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Low, medium, and high-performing schools in the Nordic countries. Student performance at PISA Mathematics 2003-2012

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ABSTRACT

Decreasing performance in several core subjects among students in Sweden and the increasing segregation of schools are urgent issues in relation to equity in education, which has been a long-term goal in Sweden. The aim of this study is to identify factors in the school environment associated with student performance in PISA in mathematics at different performance levels in the Nordic countries. In order to separate the effects of school-level variables from the effects of student background factors, and to deal with the multistage sampling design used in PISA, multilevel analysis was used in this exploratory study. Based on data from PISA 2003 and 2012, which are the most recent assessments with a focus on mathematics, results have shown that a few school-level factors seemed to be associated with student success, and then mainly among low and medium-performing schools. Overall, school-level factors associated with success (or lack of it) partially differ between countries and over the years. These results have implications for educational professionals since some of the school-level factors identified inhibit potential for change.

KEYWORDS

Large-scale comparative studies; multilevel modelling; performance levels; school-effectiveness; school-level factors

Introduction

Declining performance levels over the years in several core subjects among Swedish students and evidence that school segregation has become increasingly prominent in recent years (Swedish National Agency for Education, 2012; OECD, 2013a) has led to a public debate in Sweden concerning strategies for improving student achievement.

A significant amount of research has been conducted in Sweden regarding student achievement as well as factors that influence student success and the link with student socioeconomic background. Thus, academic achievement is well established (see e.g. Rosén, Gustafsson, & Yang Hansen, 2013; Swedish National Agency for Education, 2009; Yang Hansen & Gustafsson, 2019). However, OECD (2013a) emphasises that education can make a difference based on observations that there are countries managing to improve overall performance and thereby promote equity in education. In Sweden, Davidsson, Karlsson, and Oskarsson (2013) have analysed performance in PISA (Programme for International Student Assessment) science in several European countries, and have concluded that countries with deteriorating results also show...
increasing between-school variance, while countries with improved student performance exhibit decreased between-school variance. The greatest decreases in student performance are seen in low and medium-performing students in Sweden. It is therefore of essence to further examine this group of students in relation to factors associated with their schools.

Data from large-scale assessment programmes such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) can provide information about schools, students and their teachers. They assess educational outcomes in different countries by subject test, and collect data regarding background information from students, teachers and principals. Large-scale assessments offer a unique possibility to explore factors in the school environment that may be associated with student success among different group of students.

The two programmes are somewhat similar but differ from each other with respect to their objectives. The purpose of PISA is to examine the extent to which students are prepared to succeed in society by examining the effect of their education in reading, mathematics and science (OECD, 2013b). Furthermore, PISA places different emphasis on the subjects (reading, mathematics and science), i.e. one of the subjects is major in every wave. This also means that overall comparison of PISA results from different assessments should be carried out carefully, in particular since PISA results show that performance level is related to subject. Only a small percentage among the high-performing students are high-performers in all subjects assessed (Swedish National Agency, 2012b).

PISA 2015 exhibits a change of trend regarding the performance of Swedish students. In contrast to previous assessments, Swedish students improved their performance slightly at the most recent assessment. However, results from previous assessments exhibit declining performance over the years. Results from the PISA 2012 assessment show that Swedish students performed below the OECD mean in all three subjects (OECD, 2013c). Iceland and Norway also performed below the international average achievement, while students in Denmark and Finland performed above the OECD mean. It is also noteworthy that Finland is among the top performing countries. In addition, research has shown that students at different performance levels exhibit different trends over the years. High-performing students in mathematics exhibit a major decrease in 2006 compared to 2003 and in comparison to low-performers. Thus, the differences in decrease between the two performance groups are smaller in 2009 as compared to 2006 (Swedish National Agency for Education, 2012b). However, it is urgent to further investigate different group of students, since performance appeared to differ between subjects and performance level (Swedish National Agency, 2012b).

Research in the field of school effectiveness has shown that factors in the school environment can make a difference by “adding value” which enhances student success, regardless of the characteristics of the student body (see e.g. Creemers, Kyriakides, & Sammons, 2010). Nevertheless, research is not univocal regarding factors of importance for success (see e.g. Scheerens, 2013). Previous studies, based on large-scale assessment data from TIMSS and PISA, revealed that only a few school-level factors seemed to be associated with student success. When examining school effectiveness in relation to mathematics achievement in TIMSS (Wiberg, Rolfsman, & Laukaityte, 2013a), no significant school-level factors were found in Sweden. In similar analyses, where science achievement in
TIMSS and PISA were related to questionnaire data (Wiberg et al., 2013a, Rolfsman, Wiberg, & Laukaityte, 2013), some significant school-level factors were found in Sweden. However, the results showed that the only factors indicating importance for student success are related to structural factors, i.e. aspects related to school location and lack of resources. Consequently, “softer” factors such as the climate of the school and the administration and management seem to lack importance. Nevertheless, results from the referred PISA-studies are completely different in comparison to previous results on TIMSS data, which may be related to the fact that the two assessment programmes have different designs and may therefore partly measure different aspects, and thereby also measure different kinds of success. It is therefore urgent to explore factors of importance for student performance in other subjects and among different group of students in particular, since there is evidence that performance level is related to subject (Swedish National Agency, 2012b). In addition, performance levels may be related to a different type of school factor. As previously mentioned, a number of studies have examined school segregation but there is a lack of studies using multilevel methods exploring school-level factors in relation to different performance levels. Thus, the school unit and its characteristics regarding the composition of students with reference to different performance level are of considerable relevance. The aim of this exploratory study is to identify factors in the school environment associated with student performance in PISA mathematics in low, medium and high-performing schools in the Nordic countries.

**Methods**

**Data**

The data used in the study consists of test results in mathematics in the PISA 2003–2012, in the Nordic countries. PISA 2003 and 2012 were the most recent assessments with a focus on mathematics. Results from PISA 2006, 2009 were used for comparison purpose. The rationale for choosing only the Nordic countries is that they, in many respects, share several common features. In the “Nordic model of education,” equity, participation and welfare are viewed as major goals (Antikainen, 2006). In addition, the Nordic countries exhibit deteriorating performance in education, which make comparisons between the Nordic countries relevant. Test results from PISA mathematics are thus used as criteria for student performance, alternately denominated as student success. School-level factors are based on data generated by mutually existing questions from the schools questionnaire (answered by the principal). The rationale for this is to make use of all available data in order to explore factors associated with student performance. The selection of the student-level factors (from the student questionnaire) was based on the knowledge that these factors have been shown as being significant in many earlier studies (e.g. Haahr, Nielsen, Hansen, & Jakobsen, 2005).

Number of students sampled and schools in each Nordic country is presented in Table 1.

**Statistical analysis**

Statistical analysis consisted of two parts. In the first part, how the average performance for mathematics and the between-school variance changed from 2003 to 2012 was studied and examined whether there are any clearly identifiable relationships between
student performance and between-school variance. The descriptive statistical analysis was conducted by IEA IDB Analyser V3 (International Association for the Evaluation of Educational Achievement, 2012) together with SPSS 23. In the second part, analysis continued by dividing schools into low, medium and high-performers within each country studied. This was done by dividing schools into three equal groups according to their average performance within a country, i.e. one-third of the schools with the lowest average performance within a country became low-performing schools, etc. High and low-performing schools contain around 50% of the high and low-performing students respectively. Medium-performing schools contain around equal proportions of low, medium and high-performing students. This strategy guarantees about the same number of schools within each performance level, and thereby an adequate number of groups (schools) for multilevel analysis. If the PISA proficiency levels for division of schools are used, the end-result is very few high-performing schools in most of the Nordic countries. In the results and discussion sections, the term “school performance” or “low, medium and high-performing schools” are used, which refers to the performance of students in these three forms of schools.

PISA uses a stratified, two-stage sampling design in which students are grouped in schools. Having selected a school increases the chances of selection of students from that school, and therefore, observations are dependent. In order to take this sampling design into account, multilevel analysis was used (see, e.g. Gelman & Hill, 2006; Snijders & Bosker, 2012). Multilevel models using student background factors as Level 1 variables and school related factors as Level 2 variables were used to identify school background factors associated with the student performance in the three school performance groups in each country studied. Multilevel models were examined using Mplus7 (2014). Student-level home background factors and school-level factors were constructed from variables that were available in both PISA 2003 and PISA 2012.

At student level, the variable sex [H4] and three constructed factors [H1 – H3] were defined as follows:

[H1] *Attitude towards mathematics:* This was based on student responses to questions focusing on student attitudes towards learning mathematics. Possible responses were: 1 = Strongly agree, 2 = Agree, 3 = Disagree, 4 = Strongly disagree. First, the coding was reversed, and then the responses were averaged and classified into three categories: 0 = Low, average was less than or equal to 2.4; 1 = Medium, average was greater than 2.4 and less than or equal to 3; 2 = High, average was greater than 3.

[H2] *Socioeconomic status:* This was based on student responses to (1) number of books in student’s home: 1 = 0–10 books, 2 = 11–25 books, 3 = 26–100 books, 4 = 101–200
books, and 5 = More than 200 books. Recoded into 0 = Low (0–25 books); 1 = Medium (26–200 books); 2 = High (if > 200 books), (2) Home possessions such as study desk, student’s own room, quiet place to study, computer, educational software, internet connection, classical literature, books of poetry, work of arts, textbooks and dictionaries. Categorised as 0 = Low, if student had none or one item; 1 = Medium, if student had 2–5 items; 2 = High, if student had more than 5 items. The two indicators were averaged and classified into: 0 = Low, average was less than or equal to 0.5; 1 = Medium, average was greater than 0.5 and less than or equal to 1.5; 2 = High, average was greater than 1.5.

[H3] Parents born within test country: This was based on student responses to questions about the birth country of their parents. The responses were classified into two categories: 1 = If at least one parent was born in the country where PISA was administered and 0 = Neither of the parents were born in the test country.

[H4] Sex: Recoded as 0 for male and 1 for female.

Characteristics (mean and standard deviation) of student-level variables and factors are presented in Table 2. The results are similar in all countries examined and between the different years. However, Sweden has the lowest proportion of parents born within test country. Students from Denmark have the highest positive attitude towards mathematics, whereas Finnish students have the lowest positive attitude towards mathematics. Icelandic students have the highest socioeconomic status among the Nordic students.

At school level, 10 factors were constructed based on mutually existing questions in the PISA school questionnaire in 2003 and 2012 and were defined as follows:

[S1] School resources: Included items in which the principal was asked to what extent the school capacity to provide instruction was hindered by a shortage or a lack of resources (question 14 (2012) and question 8 (2003), such as qualified mathematics teachers, science laboratory equipment, computers for instruction, computer software for instruction, library materials, school buildings and

Table 2. Student-level factors H1 and H2 with their mean and standard deviation and the proportion of the student level factor H3 (% of at least one parent born within test country) and variable H4 (% of females).

| Country | H1     | H2     | H3    | H4    |
|---------|--------|--------|-------|-------|
| 2003    |        |        |       |       |
| Denmark | 1.14 (0.01) | 1.18 (0.01) | 93.6  | 49.1  |
| Finland | 0.72 (0.01) | 1.17 (0.01) | 98.1  | 49.9  |
| Iceland | 0.90 (0.01) | 1.37 (0.01) | 99.0  | 51.6  |
| Norway  | 0.82 (0.01) | 1.36 (0.01) | 94.4  | 50.4  |
| Sweden  | 0.85 (0.02) | 1.31 (0.01) | 88.4  | 50.1  |
| 2012    |        |        |       |       |
| Denmark | 1.10 (0.02) | 1.20 (0.01) | 90.8  | 50.3  |
| Finland | 0.75 (0.02) | 1.18 (0.01) | 96.7  | 51.4  |
| Iceland | 1.05 (0.02) | 1.30 (0.01) | 96.5  | 49.4  |
| Norway  | 0.88 (0.02) | 1.28 (0.01) | 90.5  | 51.3  |
| Sweden  | 0.97 (0.02) | 1.23 (0.01) | 84.8  | 50.8  |

H1 = attitude towards mathematics, H2 = socioeconomic status, H3 = parents born within test country, H4 = Student sex.
grounds, heating/cooling system, classrooms). Possible responses were: 1 = Not at all, 2 = Very little, 3 = To some extent, 4 = A lot. First, items were recoded as 0 for alternative 1, and 1 otherwise. Then, all the responses were summed and classified into three categories: 0 = Low, sum was less than or equal to 3; 1 = Medium, sum was greater than 3 and less than or equal to 7; 2 = High, sum was greater than 7.

[S2] **Grouping students by ability**: Included items where principal was asked whether the school organised instruction differently for students with different abilities and interests in mathematics (question 15 (2012) and question 16 (2003)). Possible responses were: 1 = For all classes, 2 = For some classes, 3 = Not for any classes. First, items were recoded as 0 for alternative 3, and 1 otherwise. Then all the responses were summed and classified into three categories: 0 = Low, sum was less than or equal to 1; 1 = Medium, sum was greater than 1 and less than or equal to 3; 2 = High, sum was greater than 3.

[S3] **Student learning barriers**: Included items in which principal was asked about the extent to which learning by students was hindered by different kind of negative behaviour (question 22 (2012) and question 25 (2003)), such as skipping classes, lacking respect for teachers, use of alcohol or illegal drugs, intimidating or bullying other students, lack of encouragement, teachers’ low expectations of students, teachers’ not meeting individual student needs, teacher absenteeism, teachers too strict. Possible responses were: 1 = Not at all, 2 = Very little, 3 = To some extent, 4 = A lot. First, the coding was reversed, and then the responses were averaged and classified into three categories: 0 = Low, average was less than or equal to 1.5; 1 = Medium, average was greater than 1.5 and less than 2.1; 2 = High, average was greater than or equal to 2.1.

[S4] **Teacher intentions**: Included items in which the principal was asked how much s/he agrees with the following statements about teachers in the school: Mathematics teachers are interested in trying new methods and teaching practice; There is a preference among mathematics teachers to stay with well-known methods and practice; There is consensus among mathematics teachers that academic achievement must be kept as high as possible; There is consensus among mathematics teachers that it is best to adapt academic standards to student level and needs; There is consensus among mathematics teachers that the social and emotional development of the students is as important as their acquisition of mathematical skills and knowledge in mathematics classes; There is consensus among mathematics teachers that the development of mathematical skills and knowledge in students is the most important objective in mathematics classes (questions 27–29 (2012) and questions 21–24 (2003)). Possible responses were: 1 = Strongly agree, 2 = Agree, 3 = Disagree, 4 = Strongly disagree. The coding was reversed, and then the responses were averaged and classified into three categories: 0 = Low, average was less than or equal to 2.3; 1 = Medium, average was greater than 2.3 and less than 3.5; 2 = High, average was greater than or equal to 3.5.

[S5] **Monitoring the practice of teachers**: Included items in which the principal was asked whether, during the last year, any of the following methods had been used to monitor the practice of mathematics teachers at the school: Tests or assessments of students achievement; Teacher peer review (of lesson plans, assessment instrument, lessons); Principal or senior staff observations of lessons;
Observation of classes by inspectors or other (question 30 (2012) and question 20 (2003)). Possible responses were: 1 = Yes, 2 = No. Responses were recoded as 0 for no, and 1 for yes. Further, all the responses were summed and classified into three categories: 0 = Low, sum was less than or equal to 1; 1 = Medium, sum was equal to 2; 2 = High, sum was greater than 3.

[S6] Responsibilities of principal: Included items in which the principal was asked about different responsibilities at the school (question 33 (2012) and question 26 (2003)). Only answers about responsibilities of principal were used, which were coded as 1 if the certain task is principal’s responsibility, and 0 otherwise. All the responses were summed and classified into three categories: 0 = Low, sum was less than or equal to 5; 1 = Medium, sum was greater than 5 and less than or equal to 9; 2 = High, sum was greater than 9.

[S7] The percentage of qualified maths major teachers: The total number of maths teachers was calculated from answers by the principal to items concerning the number of total full/part time maths teachers from question 10 (2012) and question 19 (2003). Next, the percentage of qualified maths major teachers was obtained using the answers of the principal to items about number of qualified maths major full/part time teachers (the same questions as for total number of maths teachers) and earlier calculated total number of maths teachers.

[S8] Urban school: Number of people living in the area where the school is located. Recoded as: 0 = Rural areas, 0–15 000 people; 1 = Urban areas, more than 15 000 people.

[S9] Public school: Recoded as 0 for private school and 1 for public school.

[S10] Majority of boys: The school principals’ answers to question about the total school enrolment regarding the number of boys and girls (question 7 (2012) and question 2 (2003)). The percentage of boys in a school was obtained. Coded as 1 if proportion of boys is equal to or greater than 55% and 0 otherwise.

Mean and standard deviation of the school-level factors for the Nordic countries are given in Table 3. Note, in 2012, three countries increased the monitoring of teachers’ practice by twice or even more, only Finland shows a decrease. Norway exhibits a considerable decrease in grouping students by their abilities but Denmark, Finland, and Iceland, on the contrary, have increased ability grouping of students. Iceland is the only country showing a decrease regarding the responsibilities of principals. All countries studied show an increase regarding the number of qualified maths major teachers in 2012 compared to 2003. Note, there is a very low percentage of qualified maths major teachers in Iceland.

For each country studied, and for each year, we examined two models, the null (or empty) model and the full two-level model. The five plausible values for mathematics, provided by PISA database, were used as dependent variables. The null model was used to calculate intraclass correlations (ICC) and between-school variances. ICC helps to test how homogeneous the data are within group (school) level clusters. In the null model, mathematics performance for each student was estimated as a function of the school average with a random error.
Level 1 (within schools): $Y_{ij} = \beta_{0j} + r_{ij}, i = 1, \ldots, N$,
Level 2 (between schools): $\beta_{0j} = \gamma_{00} + u_{0j}, j = 1, \ldots, J$,

where $Y_{ij}$ denotes mathematics performance for student $i$ within school $j$, $\beta_{0j}$ is the average mathematics performance for school $j$, and $r_{ij}$ is the error term representing a unique effect associated with student $i$ in school $j$. Level 2 term $\gamma_{00}$ denotes the grand mean of mathematics performance and $u_{0j}$ is the error term representing a unique effect associated with school $j$.

In the full two-level model, the association between school-level factors and student mathematics performance was evaluated while controlling for student home background. At the first level, student home background factors (H1, $\ldots$, H4) weighted with student weights, and aggregated student-level factors at the second level ($aH1$, $aH2$, $aH3$) together with school-level factors (S1,$\ldots$,S10) weighted with school weights were included. Student home background factors were grand-mean centred as we were interested in the effects of level 2 factors while controlling for level 1 factors (see e.g. Bickel, 2007; Kreft, De Leeuw, & Aiken, 1995), also to alleviate potential problems due to multicollinearity.

Level 1 (within schools):

$$Y_{ij} = \beta_{0j} + \beta_{1j}(H1)_{ij} + \beta_{2j}(H2)_{ij} + \ldots + \beta_{4j}(H4)_{ij} + r_{ij}, i = 1, \ldots, N,$$

where

Table 3. Descriptive statistics for school-level factors. Mean and standard deviation within parenthesis for factors S1-S7 and proportions for urban schools, public schools and majority boys.

|        | Denmark | Finland | Iceland | Norway | Sweden |
|--------|---------|---------|---------|--------|--------|
| 2003   |         |         |         |        |        |
| S1     | 1.27 (0.05) | 1.14 (0.04) | 0.98 (0.00) | 1.57 (0.04) | 1.29 (0.06) |
| S2     | 0.65 (0.05) | 0.76 (0.05) | 1.14 (0.00) | 1.00 (0.03) | 1.23 (0.05) |
| S3     | 0.98 (0.04) | 1.17 (0.04) | 1.13 (0.00) | 1.49 (0.05) | 1.16 (0.04) |
| S4     | 1.08 (0.02) | 1.01 (0.01) | 1.09 (0.00) | 1.05 (0.02) | 1.05 (0.02) |
| S5     | 0.42 (0.05) | 0.47 (0.05) | 0.50 (0.00) | 0.45 (0.05) | 0.56 (0.05) |
| S6     | 0.95 (0.05) | 0.62 (0.04) | 1.20 (0.00) | 0.47 (0.05) | 1.06 (0.03) |
| S7     | 61.87 (2.34) | 44.71 (2.33) | 2.57 (0.01) | 39.83 (3.81) | 61.79 (2.60) |
| S8     | 38.4 | 56.1 | 49.5 | 39.1 | 55.8 |
| S9     | 78.3 | 93.4 | 98.4 | 99.1 | 95.6 |
| S10    | 6.4 | 9.1 | 11.8 | 11.1 | 12.7 |

|        |         |         |         |        |        |
| 2012   |         |         |         |        |        |
| S1     | 1.14 (0.05) | 1.11 (0.05) | 1.14 (0.00) | 1.35 (0.06) | 1.03 (0.05) |
| S2     | 1.04 (0.05) | 0.91 (0.05) | 1.39 (0.00) | 0.58 (0.05) | 1.06 (0.04) |
| S3     | 1.00 (0.04) | 1.23 (0.05) | - | 1.30 (0.04) | 1.14 (0.05) |
| S4     | 1.14 (0.02) | 1.03 (0.01) | 1.57 (0.00) | 1.08 (0.02) | 1.12 (0.02) |
| S5     | 1.02 (0.06) | 0.31 (0.03) | 0.76 (0.00) | 0.89 (0.06) | 1.28 (0.06) |
| S6     | 1.11 (0.04) | 0.84 (0.04) | 0.95 (0.00) | 0.69 (0.04) | 1.22 (0.04) |
| S7     | 71.58 (2.62) | 61.58 (2.14) | 5.79 (0.09) | 54.13 (1.98) | 65.38 (2.04) |
| S8     | 45.9 | 62.4 | 55.9 | 47.5 | 62.4 |
| S9     | 76.7 | 96.8 | 98.5 | 98.3 | 86.0 |
| S10    | 15.0 | 14.3 | 5.6 | 9.8 | 10.2 |

S1 = school resources, S2 = grouping students by ability, S3 = student learning barrier, S4 = teacher intentions, S5 = monitoring the practice of teachers, S6 = responsibilities of principal, S7 = the percentage of qualified maths major teachers, S8 = urban school, S9 = public school, S10 = majority of boys.
Level 2 (between schools):

\[ \beta_{0j} = \gamma_{00} + \gamma_{01}(S1)_{j} + \ldots + \gamma_{010}(aH1)_{j} + \ldots + \gamma_{013}(aH3)_{j} + u_{0j}, \quad j = 1, \ldots, J, \]

\[ \beta_{1j} = \gamma_{10}, \quad \beta_{2j} = \gamma_{20}, \ldots, \beta_{4j} = \gamma_{40}. \]

Every analysis was carried out separately for each plausible value, and then combined using the Rubin’s (1987) method implemented in Mplus.

The Bayesian Information Criterion (BIC) was used to determine which models to use. BIC (Schwartz, 1978) allows us to compare competing models (whether or not they are nested) as long as the sample remains constant (McCoach & Black, 2008).

Results

Regarding changes in the average performance in mathematics in the countries studied, only Finland and Denmark have a mathematics score above the international average throughout all four years (see Table 4). Nevertheless, all the Nordic countries exhibit a decrease in performance in 2012 compared to 2003. Finland, Sweden and Iceland exhibit the greatest changes in average mathematics performance. All three countries have decreased performance by more than 20 points in 2012 compared to in 2003. Norway has the smallest decrease of 6 points. Note, the international average also shows a non-statistically significant, but decreasing trend (Table 4, OECD (2016)). Effect sizes, Cohen’s d (Cohen, 1988), that are used to describe the strength of phenomena show that changes in performance are very small or small in all the Nordic countries.

Figure 1 illustrates trends in the average performance as change in the difference between the average mathematics performance and OECD average in 2003–2012. The mathematics score for Finland, Iceland and Sweden has decreased along all percentiles over the years. For Denmark, we can notice a greater decrease for high-performing students and some increase for low-performing students. For Norway, some increase for high and medium-performing students and a slight decrease for low-performing students can be registered. Standard errors for the average mathematics performance along the percentiles varied from around 2 to 5 for all countries and years. Standard errors for the OECD averages varied from 0.5 to 0.9.

Table 4. The average mathematics performance in the Nordic countries with standard errors within parenthesis, the change (in points) of the average mathematics performance between 2003 and 2012, and effect sizes of the change (Cohen’s d).

| Country    | 2003  | 2006  | 2009  | 2012  | Change between 2003–2012 | Effect sizes (Cohen’s d) |
|------------|-------|-------|-------|-------|--------------------------|--------------------------|
|            | (PISA 2012 – PISA 2003) |        |        |       |                          |                          |
| Denmark    | 514 (2.7) | 513 (2.6) | 503 (2.6) | 500 (2.3) | −14 (4.1)                | 0.17                     |
| Finland    | 544 (1.9) | 548 (2.3) | 541 (2.2) | 519 (1.9) | −26 (3.3)                | 0.30                     |
| Norway     | 495 (2.4) | 490 (2.6) | 498 (2.4) | 489 (2.7) | −6 (4.1)             | 0.06                     |
| Sweden     | 509 (2.6) | 502 (2.4) | 494 (2.9) | 478 (2.3) | −24 (3.9)                | 0.33                     |
| Iceland    | 515 (1.4) | 506 (1.8) | 507 (1.39) | 493 (1.7) | −22 (2.9)                | 0.24                     |
| OECD average | 500 (0.6) | 494 (0.5) | 496 (0.5) | 494 (0.5) |                          |                          |
Figure 1. Trends in average performance for Nordic countries, 2003–2012. Y-axis represents the difference between the average mathematics achievement in a particular country and OECD average (Points – OECD average). Note, the scale of y-axis is different for Finland.

Figure 2 presents distribution of mathematics achievement in 2003 and 2012 and shows that deviation from the OECD average among the five countries differs over the years, in particular in Finland and Denmark. Low-performers in Finland performed remarkably lower in 2012 compared to in 2003, while in Denmark high-performers exhibit a radical decrease in 2012.

So far, results have shown that there are some differences in changes of average mathematics achievement among and between low-achieving and high-achieving students with different tendencies among the countries (Figures 1 and 2). Regarding between-school variance, compared to the international average, almost
all the Nordic countries have increased between-school variance with Iceland showing the largest increment. Only Denmark showed a very slight decrease in the between-school variance. In addition, an increase in the between-school variance does seem to exert an effect on performance for high-performing students only. The correlation between changes in performance and between-school variance is less than 0.1 for low and medium performers. However, the coefficient of correlation is around 0.7 for high-performers. If we exclude Iceland from the computations, the correlation coefficient increases to 0.5 for medium-level performers and up to 0.85 for high-level performers.

Factors associated with student success

For multilevel analysis, schools are divided into low, medium and high-performers based on school average performance in order to further examine factors associated with student success (see Table 5). The number of schools varied from 34 (in Iceland) to 73 (in Denmark) per performance level in 2003, and from 40 (in Iceland) to 118 (in Denmark) per performance level in 2012. In the following, initial focus is placed on studying whether school-level factors exert a positive or a negative effect on student success within the five Nordic countries, and then on school-level factors in relation to different performance levels.
Student-level factors

The two student-level factors, *Attitude towards mathematics* and *Socioeconomic status*, were associated with student success in all Nordic countries in 2003 as well as 2012 (see Table 5). The factor *Parents born within test country* also seems to have a positive effect on success in all countries except Iceland. The variable *Sex* (being a female) appeared to be statistically significant only in some countries and at some performance levels. Moreover, *Sex* exerts both, positive and negative effects on student success.

School-level factors by country

Overall, school-level factors associated with success, or lack of success, differ partially between the countries and over the years. In addition, there are some school-level factors that occur in 2003 only and not in 2012 in any of the countries, and vice versa. The results described in this section are presented in Table 5 or in more detail in the Appendix.

Denmark

School-level factors of importance for student performance in Denmark overall have varied over the years. The only school-level factor that appear to be of importance for student success in 2003 as well as in 2012 is related to the student body, regarding the mixture of student socioeconomic background at the school (*aggregated Socioeconomic status*). In the same way *Responsibilities of the principal* is the only recurrent factor exerting a negative effect on student performance over the years, although at different

Table 5. Student performance in PISA 2003 and PISA 2012 among the Nordic countries, distributed by performance level.

| Country /year | Average student performance | School variables by performance level |
|--------------|----------------------------|--------------------------------------|
|              |                           | associated with success | associated with lack of success |
|              |                           | General Low Medium High | General Low Medium High |
| Denmark 2003 | 514 (2.7)                 | aH2 S7 S10              | S6 aH1 aH2 |
|              | 500 (2.3)                 | aH2 S8                  | S3 S4 aH3 S6 |
| Finland 2003 | 544 (1.9)                 | S7 S9                   | aH2 S8 |
|              | 519 (1.9)                 | aH2 S8                  | S5 aH3 aH3 |
| Island 2003  | 515 (1.4)                 | aH2 S8                  | S4 |
|              | 493 (1.7)                 | aH2 S8                  | S1 aH1 aH2 |
| Norway 2003  | 495 (2.4)                 | aH2 S8                  | S1 aH1 aH2 |
|              | 489 (2.7)                 | S7 S8 aH3 S7 S8 S4      | aH1 aH3 |
| Sweden 2003  | 509 (2.6)                 | S7 S8 aH3 S7 S8 S4      | aH1 aH3 |
|              | 478 (2.3)                 | aH2 S8                  | aH3 |

aH1/aH2/aH3 = aggregated attitude towards mathematics/socioeconomic status/parents born within test country, S1 = school resources, S2 = grouping students by ability, S3 = student learning barrier, S4 = teacher intentions, S5 = monitoring the practice of teachers, S6 = responsibilities of principal, S7 = the percentage of qualified maths major teachers, S8 = urban school, S10 = majority of boys.
performance levels in 2003 and in 2012. Considering the different performance levels, there is a trend towards slightly fewer factors associated with success, and more factors associated with a negative effect on performance.

Finland
In Finland, school-level factors of importance for student performance are few and have varied over the years. No school-level factors were identified as exerting a positive effect on student success in both 2003 and 2012. Considering the different performance levels and the occurrence of factors associated with success, Finland exhibits the same trend as Denmark, i.e. fewer factors associated with success in 2012 compared to 2003, and more factors associated with a negative effect on performance.

Norway
In Norway, only one school-level factor is associated with student success and only in 2003 (aggregated Socioeconomic status). However, the number of school-level factors having a negative effect on student performance is high in 2003 when looking at different performance levels, but lower in 2012. The only factor that is recurrent in 2012 is aggregated Attitude towards mathematics. In addition, Norway exhibits a pattern where fewer factors are significant overall in 2012.

Iceland
In Iceland, no statistically significant school-level factors were identified in 2003, however a few school-level factors were associated with success as well as lack of success in 2012.

Sweden
Overall, school-level factors of importance for student performance in Sweden differ between the years. This is also the case for school-level factors exerting a negative effect on student performance. The only common factor associated with student success in 2003 as well as in 2012, is Urban school. The number of school-level factors exerting a positive or negative effect on student performance has remained about the same over the years.

School-level factors by performance level
Overall, few school-level factors seem to be associated with student success at all performance levels in 2003 as well as in 2012. However, the three performance levels exhibit some differences (see Table 5).

Low-performers
The mixture of student origin (aggregated Parents born within test country), Public school, Majority of boys and Percentage of qualified maths major teachers are the only school-level factors associated with success in 2003 and only Student learning barriers and aggregated Socioeconomic status in 2012. However, school-level factors exerting a negative effect on student success include several different school factors which differ between countries and over the years. None of these occurs in more than one country or is consistent over the years.
Medium-performers

Only one school-level factor appears to be associated with success among students performing at average and only in 2003 (the Percentage of qualified maths major teacher, in Sweden). However, the pattern regarding factors exerting a negative effect on medium-performers is different, since there are some school-level factors that occur in several countries. Two such factors are aggregated Attitude towards mathematics and aggregated Socioeconomic status which occur in three of the five countries in 2003. Aggregated Parents born within test country, is consistently a factor in all countries except Iceland in 2012.

High-performers

Among high-performers, only a few school-level factors seem to be associated with success or lack of success, in particular in 2003. School-level factors seem to be of relevance only in Denmark (aggregated Socioeconomic status, Urban school and Responsibilities of the principal in 2012) and in Sweden (Urban school and Teacher’s intentions in 2003; Grouping students by ability and aggregated Parents born within test country in 2012) for high-performing students, regardless of whether they have a positive or a negative effect on student performance.

Discussion and conclusions

The focus of this study was to identify school-level factors associated with student performance in mathematics, based on PISA data collected in 2003 and 2012, for students in the Nordic countries and at different performance levels. The rationale for choosing 2003 and 2012 was that these waves both placed emphasis on the same subject (mathematics) which makes the two assessment waves more similar to each other than comparisons between waves with emphasis on different subjects. The results of our analysis show that there are differences in the trends concerning average mathematics performance between low-performing and high-performing schools with different tendencies among countries. In contrast to a previous study which is focussed on science (Davidsson et al., 2013) we found no evidence regarding the relationship between the average student performance in mathematics and the between-school variance. Consequently, one conclusion is that increasing between-school variance does not, in general, lead to loss of performance. Subjects and performance levels have to be considered, since a positive correlation was identified between school variance and performance of high-performing students. Hence, by examining the influence of school factors in relation to different performance levels, our ambition has been to achieve a more refined view of the relevance of factors in the school environment to different groups of students in a Nordic context.

Regarding the occurrence of school-level factors, the Nordic countries share some common tendencies but also exhibit differences. Overall Denmark and Finland show an increase regarding the relevance of almost all school-level variables in 2012 compared to 2003 (see Table 2). Furthermore, a common tendency for all Nordic countries is that factors predicting success as well as lack of success vary over the years (see Table 5). The Percentage of major maths teachers is the only factor where all countries exhibit an increase over the years, i.e. the school can provide teachers that are more qualified. One
The factor showing the opposite trend among all countries is School resources, which is a result indicating that the school capacity to provide instruction does not seem to be an emerging problem in 2012 compared to in 2003. The only countries exhibiting recurrent factors over the years, exerting both a positive and a negative effect are Denmark (aggregated Socioeconomic status) and Sweden (Urban school). Iceland does not exhibit any statistically significant, school-level factors at all in 2003. In addition, it should be noted that there are some school-level factors that do not turn out to be statistically significant in any country (in 2003: Student learning barriers and Monitoring the practice of teachers, and in 2012: The percentage of qualified teachers, School resources, and Public school).

Regarding the occurrence of factors that promote or detract success over the years, considering the different performance levels a common trend for Denmark, Finland and Sweden is that about the same number, or slightly fewer, factors appeared to be associated with success in 2012 as compared to 2003. In contrast, more factors exerting a negative effect on student performance occur in 2012 as compared to 2003 for all these countries. Norway exhibits the opposite trend.

Regarding performance levels overall, only a few school-level factors seemed to be associated with student success over the years. Nevertheless, school-level factors exerting a negative effect on student success include several different school factors among students at the low-performing schools but only a few among students at the medium-performing schools and almost none among students at the high-performing schools. Hence, recurrent school-level factors between the countries are only found among the medium and low-performing schools. Aggregated factors, regarding Attitude towards mathematics, Socioeconomic status, and Parents born within test country are all school-level factors exerting a negative effect on the students at medium-performing schools in at least two countries. Parents born within test country is the only factor shared by all the countries (except Iceland) among the students at medium-performing schools, but only in 2012. The only factor, exerting a negative effect among students at low-performing schools that occur in more than one country (in 2012) is where the Boys constitute the majority in the school (55% or more).

Overall, our results have shown that few school-level factors seemed to be associated with student success. It is noteworthy that there are different trends regarding the distribution of significant factors predicting lack of student success over the years. One conclusion is that different school-level factors seem to be related to different performance levels. Overall, school-level factors have been identified only among low and medium-performing schools. School-level variables related to success or lack of success among high-performing schools have been identified only in two of the countries: Denmark and Sweden. These results raise several questions in relation to the student population and the value-added elements that schools can, or cannot, provide for different group of students and hence in particular for high-performing students. These results are in line with previous research (cf. Swedish National Agency, 2012b) and can be interpreted as a reflection of the educational system’s incapacity to provide support for high-performing students and to enhance their learning. Another interpretation may be that factors of importance for high-performing students may lay outside the school. However, it should be remembered that school-level factors are not homogenous since they include structural factors as well as factors related to the
intentions and the practice of the educational professionals (teachers and the principal) but also the characteristics of the student body. In general, there is a mix of these different types of variables in relation to their explanatory value for student success or lack of success. Nevertheless, our results identify some specific factors of importance for success or lack of success for a fairly large group of the student population, i.e. students at low and medium-performing schools. This finding may be of practical use for everyday life in school and for educational professionals since the factors identified indicate a “direction for action.” To our knowledge, no previous studies have been conducted on PISA which analyse student success in relation to school-level factors by focusing on performance levels. However, although the interpretations of specific factors must be used with care they can be used as an indication of areas or issues that need further examination, in particular the factors that inhibit potential for change in particular for the low and medium-performing schools. Our findings are therefore in line with the OECD observation (2013a) that education can make a change.

Our findings also raise the question of whether large-scales assessments like PISA assess relevant variables that can actually explain student success or lack of success for all students or only in relation to certain performance-levels and in some countries. Are there other school-level variables not included in the assessment programme which are better suited to exploring student success or lack of success in performance at different levels, and in particular among students at high-performing schools? These are questions that should be addressed in future studies, since the results of this study indicate that performance level is a factor that should be taken into consideration in the design of future studies based on PISA, and perhaps also in other large-scale assessments.

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Table A1. Student performance in PISA 2003.

|        | Denmark | Finland | Iceland | Norway | Sweden |
|--------|---------|---------|---------|--------|--------|
|        | Ge      | Lo      | Me      | Hi     | Ge     |
| H1     | 31.35\(^1\) | 28.94\(^1\) | 28.18\(^1\) | 33.18\(^1\) | 30.94\(^2\) |
|        | (2.54) | (4.22) | (2.97) | (2.26) | (4.47) |
|        | 38.60\(^1\) | 38.01\(^1\) | 35.79\(^1\) | 38.16\(^1\) | 37.19\(^2\) |
|        | (3.75) | (6.47) | (4.51) | (3.80) | (5.42) |
| H2     | 45.87\(^1\) | 58.93\(^1\) | 52.19\(^1\) | 73.44\(^1\) | 67.34\(^2\) |
|        | (14.03) | (16.40) | (14.48) | (10.79) | (19.00) |
| H3     | 9.04\(^1\) | 7.95\(^1\) | 9.76\(^1\) | 8.76\(^1\) | 3.14 |
|        | (3.82) | (7.26) | (4.63) | (4.40) | (2.63) |
| aH1    | −52.31\(^1\) | −40.64\(^1\) | (9.12) | (10.48) | −33.67\(^2\) |
| aH2    | 78.00\(^1\) | −46.35\(^1\) | −50.43\(^1\) | −36.01\(^1\) | 32.08\(^1\) |
|        | (18.63) | (9.07) | (13.07) | (10.94) | (13.43) |
| aH3    | 48.29\(^1\) | 32.08\(^1\) | (13.85) | (13.85) | (13.85) |
| S1     | −9.06\(^1\) | 4.07 |
| S2     | 16.62\(^2\) | (5.47) |
| S4     | −29.98\(^1\) | (13.09) |
| S6     | −11.33\(^1\) | (4.73) |
| S7     | 0.36\(^1\) | 0.45\(^1\) | 0.18\(^2\) | 0.34\(^1\) | 0.41\(^1\) |
|        | (0.15) | (0.28) | (0.07) | (0.07) | (0.17) |
| S8     | 23.93\(^1\) | 25.20\(^1\) | (10.64) | (10.21) | (10.21) |
| S9     | 30.79\(^2\) | 35.95\(^1\) | (11.87) | (6.96) | −34.27\(^2\) |
| S10    | 34.80\(^1\) | (14.54) | (10.75) | (10.75) | (10.75) |

\(^1\)p-value <0.001, \(^2\)p-value <0.01, \(^3\)p-value <0.05

H1 = attitude towards mathematics, H2 = socioeconomic status, H3 = Parents born within test country, H4 = Student sex, aH1/aH2/aH3 = aggregated H1/H2/H3, S1 = school resources, S2 = grouping students by ability, S4 = teacher intentions, S6 = responsibilities of principal, S7 = the percentage of qualified maths major teachers, S8 = urban school, S9 = public school, S10 = majority of boys.

Ge = General model, Lo = Low-performing schools, Me = Medium-performing schools, Hi = High-performing schools.

Appendix.
### Table A2. Student performance in PISA 2012.

|           | Denmark | Finland | Iceland | Norway | Sweden |
|-----------|---------|---------|---------|--------|--------|
| Ge        | Lo      | Me      | Hi      | Ge     | Lo     |
| H1        | 28.82   | 19.34   | 27.98   | 30.84  | 34.02  |
| (2.10)    | (4.36)  | (2.75)  | (3.67)  | (1.94) | (3.58) |
| H2        | 35.50   | 37.38   | 32.24   | 31.63  | 38.78  |
| (3.58)    | (6.11)  | (5.82)  | (5.71)  | (3.74) | (6.57) |
| H3        | 58.29   | 58.50   | 56.47   | 31.63  | 78.96  |
| (4.93)    | (8.28)  | (7.14)  | (5.71)  | (8.43) | (6.19) |
| H4        | 10.64   | 7.73    | 5.67    | 20.06  | 2.43   |
| (3.06)    | (5.42)  | (4.51)  | (4.78)  | (3.84) | (9.34) |
| aH1       |         |         |         |        |        |
|           |         |         |         |        |        |
| aH2       | 95.61   | 62.43   | 56.71   | 109.05 | 41.40  |
| (23.98)   | (27.75) | (23.68) | (18.72) | (20.05)| (18.79)|
| aH3       | -33.43  | -38.98  | -51.72  |        | -57.24 |
| (14.85)   | (14.46) | (17.34) |        |        | (12.36) |
| S2        |         |         |         |        |        |
|           |         |         |         |        |        |
| S3        | -7.26   |         |         |        |        |
| (3.47)    |         |         |         |        |        |
| S4        | -22.50  |         |         |        |        |
| (9.16)    |         |         |         |        |        |
| S5        | -7.16   |         |         |        |        |
| (2.75)    |         |         |         |        |        |
| S6        | -8.00   | -11.56  |         |        |        |
| (3.80)    | (4.82)  |         |         |        |        |
| S8        | 10.42   | 12.66   |         |        |        |
| (5.30)    | (5.46)  |         |         |        |        |
| S10       | -22.66  | -9.21   |         |        |        |
| (7.46)    | (4.25)  |         |         |        |        |

*p-value <0.001, **p-value <0.01, *p-value <0.05

H1 = attitude towards mathematics, H2 = socioeconomic status, H3 = Parents born within test country, H4 = student sex, aH1/aH2/aH3 = aggregated H1/H2/H3, S2 = grouping students by ability, S3 = student learning barrier, S4 = teacher intentions, S5 = monitoring the practice of teachers, S6 = responsibilities of principal, S8 = urban school, S10 = majority of boys.

Ge = General model, Lo = Low-performing schools, Me = Medium-performing schools, Hi = High-performing schools