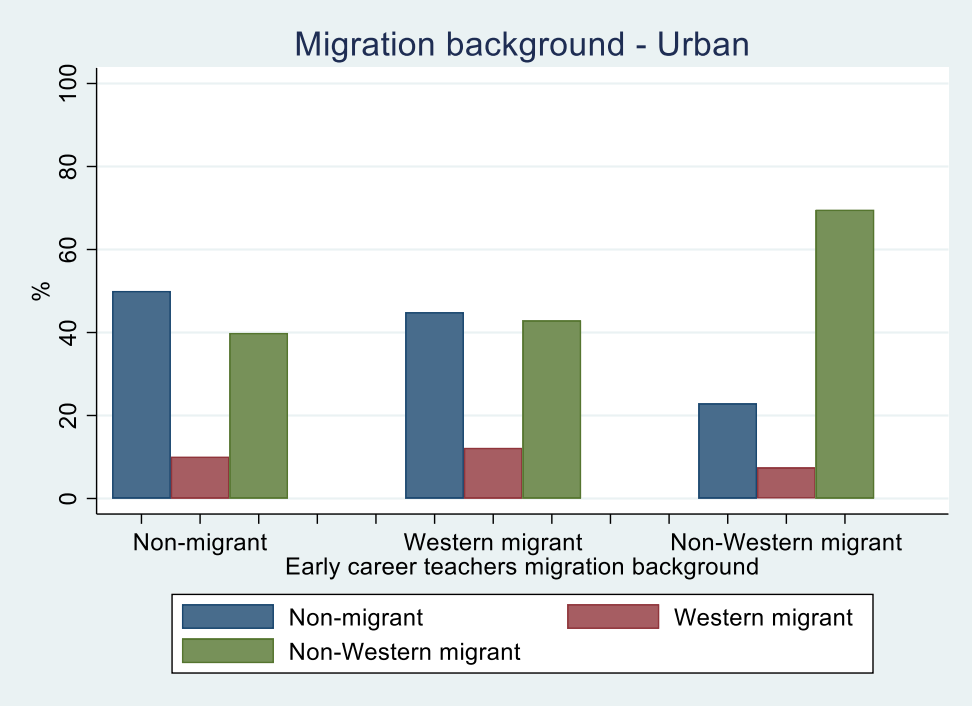
Source: DUO 1cijferPO, DUO 1cijferHO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.

Figure 4A: Average percentage of students from a certain migration background per early career teachers' migration background - Netherlands



Source: DUO 1cijferPO, DUO 1cijferHO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.

Figure 4B: Average percentage of students from a certain migration background per early career teachers' migration background - Urban



Source: DUO 1cijferPO, DUO 1cijferHO, DUO Functiemix, and Statistics Netherlands highest achieved level of education databases.