UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Teacher certification and student achievement

- A quantitative study of Swedish compulsory schools

Zhila Azez

Supervisor: Mikael Lindahl

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Graduate School, School of Business, Economics and Law, University of Gothenburg, Sweden

Abstract

This paper aims to study the impact of teacher certification on student achievement in Swedish compulsory schools by using panel data from the Swedish National Agency for Education for the period 2014/2015 – 2018/2019. In 2011, Sweden introduced new school reforms with stricter policies for teacher certification. To my knowledge, no studies have investigated the impact of teacher certification on student achievement after the reform. The fixed-effect model is applied, allowing to control for the non-random sorting of teachers and students across schools. The main results suggest that increasing the share of certified math teachers will have a small positive impact on student test scores in math. However, the impact of certified English teachers on student achievement in English test scores did not yield any statistically significant estimates. These results are mostly in line with previous research finding a positive impact of certified math teachers on student achievement, but inconclusive effects of certified English teachers.

Keywords: Teacher certification, student achievement, compulsory schools, Fixed-effect model

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1. Introduction

According to the Swedish National Agency for Education, every student in the country should have access to and receive an equal education. However, differences between schools have increased, both in student composition and in student achievement (Skolverket, 2018). In 2011, the government implemented new school reforms to improve student achievement and decrease the differences in the quality of education across the country. Particularly, a new school law, curriculum, and grading system were adapted alongside with new policies regarding teacher certification (Skolverket, 2015).

Nevertheless, over the past years, the share of students without completed grades when finishing compulsory school has increased. In 2019, approximately 25 per cent of 9th-grade students finished compulsory school without achieving the knowledge requirements in at least one subject (Skolverket, n.d.). The high share of students failing compulsory school continues the debate on what improves student achievement and whether stricter policies for teacher certification are the solution. An argument for implementing teacher certification as a requirement for teaching is that it could enhance teacher quality and therefore improve student achievement. However, a counterargument is whether new restrictions and stricter policies will make the profession even more unattractive since teacher shortage already characterises the teacher labour market (Santiago, 2004; Andersson & Waldenström, 2007b). Thus, it is interesting to study if the new stricter policies regarding the certification of teachers improve student achievement in Sweden.

Furthermore, it is in the interest of the Governments on how to improve student achievement since they usually are responsible for providing, finance and regulate the education system (Dolton 1996; Santiago 2004). In Sweden, the cost of education has increased, particularly for compulsory schools. During 2013-2017, the total cost of education, which includes pre-school classes, compulsory school, high school, and university, increased by 19 per cent. The most substantial increase was in compulsory school with an increase of 29 per cent, followed by 18 per cent in pre-school classes, 11 per cent in high school, and 10 per cent in university (SCB, 2018).

This paper aims to investigate if certified teachers in compulsory schools improve student achievement between 2014/15 – 2018/19[1] in Sweden. More specifically, I will examine if the share of certified teachers in the subjects English and math will improve the standardised test scores in the two subjects, respectively.

[1] School period of 2014/2015 – 2018/2019 will further be referred to as 2015 – 2019.

Previous research on the subject often concludes a positive impact of certified teachers on student achievements in math. However, the studies on the effect of teacher certification on student achievement in other subjects do not provide an apparent effect as in math. Goldhaber and Brewer (1997) estimated two different models with two different estimates of teacher certification. They found for both models a positive impact of teacher certification on student achievements in math but no evidence for English. Monk & King (1994) studied the impact of teacher characteristics, measured as experience and teachers subject-matter education, on student test results in math and science in the US. The paper yielded many insignificant results, but they found math teachers to be positively associated with students test score in math. Clotfelter et al. (2007) find positive and significant of teacher's experience, test scores and certification on student achievement for both test scores in math and in English, where the effect is more substantial for math. In the Swedish context, few papers examine this relationship, and the ones available concludes that increasing the share of non-certified teachers negatively impacts student achievement, measured as Grade Point Average (Anderson et al., 2011, Andersson & Waldenström, 2007a).

To my knowledge, the papers studying the impact of certified teachers on student achievement in the Swedish context consider periods before 2011. This paper contributes to previous research by using recent data on Swedish compulsory schools for the period 2015-2019. Moreover, the recent data available provides information on teacher certification based on each subject. This allows studying if teacher's subject-specific knowledge will improve student achievement.

The research question of this paper is whether a higher share of certified teachers improves student achievement. Specifically, I will study the impact of certified teachers in the core subject math and English on student test result in each subject, respectively. The econometric approach is a fixed-effect model where I will control for school- and time-fixed effects to control for time-constant unobserved effects and the non-random sorting of students and teacher across schools. In line with previous research, I find a positive and statistically significant effect of certified math teachers on test scores in math. For English test results, I find no statistically significant relationships.

The structure of the remaining parts of the paper is as follow. Next section briefly describes the education system in Sweden. Section 3 describes previous research on the subject, and section 4 presents the theory. Section 5 presents the methodology, and the data is described in section 6. The results are presented in section 7 and discussed in section 8. Section 9 concludes.

2. Compulsory schools in Sweden

Compulsory school in Sweden is nine years long, and students receive final grades when finishing 9^{th} grade. Since 1991, Sweden adapted the free school choice and allowed the establishment of independent schools. Parents could now choose where they want their children to go to school, public or independent, instead of being allocated by place of residence. The increasing school segregation in Sweden since 1990 has been a result of both increasing residential segregation and the free school choice. School segregation contributes to both social and ethnic divisions, where different groups of students' cluster in specific ways. However, the segregation based on the ethnic background has lately declined due to increased migration, resulting in more diversity across schools. Moreover, the distribution of teachers seems to increase the initial differences in opportunities. Public schools with students in need of more resources have teachers with lower skills compared to public schools with high-performance students. Also, the teacher turnover seems to be higher in these public schools too (Holmlund, Sjögren & Öckert, 2019).

The introduction of the latest reform was in 2011, with new policies for teacher certification, grades, and curriculum. The new and stricter policies for teacher certification aimed to improve teacher quality, where students were taught and graded by teachers with the right education. Schools had until 2015 to adapt to the new policies, and from that year, schools should only hire certified teachers to be responsible for teaching and grading. The National Agency for Education provides teacher certification to teachers who apply for it after finishing a teaching degree. Nonetheless, non-certified teachers could still be employed, but only if certified teachers are not available. However, they can only be hired at a fixed-termed contract of maximum one year. When employing non-cerIf schools decide to employ non-certified, the teachers can teach, however, when grading the students, a certified teacher must be included and approve the grade. If the teachers cannot agree on a grade, the opinion of the certified teacher weights more.

In addition to new policies for teacher certification, a new grading system was implemented in 2011. The grading system before 2011 was a four-scale system which changed to a six-scale system after the reform. Moreover, students would start to receive grades from 6^{th} grade and also to take the standardised test in the core courses instead of 8^{th} grade. Changes in the grading system required a change in the curriculum since it provides guidelines on how to grade students, among other things (See Skolverket, 2015 for more information about the reform).

3. Literature review

Many studies have investigated how teacher quality impacts student achievement, but there is not a standard definition of teacher quality. However, most studies define and measure teacher quality as teacher experience, certification, credentials or some type of degree. The definition varies between, and sometimes within, countries. For instance, in the United States, the types of teacher certification differ between states (Goldhaber et al., 2007; Andersson & Waldenström, 2007b; Wayne & Youngs, 2003).

Goldhaber and Brewer (2000) compared math and science students of teachers with standard certification to students of teachers with emergency, private school, probationary, or no certification. They found a strong positive and significant relationship between teachers with standard certification and students test results in both subjects, where the effect was more substantial for math. However, for other types of certification, such as private school certification, they did not find consistent results for either subject. Therefore, they concluded that teacher certification should not be required. Darling-Hammond and Berry (2001) opposed the conclusion of Goldhaber and Brewer (2000). They claimed that the substantial and significant results of certified math teachers on test scores in math should not be rejected, and further referred to other empirical studies supporting the positive impact of teacher certification. Moreover, they criticised the methodology of Goldhaber and Brewer for including variables highly correlated with certification, such as bachelors' degree, masters' degree, and teaching experience. They claimed the coefficient for certification to be underestimated since the estimates remained positive and significant despite the correlations.

The information on certification available is crucial which Goldhaber & Brewer (1997) provided support for. They estimated two different models on the impact of teacher certification on student achievement. In the first model, teacher certification was defined as either having a certification or not and in the second model, it was specified in what subject the teachers had a certification. This way, they could estimate the impact of teachers subject-specific knowledge on student achievement. They found a positive association between certified teachers and students test results in math. However, the effect was more substantial in the second model, where they estimated the effect of certified math teachers. For English, the first model yielded a negative and significant effect of certified teachers on English test scores, but the effect turned inconclusive in the second model.

In later years, Goldhaber et al. (2007) studied the distribution of teachers certified by the National Board for Professional Teaching Standards (NBPTS) in North Carolina over four years on three different levels; classrooms, schools, and districts. Not only did they compare districts, schools and students taught by National Board-Certified Teachers (NBCTs) to non-NBCTs, but also teachers before and after they became certified by NBPTS. By using the Gini-coefficient as an indicator, they could study the distribution of NBCTs over time and analyse whether clustering of NBCTs occurred in specific districts or schools. They found a positive relationship between financial incentives and the density of certified teachers in districts. Since the investment of most state funds is in schools and districts with a high share of NBCTs, the authors conclude that NBCTs are least likely to teach students in the most disadvantaged schools and districts.

The non-random sorting of teachers into schools is something Allen, Burges and Mayo (2018) also analysed. They studied the teacher market in England by looking at the relationship between teacher turnover and the level of disadvantage of schools by applying a search and match model. By including data on the different type of contracts teachers had, they were able to analyse how teachers were matched and re-matched with different schools. They found a small positive correlation between teacher's turnover rate and the level of disadvantaged neighbourhoods. As they controlled for school-, student- and local teacher labour market characteristics, the effect diminished, and the remaining effects were interpreted to be associated with teacher characteristics. Moreover, disadvantaged neighbourhood hires younger teachers to a greater extent. The authors conclude that the allocations were due to either the preferences of younger teachers to teach in schools located in deprived areas or as a low general interest to teach in disadvantaged schools. The studies by Goldhaber et al. (2007) and Allen et al. (2018) provide valuable information on the non-random sorting certified teachers into schools which are essential to control for when studying the impact of certified teachers on student achievement.

In the Swedish context, Andersson and Waldenström (2007b) studied if the differences in the share of the non-certified teachers between schools and municipalities could be due to restrictions in the supply of certified teachers. Studying the public Swedish compulsory schools in Sweden between 1995/96 – 2003/04, they found that the Wärnersson Grant (WG) contributed to an increase in the share of certified teachers in areas with lower supply restrictions, that is, areas with relatively high unemployment of certified teachers. The WG was a targeted grant provided by the government in order to increase the number of teachers in schools. Every public compulsory school applying for the grant received it. Schools and municipalities could not affect the size of the grant received since the only determining criteria were demography. Moreover, they found that in areas with high supply restrictions, that is, areas with relatively low unemployment of certified teachers, the share of non-certified teachers increased. Thus, the authors conclude that the introduction of the WG is the reason for the increased share of non-certified teachers over time.

In later years, Anderson et al. (2011) studied the impact of teacher certification on school results for the period 1997/1998 – 2003/2004. They adapted the Ordinary Least Squares (OLS) with school- and year-fixed effects and also the IV method to control for the non-random sorting of teachers. The OLS results yield a small negative association between non-certified teachers and student achievement when controlling for background characteristics. However, when including school-fixed effects, the results were not statistically different from zero. In addition to the fixed-effect approach, they also used the IV approach with the Wärnersson Grant (WG) as an instrument variable. These results yielded statistically significant estimates suggesting that increasing the share of non-certified teachers by one percentage point decreased the student performance, measured as average Grade Point Average, by approximately 1.8 standard deviations. At that time, non-certified teachers were still authorised to grade students and to control for eventual grading bias the authors also estimated the effect of non-certified teachers on students standardised test scores in the core courses math, Swedish and English. They found small and negative effects of non-certified teachers on the test results in these subjects. The results suggest that increasing the share of non-certified teachers by one percentage point affects the English test scores with 0.02 standard deviations and the math test scores by 0.03 standard deviations, at a 10 and 5 per cent significance level.

4. Theory and hypothesis

This section provides the theoretical framework for the labour market for teachers and what drives equilibrium. The simple model of demand and supply will explain mechanisms that drive the market for teachers, and the matching model will further explain the distribution of the teachers.

Inputs and outputs can explain the economics of education. Student achievement is the output, and it is a function of inputs controlled by and inputs not controlled by policymakers. The inputs controlled by policymakers are school resources, teacher characteristics, and curriculum, whereas inputs not controlled by policymakers are family and student characteristics (Hanushek, 2020). Thus, the expression of student achievement is:

$$A = \Phi\ (\mathrm{S}, \mathrm{I}) \qquad (1)$$

Where A denotes student achievement as output, S denotes policy-related and school resource inputs, and I denote background characteristics of the students. Teacher characteristics are considered as policy-related resources since the government sets standards such as teacher quality, where teacher certification could be a measure for it. Since mechanisms are affecting the share of certified teachers in the labour market, the following section will describe the labour market for teachers.

4.1 Teacher demand and supply

The share of certified teachers in a school can be dependent on several factors, where the demand and supply of certified teachers matter. Zabalza et al. (1979) initially described the basic model of demand and supply of the teacher labour market, and Dolton (1996) further developed model. The elements determining the market for teachers are the interrelationship between student-teacher ratios, educational expenditure on the employment of teachers, and the average level of teachers' salaries.

According to Dolton (1996), the government usually have much power to affect both the demand and the supply for certified teachers. Since most schools are public schools, the public sectors are the leading employers of teachers. Moreover, the government controls the supply since it is the provider of trained teachers. Thus, the government can control many determinants of demand and supply through policies for class size, student-teacher ratio, and the supply of training programs for teachers. The market for teachers is not as competitive as other markets which teacher shortages reflect, and this model illustrates how. The demand for teachers depends on the student population, and the desired class size governments set as plausible. Thus, the demand for teachers is a function of the student-teacher ratio and the student population, expressed as:

$$D^T = STR * Y_S \tag{2}$$

Where D^T denotes demand for teachers, STR denotes the student-teacher ratio, and Y_S denotes the student population. Moreover, a binding budget constraint restricts the number of teachers the hiring authority, usually the public sector, can hire. It is a function of teachers wages and the desired level of STR and can be expressed as:

$$\bar{E} = STR^* * W^T \tag{3}$$

Where $\bar{E}$ denotes educational expenditures by the government, STR* denotes the desired level of STR, and W^T denotes the average teacher wage.

Several factors determine the supply of teachers, such as the working conditions for the profession and relative wages. Working conditions include working load and opportunities to develop, among other things. The relative wage is the relationship between the teacher wage and the non-teacher wage, where the teacher wage reflects relative working conditions. Thus, the aggregated supply is an increasing function of the wage level for teachers, given a fixed non-teacher wage. The expression of the aggregated supply of teachers is:

$$S^T = \frac{W^T}{\hat{W}^N} \tag{4}$$

Where S^T is the supply for teachers, W^T is the average wage for teachers, and $\hat{W}^N$ is the fixed wage for non-teachers.

Equilibrium in this model should be the intersection between demand and supply (see appendix A for illustration). However, the budget constraint, $\bar{E}$, will interfere with the equilibrium by both lowering the teacher wages and the number of certified teachers, creating a teacher shortage. Strategies to overcome the shortage requires governmental interventions on either the supply or the demand side. On the supply side, relaxing the entry requirements for the profession is one way to increase the supply of teachers. Alternatively, allowing non-certified teachers to teach is another option to overcome the shortage. On the demand side, the government can increase the teaching load by adjusting the required class size, or by increasing the number of classes each teacher are held responsible. Either way, the interventions will cost the quality of teachers (Santiago, 2004).

As the simple model of supply and demand for teachers describes the determinants of the labour market and equilibrium at the aggregated level, it is not sufficient in explaining the behaviour of teachers already being on the market. Thus, a matching model is also relevant for explaining the behaviour of teachers on the market, considering the behaviour of teachers and the non-random sorting into schools discussed in previous studies.

4.2 Two-sided matching model

Boyd et al. (2013) presented a game-theoretic two-sided matching model to explain the sorting of teachers into schools. The model approaches two groups, a group of workers (teachers) and a group of agents (schools) which will match with each other. It is a two-sided matching model when the match is a result of both parties' separate choices. Moreover, a teacher will not only base an acceptance to a school on the characteristics of the school but also the other possible schools available. A teacher with many job opportunities elsewhere can be more selective in the choice of accepting a school.

When schools evaluate the potential candidates, the qualifications of the teachers are the main determining factor. Teacher certification is a proxy for teacher qualification, and the better qualifications, the higher probability of being hired. Reasons for unemployment of qualified teachers depend on the preferences of the teacher rejecting the offer. Boyd et al. (2011) confirm this in a study where they found that qualified teachers are more likely to be hired, but the unwillingness of teachers to teach at schools with a lower share of certified teachers was the reason for unemployment.

For the individual candidate searching for a teaching job, several factors and school characteristics are essential. Urban schools are less attractive among teachers searching for jobs. However, distance is a crucial factor where teachers tend to accept an offer close to their residence. They will even accept to work at a close urban school with more minority students, students in poverty, and a slightly lower salary compared to a suburban school, given the distance between the two schools. The authors could not find a robust significant effect of salary differences, and the small variation observed across districts are argued to most likely be due to unobserved working conditions.

4.3 Hypothesis

Given the previous research and the theoretical framework presented, I will empirically test the following hypothesis of the impact of certified teachers on student achievement. The null hypotheses are the following.

H_0: Increasing the share of certified English teachers does not improve 9^{th}-grade students' average test score in English.

H_0: Increasing the share of certified math teachers does not improve 9^{th}-grade students' average test score in math.

5. Empirical model and strategy

Since this paper aims to estimate the effect of the share of certified teachers on student achievement, the education production function in equation (1) can be re-written as:

$$Achievement_{ist} = \beta_0 + \beta_1 Certified_{ist} + \varepsilon_{ist} \quad (5)$$

Where $achievement_{ist}$ and $certified_{ist}$ denote the average test score and the share of certified teachers at school *i* in subject *s* at time *t*, respectively and ε_{ist} denotes the error term. β_1 can be estimated using OLS but would most likely generate biased estimates due to sources of endogeneity.

Sources of endogeneity are omitted variable bias, non-random sorting of students and teachers, and reverse causality. The first source of endogeneity, omitted variable bias, occurs when variables correlated with certified teachers are excluded because they are unobserved or hard to measure. The second source of endogeneity could be due to the non-random sorting of teachers and students across schools and classrooms. There are two channels of the non-random sorting. First, parents can select which school they want their children to attend and can, therefore, choose schools with better reputations, resources, and higher shares of certified teachers. Second, teachers can also be selective when applying for schools prioritising schools with better reputations, characteristics, and higher shares of high achieving students. If the model fails to account for the unobserved ability of teachers and students to non-randomly sort into schools, the OLS regression will overestimate the impact of certified teachers. A possible third source of endogeneity could be reversed causality, which questions if certified teachers affect students test results or if the students test results affect the teacher composition at the school. This could be violated if past values of student achievement affect the present values of the share of certified teachers.

Including a vector of control variables, school- and year-fixed effects will control for omitted variable bias and the non-random sorting of teachers into schools. Omitted variables and the non-random sorting of teachers into schools could be related and simultaneously including control variables, school- and year-fixed effects could generate consistent estimates. For instance, if there are non-random behaviour of teacher into schools, including schools fixed effects and background characteristics of the schools could capture the effect and thus, generate correct estimates. The model is expected to capture time-invariant school characteristics and thereby mitigating the selection bias due to the non-random behaviour of students and teachers into schools and omitted variables. For the fixed-effect approach to generate consistent estimates, the strict exogeneity assumption must hold. That is, the idiosyncratic error term must be uncorrelated with the teacher certification variable at all time.

If student test results in year *t* are not satisfying, the school might want to hire more certified teachers in year *t+1*. Thus, student achievement and the idiosyncratic error term in year *t*, would affect the share of certified teachers in year *t+1*, violating the strict exogeneity assumption. Such a scenario would cause an upward bias in certified teacher estimate since the impact of teacher certification would be overestimated. However, it is hard to prove the existence of such a scenario and fixed-effect model is still an appropriate method (Andersson & Waldenström, 2007a). Moreover, when estimating the effect of teacher certification on student achievement, previous research highlights that the main challenge is controlling for the non-random distribution of teachers into schools and (Wayne & Youngs, 2003; Andersson et al., 2010; Kukla-Acevedo, 2009).

There are advantages with this study which some of the previous studies highlights are essential and matter for consistent estimates. First, the data on teacher certification is available for each subject which makes it possible to estimate teachers subject-specific knowledge on student achievement, which Wayne and Youngs (2003) and Goldhaber and Brewer (1997) acknowledges being important. Second, the definition of teacher certification and the process to become certified is the same across all municipalities in Sweden and the National Agency for Education is responsible for providing them. Finally, school- and year fixed-effects are included to control for the non-random behaviour of students and teachers into schools. Thus, the fixed-effect model is expected to generate consistent estimates of the impact of teacher certification on student achievement.

The econometric specification capturing school- and year fixed-effects is expressed as:

$$Achievement_{ist} = \alpha + \delta certified_{ist} + \beta X'_{it} + \lambda_i + \gamma_t + \varepsilon_{ist} \qquad (6)$$

Where the dependent variable Achievement_{its} is the average test score for school *i*, in subject *s*, at time *t*. The independent variable $\delta\text{certificate}_{its}$ is the percentage of teachers with certification for school *i*, in subject *s*, at time *t*. $\beta X'_{it}$ is a vector of control variables for school *i* at time *t* which includes the average level of parents education, percentage of newly immigrated students, the share of female students, and the student/teacher ratio. Finally, λ_i is the school-fixed effects, γ_t is the year-fixed effects, and ε_{ist} is the error term. Regular standard errors are most likely incorrect in this type of panel data if there is a correlation in the unobserved factors over time. Thus, I will cluster standard errors at the school level, allowing correlation between the standard errors within schools over time. As a result, the clustered standard error will be larger than the regular standard errors.

5.1 Alternative estimators

To evaluate the sensitivity and robustness of the main model, I will modify the model in several ways. First, I will change the dependent variable to the final grade in the two subjects to evaluate how sensitive the model is to a change in the dependent variable. The final grade in the subject also reflect student achievement, and the results are expected to be similar to the main estimates.

In a second robustness test, I will limit the sample to schools teaching only 7^{th} – 9^{th}-grade students to control for possible measurement error. The data on students test scores are for 9^{th} grade students only, whereas the data on certified teachers are on the entire schools teaching staff. Thus, measurement error could be a possibility when estimating the effect of the share of certified teachers for the entire school on student test results in 9^{th} grade. If the share of certified teachers is higher (or lower) in earlier (or later) classes, then the estimates might be biased when interpreting the effect on 9^{th}-grade students tests results.

In a third robustness test, I will include the share of certified teachers for both subjects as dependent variables in the same regression. As the fixed-effect estimate captures time-constant unobserved variables, I will include the share of certified teachers for both subjects in the same regression. Since the share of certified teachers in the other subject is not constant over time, it will test for whether a time-varying variable affects the results. For example, when estimating the effect of certified math teachers on test scores in math, including the variable for certified English teachers should not affect the results. If the share of certified English teachers has a significant impact on math test scores, the strict exogeneity assumption is violated in the main model.

6. Data

This section presents the data used in this thesis and provides summary statistics for the chosen variables. Furthermore, it presents the methodology and possible limitations of the empirical strategy.

Data and summary statistics

The panel data used in this paper origins from the Swedish National Agency for Education (NAE) for compulsory schools in Sweden between 2014/15 – 2018/19. Initially, the data consisted of 1660 compulsory schools in all of Sweden's 290 municipalities. However, the exclusion of special schools[2], schools for newly immigrated, and schools with missing data[3] decreased the sample. Moreover, the National Agency for Education provides a unique dataset on 9th-grade students called SALSA, and they developed this dataset to compare 9th-grade student across the county. Thus, it includes data on average test scores and the other control variables for 9th-grade students only. Schools included in SALSA have at least 15 students, and information on background characteristics for 75 per cent of the students (Skolverket, 2020b). Hence, using SALA, additional schools were excluded if they did not fulfil the two requirements. The final dataset includes a total of 982 compulsory schools between 2015-2019, of which 210 are independent schools. Moreover, due to the exclusion of schools, 29 municipalities got excluded from the sample[4]. Furthermore, the dataset includes information on parents' average education level, the percentage of newly immigrated students, the percentage of female students, the percentage of certificated teachers in each subject, and the student/teacher ratio at the school level.

6.1 Dependent variables

Student achievement is the outcome variable in equation (1), and it will be defined as students test scores. In 3rd, 6th, and 9th grade, students are tested in the core courses Swedish, English, and math by taking standardised tests which all student are taking at the same time in the whole country. In the 9th grade, the test in math consists of four parts; one oral and three writing parts. Furthermore, the test in English also consists of four parts; speaking, reading, listening, and writing, whereas the test in Swedish consist of three parts; speaking, reading, and writing. Swedish is taught either as Swedish or Swedish as a second language, depending on the student's first language (Skolverket, 2020a). Thus, the dependent variable is the average test scores of the standardised test 9th-grade students take in math and English. Test results for Swedish and Swedish as a second language will not be included in the analysis due to many missing values. The scoring of each part is between 0 – 20, and the aggregated score is the average of all four parts in each subject.

Table 1 provides summary statistics of the variables and shows that the mean of the average test scores in math for the sample is 11.10 points. There is a considerable variation

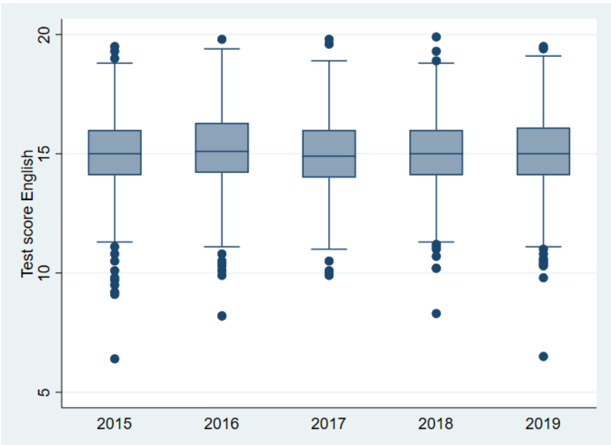
[2] compulsory school for children with intellectual disabilities

[3] Missing data includes schools with gaps of number of observations during the period due to either being closed or newly established.

[4] The municipalities excluded are small municipalities, with one or a few compulsory schools. These schools either did not fulfil the requirements to be included in SALSA, or have missing data on the other variables, such as reported test results.

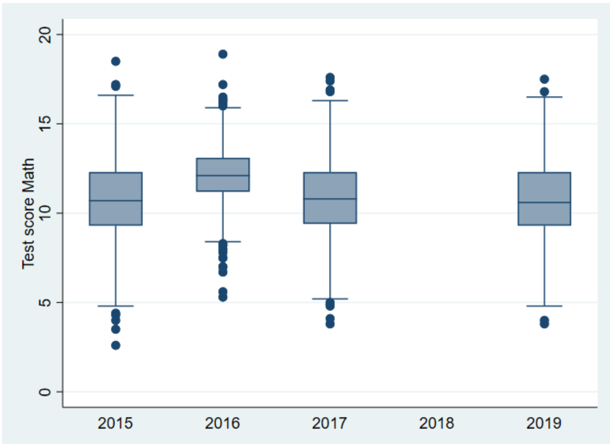
between schools where the lowest average test score is 2.6, and the highest average test score is 18.9 during the period. In English, the mean of the average test score is 15.07, and the variation between schools is also large here, where the lowest average test score is 6.4, and the highest average test score is 19.9. Figure 1 and 2 shows the distribution of the average test scores in English and math, respectively, over the period. The trend shows a rather stable change in English test score, but for math, the median test score increased in 2016 and decreased back in 2017. As figure 2 shows, there are not any reported test result for math in 2018. During this year, parts of the math test were leaked, and following the recommendations of NAE, schools used a replacement test instead. NAE does not record test scores for the replacement tests, hence, the gap in 2018. Some schools also used the replacement test in English, but not in the same extent as in math.

Figure 1. Distribution of English test score.



***Note**: The distribution of the average English test scores during 2015-2019. The figure shows a relatively stable average test score during the period*

Figure 2. Distribution of Math test score



***Note**: The distribution of the average Math test scores during 2015-2019. The figure shows that the average test scores in math overall increased in 2016 and then decreased back in 2017. All schools used a replacement test for math in 2018 due to the test beaing leaked.*

The standardised test scores are a tool measuring the level of the students' knowledge, but a student can receive a different final grade based on the overall presentation during the year. Therefore, I will also use the final grade in each subject as the dependent variable, which also scores between 0-20. The relationship between grades and the share of certified teachers is interesting since non-certified teachers are not allowed to grade student independently. Table 1 shows that the mean value for the average final grade in English is lower than the average test score, and for math, it is the opposite where the mean value of the average final grade is higher than the average test score[5].

6.2 Independent variables

On the input side of the production function of education, teacher quality is one input that the government can affect. In this thesis, teacher quality is defined as teacher certification, which the Swedish government decided on in 2011. The percentage of certified teachers in math and English are the independent variables for each school s at time t. These variables are calculated at the school level and give the percentage of certified teachers at the entire school and not just teachers for 9th-grade students. Andersson and Waldenström (2007a) estimated the impact of non-certified teachers for the entire teaching staff at the school on 9th-grade student achievement. The authors argued that the average quality of teachers in the 9th grade should reflect, and be the same, as the average quality of all teachers at the school. I will, in this thesis, also rely on that assumption and argue that it should not impact the results. Though, I will in a robustness test, limit the sample to schools teaching 7th – 9th grade only[6], to control for possible measurement error.

Table 1 presenting summary statistics shows that the mean of the share of certified math teachers is 71.71 per cent. The variation shows that some schools have no certified teachers, whereas in other schools all the teachers in the subject are certified. The mean value of the share of certified English teachers is 62.11 per cent, and the variation between the average share of certified teachers in schools are also here between no certified teachers to all the certified teachers in the subject.

Figure 5 shows how the distribution of the share of certified teachers throughout 2015-2019 in Sweden for the sample. The share of certified teachers in math is higher than the share of certified teachers in English over the entire period. For both subjects, the average share of certified teachers increased in 2016, but the median share slightly decreases the year after and remains relatively the same.

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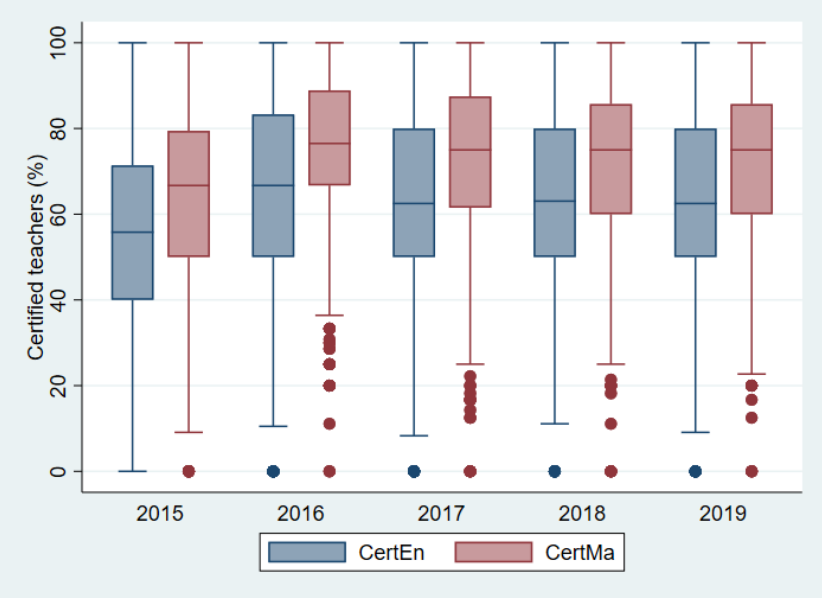
[5] See appendix B for distribution of average final grade in relation to average test scores over the period.
[6] In the full sample, some schools are teaching nursery class – 9th grade, some 4th – 9th grade and others only 7th – 9th grade. See appendix B for summary statistics and distribution of certified teachers in the sample for schools teaching 7th – 9th grade only.

Figure 3. Distribution of share of certified teachers over the period.



***Note**: The distribution of the share of certified math teachers are on average higher than the share of certified English teachers during the period. The share of certified teachers increased on average for both subjects in 2016 compared to the previous year and stayed rather stable the years after.*

6.3 Control variables

From theory and equation (1), backgrounds characteristics are crucial to include since student achievement is a function of both teacher quality and background characteristics of the schools. The control variables are included in the empirical model as a vector denoted X' including the average level of parents' education, percentage of newly immigrated students, percentage of female students, and the student-teacher ratio (STR).

The calculation of the average level of parents' education is the average of one or both parents' educational level. It scores between 1-3 where 1 denotes completed compulsory school, 2 denotes completed secondary school, and 3 denotes completed tertiary education. As table 1 shows, the mean of the average level of parent education in the sample is approximately 2.3, indicating that the average completed education level is high school.

The percentage of newly immigrated students are students immigrating to Sweden for the first time during the last four years. It includes students with unknown backgrounds, which are students without Swedish personal numbers. Both the parents' education level and migration background matters for student achievement and are essential to control for. Share of female students is the share of female students in the 9th grade at the school. It is also a relevant variable to control for since girls, on average receive higher grades than boys (Skolverket, 2018, 2019).

The STR is according to the theories presented an input in the education production function that the government can manipulate on the demand side for teachers. The expected impact of STR on student achievement is negative since larger classes expect to lower student achievement (Koc & Celik, 2015). Unlike the previous variables, STR is calculated at the aggregated school level and not only for the 9th-grade students. It is important to consider that the STR variable might bias the estimates of certified teachers. A change in the share of certified teachers could cause a change in the STR if certified teachers have higher wages than non-certified teachers. Schools would face choosing between either smaller classes or a higher share of certified teachers at the cost of higher STR. If the expected sign of the coefficient for STR is negative, and schools face the negative correlation between certified teachers and STR, then the estimates of teacher certification would be biased upwards. Nevertheless, the variable is still essential to include since it could control for differences in school resources. Schools characterised with lower student achievement might be distributed more resources to hire more certified teachers.

Table 1. *Summary statistics of Swedish compulsory schools between 2015-2019.*

VARIABLES	(1) Mean	(2) Sd.	(3) Min.	(4) Max.	(5) Obs.
Dependent variables					
Average test score, English	15.07	1.518	6.400	19.90	4,758
Average test score, math	11.10	2.141	2.600	18.90	3,916
Average Final grade English	14.48	1.811	5.600	19.80	4,910
Average Final grade math	12.28	1.745	5	18.90	4,910
Independent variables					
Share of certified English teachers	62.11	23.44	0	100	4,910
Share of certified math teachers	71.71	19.77	0	100	4,910
Control Variables					
Average level of parents' education	2.276	0.232	1.320	2.950	4,910
Average share of newly immigrated	5.759	6.721	0	51	4,910
Average share of girls	48.16	8.353	6	88	4,910
Average share of STR (school level)	12.47	2.134	5.500	27.20	4,910
Number of schools	982	982	982	982	982

7. Results and analysis

In this section, I will present the result for my main model with and without control variables, school-fixed effects, and year fixed-effects. Moreover, I will also present the results of the different robustness tests to evaluate the accuracy of the estimates in my main model.

7.1 Main results

In this section, I will present the result, where I estimate the OLS with and without control variables, school- and year fixed effects. Table 2 shows the estimates of the main variables of interest[7] and test scores as the dependent variables. Column (1) – (5) present the result for test scores in English as the dependent variable and column (6) – (10) outlines the result for test scores in math as the dependent variable. Column (5) and (10) are the main results of interest since it includes both control variables and fixed-effects. Starting with the regressions for test scores in English, column (1) includes neither control variables, nor fixed-effects. It indicates that increasing the share of certified English teachers by 10 percentage points increases average test score in English by 0.04 standard deviations. In column (2) background characteristics are controlled for, which turns the estimate for certified English teachers negative and statistically insignificant. Columns (4) and (5) shows the same negative pattern when adding year- and school-fixed effects in the regression. Since the estimates of certified English teachers on English test score were not statistically significant, the null hypothesis cannot be rejected. Thus, the main specification of interest cannot prove that increasing the share of certified English teachers will improve students test score in English.

The impact of certified math teachers yields robust estimates on students' test scores. Column (6) shows a positive and significant relationship between the share of certified math teachers and test scores in math, when not controlling for background characteristics and fixed-effects. The results suggest that increasing the share of certified math teachers by 10 percentage points would increase average test scores in math by 0.12 standard deviations. However, since the magnitude of the coefficient decreases when adding control variables and fixed-effects, the estimate is biased upwards. When adding control variables in column (7), the magnitude of the estimate decreases to 0.011. It suggests that some of the effects in the previous regression are explained by background characteristics of the schools rather than the impact of certified math teachers.

[7] See appendix C for results for all variables

Column (9) only controls for year-and school-fixed effects and control variables are added in column (10). The difference in the magnitude of the estimate between columns (9) and (10) is rather small, suggesting a positive relationship between certified math teachers and student achievement in math.

The estimates of the share of certified math teachers are significant at a 1 per cent significance level through all the regressions, suggesting that increasing the share of certified math teachers will improve student test results in math. A 10 percentage point increase in the share of certified math teachers increases the average test score in math by 0.03 standard deviations. Due to the significant and positive impact of certified teachers on test result in math, the null hypothesis can be rejected.

Although table 2 does not show the estimates for the control variables, it is worth analysing STR as a control variable. While the variable is significant and positive for English test scores, it is not significant when controlling for math scores. When excluding fixed effects in the model, STR is positive, but it turns negative when including year fixed effects and school fixed-effects. As discussed in section 6.3, STR controls for class size and is expected to impact student achievement negatively. The positive and significant estimates of STR on English test scores is therefore surprising.

Table 2: *Regression results for Test scores in reduced form*

	(1) English	(2) English	(3) English	(4) English	(5) English	(6) Math	(7) Math	(8) Math	(9) Math	(10) Math
Average share Certified teachers	0.006***	-0.001	0.000	-0.000	-0.001	0.025***	0.011***	0.014***	0.007***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Intercept	14.673***	4.075***	15.061***	15.061***	9.165***	9.317***	-2.188***	10.113***	10.334***	1.767**
	(0.102)	(0.281)	(0.046)	(0.046)	(0.417)	(0.159)	(0.441)	(0.128)	(0.121)	(0.756)
Obs.	4758	4758	4758	4758	4758	3916	3916	3916	3916	3916
R-squared	0.010	0.630	0.000	0.010	0.104	0.054	0.451	0.023	0.256	0.312
Control variables	NO	YES	NO	NO	YES	NO	YES	NO	NO	YES
Year fixed effects	NO	NO	NO	YES	YES	NO	NO	NO	YES	YES
School fixed effects	NO	NO	YES	YES	YES	NO	NO	YES	YES	YES

Note: Clustered standard errors are in parenthesis (cluster=school). Column (1) – (5) estimates the impact of certified English teachers on English test scores. Column (6) – (10) estimates the impact of certified math teachers on test result in math.
**** p<0.01, ** p<0.05, * p<0.1*

7.2 Sensitivity and robustness analysis

In this section, I will present the results of the different robustness and sensitivity analysis to evaluate if the fixed-effects approach generated consistent estimates. The first test will estimate the impact of certified teachers on the average final grade in each subject. The second test will limit the sample to schools teaching 7^{th}-9^{th} grade only since the certified teacher variable is at the school level, and there might be differences in the teacher composition across grades. Lastly, both variables for certified teachers will be included in the same regression to evaluate the correlation between teacher certification variables and unobserved effects.

7.2.1 Final grade as the dependent variable

To evaluate how sensitive the baseline model is to changes, I will estimate the baseline specification with the final grade in math and English as the dependent variable. Table 3 present the impact of increasing the share of certified math and English teachers on the final grades in the subjects, respectively[8]. Column (1) – (3) shows the result for the final grade in English and (4) – (6) for math.

Similar to the results in table 2, the result for English in table 3 shows the insignificant and negative effect of the share of certified teachers on the final English grade. The standard deviations are also similar to the main results, but the R-squared is slightly higher in this model. The insignificant estimates of certified English teachers suggest that teacher certification does not matter for students final grade in the subject.

For math, the magnitude of the coefficient has decreased and turned insignificant. In column (4), when only accounting for school fixed effects, increasing the share of certified teachers by 10 percentage point is expected to have almost zero impact on the final test scores in math. Including background characteristics, and year-fixed effects in column (6) the coefficient turns negative, and the results remain insignificant. As mentioned earlier, the mean value of the average final grade in math is usually higher than the average test scores in math and the opposite for English scores. The NAE (2019) outlines that there are significant differences in the grading between schools, where some schools grade higher than the standardised test results and some schools lower. Mostly, independent schools are more generous in giving higher grades. This implies that grade inflation occurs, hence, using the final grade as the dependent variable might not estimate the impact of teacher certification on the actual student achievement.

[8] See appendix C for table showing all the estimates

Table 3: *Sensitivity analysis, the impact of certified teachers on final grades*

	(1) English	(2) English	(3) English	(4) Math	(5) Math	(6) Math
Certified Teachers in the subject	-0.000 (0.001)	-0.000 (0.001)	-0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	-0.000 (0.001)
Intercept	14.505*** (0.050)	14.582*** (0.051)	8.651*** (0.444)	12.179*** (0.075)	12.283*** (0.074)	5.275*** (0.498)
Obs.	4910	4910	4910	4910	4910	4910
R-squared	0.000	0.029	0.211	0.001	0.077	0.186
Control variables	NO	NO	YES	NO	NO	YES
Year fixed effects	NO	YES	YES	NO	YES	YES
School fixed effects	YES	YES	YES	YES	YES	YES

Note: Clustered standard errors are in parenthesis (cluster=school). Columns (1) – (3) estimates the impact of certified English teachers on final grades in English. Columns (4) – (6) shows results for estimating the share of certified math teachers on final grades in math.
**** p<0.01, ** p<0.05, * p<0.1*

7.2.2 Schools teaching 7th – 9th grade

The average share of certified teachers is for the entire school's staff composition, and we are mainly interested in 9th-grade students. A robustness test will limit the sample to schools teaching only the 7th – 9th-grade students. The reason for this is to control if the share of certified teachers is higher (or lower) among earlier grades. If such concentration of certified teachers exists, the estimates for the full sample might be biased due to measurement errors.

Table 4 present the results for increasing the share of certified math and English teachers in compulsory schools with 7th–9th-grade students only[9]. Column (1) – (5) shows the impact of increasing the share of certified English teachers on English test scores and column (6) – (10) shows the results for math. The results in table 4 yield almost identical estimates of the impact of certified teachers, as in table 2. The difference is the significance level of the teacher certification estimates for math which decreased to a 10 per cent significance level in columns (9) and (10). However, the magnitude of the effect remains the same and suggest that increasing the share of certified teachers by 10 percentage points increases the average test score in math by 0.03 standard deviations. These results indicate that there is not any bias overestimating the impact of certified teachers on test scores for math. Thus, the assumption that the average quality should be the same for 9th grade as the rest of the school is reliable.

[9] See appendix C for table with all estimates

Table 4: *Sensitivity analysis, impact of certified teachers on test score, 7th-9th grade school sample*

	(1) English	(2) English	(3) English	(4) English	(5) English	(6) Math	(7) Math	(8) Math	(9) Math	(10) Math
Certified teachers in the subject	0.012***	0.001	0.002	0.001	0.001	0.022***	0.011***	0.015***	0.006*	0.006*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Intercept	13.884***	4.695***	14.565***	14.600***	8.857***	9.271***	0.187	9.779***	10.206***	2.315
	(0.140)	(0.585)	(0.081)	(0.081)	(0.712)	(0.245)	(0.955)	(0.253)	(0.229)	(1.495)
Obs.	1256	1256	1256	1256	1256	1023	1023	1023	1023	1023
R-squared	0.048	0.591	0.002	0.017	0.114	0.072	0.379	0.039	0.354	0.398
Control variables	NO	YES	NO	NO	YES	NO	YES	NO	NO	YES
Year fixed effects	NO	NO	NO	YES	YES	NO	NO	NO	YES	YES
School fixed effects	NO	NO	YES	YES	YES	NO	NO	YES	YES	YES

Note: Clustered standard errors are in parenthesis (cluster=school). Columns (1) – (5) show the result for estimating the impact of certified English teachers on test scores in English. Columns (6) – (10) show results for estimating the share of certified math teachers on test scores in math
**** p<0.01, ** p<0.05, * p<0.1*

7.2.3 Including both variables for Certified teachers

As mentioned in section 5.2, there are possible sources of endogeneity when estimating the specified model. The estimates of the fixed-effect approach are dependent on the strict exogeneity assumption. In order for it to hold, the share of certified teachers must be uncorrelated with the error term at all *t*. Violation of the assumption occurs when unobserved time-varying variables correlate with the share of certified teachers. A test for this could be to include both teacher certification variables. Therefore, by including the share of certified English teachers as a control variable when estimating the impact of certified math teachers on test scores in math, I would control for if the time-varying variable, certified English teachers, is correlated with certified math teachers. Table 5 shows the result of such test where column (1) outlines the result for when estimating the impact of certified math teachers on test scores in math while controlling for the share of certified English teachers. Column (2) includes the share of certified math teachers when estimating the effect of certified English teachers on English test scores.

The results in column (1) confirm robust estimates of the coefficient for certified math teachers since the magnitude of increasing the share of certified math teachers by 10 percentage points is still associated with increasing the test score by 0.03 standard deviation at a one per cent significance level. The control variable (the share of certified English teachers) is both smaller in magnitude, positive, and insignificant. Hence, the share of certified math teachers is not driven by the share of certified English teachers.

Column (2) shows the result for estimating the impact of certified English teachers on test score in English when controlling for the share of certified math teachers. The impact of certified English teachers on test scores in English is still negative and insignificant. However, the coefficient for certified math teachers is both larger in magnitude and significant at a 10 per cent level. Thus, time-varying unobserved effects drive the English test results, which violates the strict exogeneity assumption. Hence, the regression models for estimating the share of certified English teachers on student achievement suffers from endogeneity bias.

Table 5: *Regression results controlling for certified teachers in the other subject*

	(1) Math	(2) English
Percentage of certified math teachers	0.006***	0.002*
	(0.002)	(0.001)
Percentage of certified English teachers	0.001	-0.001
	(0.002)	(0.001)
Constant	1.754**	9.098***
	(0.758)	(0.417)
Obs.	3916	4758
R-squared	0.312	0.105
Control Variables	YES	YES
Year fixed effects	YES	YES
School fixed effects	YES	YES

Note: Clustered standard errors are in parenthesis (cluster=school).
**** p<0.01, ** p<0.05, * p<0.1*

8. Discussion

Does the share of certified teacher improve student achievement? The results of this paper find some support that certified teachers matter for student achievement. There is a small positive effect of certified math teachers on test scores in math, but for English, the results are not statistically significant.

The effect of increasing the share of certified math teacher has a positive and significant impact on the average student test scores in math, which is in line with previous research. Anderson et al. (2011) mainly focused on the impact of non-certified teachers on student achievement measured as GPA and estimated both a fixed-effect approach and an IV-approach. When estimating the fixed-effect model of non-certified teachers on students GPA, they found no statistically significant relationships when including control variables, year, and school fixed effects. Nevertheless, their estimates from the IV-method yield statistically significant estimates suggesting that increasing the share of non-certified teachers would decrease the GPA by 1.8 standard deviations. Contrary to their results from the fixed-effect model, I find statistically significant effects of certified math teachers on students test scores in math.

Moreover, they also tested the effect of non-certified teachers the standardised test scores in the core subjects and found negative relationships. Comparing the magnitude of the estimates of their result to the results of this paper is not accurate for two reasons. First, they estimated the effect of non-certified teachers on student achievement, and they did this on student-level. In contrast, I estimate the impact of certified teachers on student achievement on school-level. Second, they do not have information on the subject teachers hold certification, whereas, in this paper, the share of certified teachers is defined for each subject. The data available today is preferred since it allows to distinguish between the different subjects.

My results failed to reject the null hypothesis that certified English teachers does not improve student test results in English. Thus, the results I receive in English compared to math are more uncertain and not possible to interpret. The statistically insignificant results of certified English teachers on test scores in English are in line with previous research. While most studies find strong and robust results for math, the effect of certified teachers on other variables for student achievement such as test scores in English, science, and reading scores are inconclusive (Wayne & Youngs, 2003). Goldhaber and Brewer (1997) conducted two different models in a study where the first one includes a variable of teacher certification, without specification in which subject. The results suggested that teacher certification negatively impacts student achievement in English. In the second model, when specifying the subject teachers held certification, the result of English became inconsistent. For math, the impact of certified teachers showed positive and significant effects on student achievement in both models, where the effect was more substantial in the second approach. This highlight the importance of how teacher certification is defined and provides some explanation on why studies conclude differently on the impact of teacher certification.

When estimating the robustness test, surprising outcomes from the estimations is the difference in the result when using the average final grade score as the dependent variable instead of the average test scores in the subjects. The effect of certified teachers on student achievement did not differ much for English, but for math, it both turned negative and insignificant. The negative sign of the estimate suggests that increasing the share of certified math teachers will decrease the average final grade in math. Although the estimates were statistically insignificant, it is interesting to analyse the outcome since non-certified teachers can teach classes, but a certified teacher must decide the final grade. If the teachers cannot decide on the grade, the certified teacher's opinion will determine given that the certified teacher is authorised to teach the concerned subject.

Moreover, the standardised test scores are essential guidelines when deciding on final grades. Nonetheless, it should not be the sole determinant of the grade, but it provides valuable information about the student's knowledge and achievement level (Skolverket, 2020c). Looking at table 1, the mean value for the average final grades are overall higher than the average test scores in math, which figure B2 in Appendix B also illustrates. If students are rewarded a higher grade compared to actual student knowledge and achievement, then grade inflation explains the pattern. In Sweden, the level of grades has increased, whereas student's knowledge decreased due to grade inflation. School competition can explain grade inflation since attracting students is essential as competition increases. Using higher grades as a tool to attract students could be likely, especially when financing of a school is linked to the number of students attending the school (Vlachos, 2010). Using the test scores from the standardised test in math and English are better measurer for student achievement since the standardised test aim to measure how well the knowledge requirements are fulfilled (Skolverket, 2011).

Furthermore, the grades for the standardised tests can be interpreted as more objective measures for two reasons. First, the teachers do not conduct the test and can therefore not affect the content of the test and adapt the questions to subjects the class have focused on through the year. Second, the teachers do not correct the test for their students, hence, a more objective grading.

In summary, the results in this paper suggest that increasing the share of certified math teachers has a small positive impact on student achievement in math. The estimates of certified English teachers on student achievement in English did not yield any statistically significant estimates, leaving the impact of certified English teachers without interpretation. The estimations of certified teachers on final grades in math did not give significant results consistent results, leaving test scores in the standardised test as a more appropriate estimation of student achievement. Hence, this paper provides some support that teacher certification improves student achievement in math.

9. Conclusion

This thesis aims to examine the impact of teacher certification on student achievement in Swedish compulsory schools. The debate on whether stricter certification policies will improve student achievement is widely discussed. This paper contributes to previous studies in Sweden by using recent data, including information on the subjects teachers have certification.

I study how the share of certified math and English teachers affects the average student test results in Sweden. Using panel data from the Swedish National Agency for Education, 982 compulsory schools in 261 municipalities were included in the study. I applied a fixed-effect model to examine the effect of certified teachers on student achievement. Furthermore, I controlled for background characteristics, school-fixed effect and year-fixed effects to avoid biases caused by omitted variables and non-random sorting behaviour of teachers and students into schools.

In line with previous research, there is a positive and significant impact of increasing the share of certified math teachers on standardised test scores in math. I use several robustness tests to evaluate the sensitivity of the main model. The tests generate robust estimates of the impact of certified math teachers on the student test scores in math. However, when observing the impact of certified teachers on the final grade, evidence was for neither math nor English. This could be due to grade inflation, which means that students receive higher grades than those corresponding to their actual knowledge and achievement. Even if it is outside the scope of this study, grade inflation is interesting to evaluate since the latest reforms in Sweden changed the policies on non-certified teachers' authorisation to grade students.

For English, the results fail to reject the hypothesis since no evidence was found on the impact of certified English teachers on student achievement. Moreover, previous studies found either a small significant impact of teacher certification on student achievement or no statistically significant estimates for student achievement in English. Either way, the only robust impact of teacher certification is on math, thus, the subject requires further research. Since math and English challenges different cognitive skills other, still unobserved factors, might be relevant characteristics for English teachers. Hence, a suggestion for further research on the subject in Sweden is to evaluate the effect of certified teachers on the different parts of the standardised test to account for variables that are crucial for student achievement in English. Such an evaluation would, however, require studying student achievement on the individual level and not on an aggregated level.

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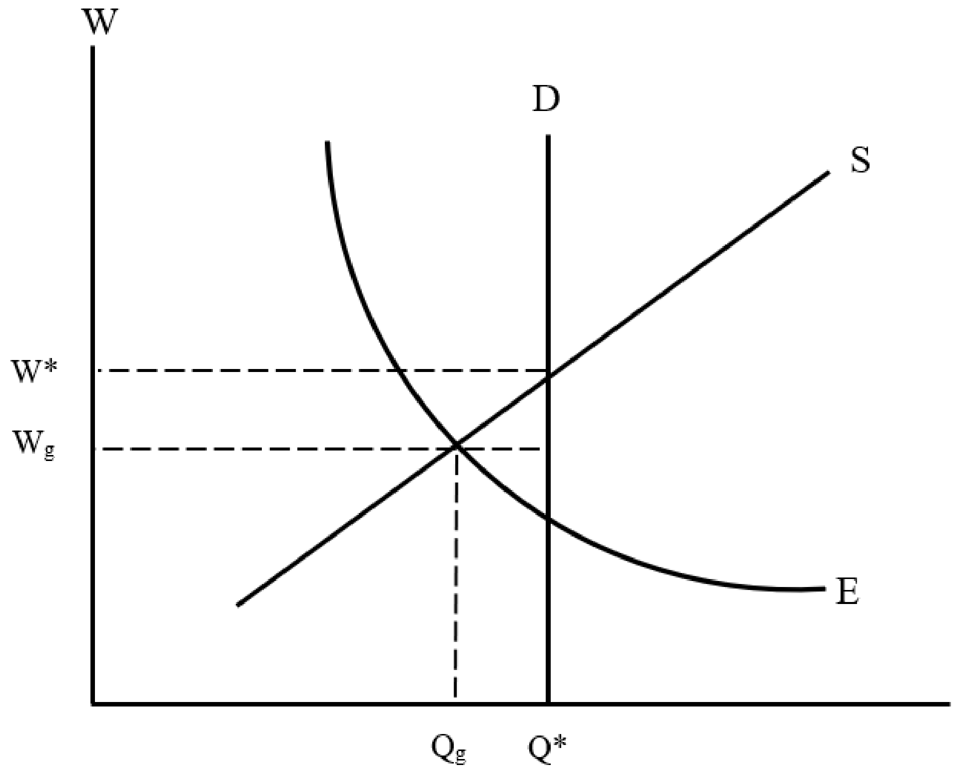
Appendix

Appendix A – Illustration of equilibrium

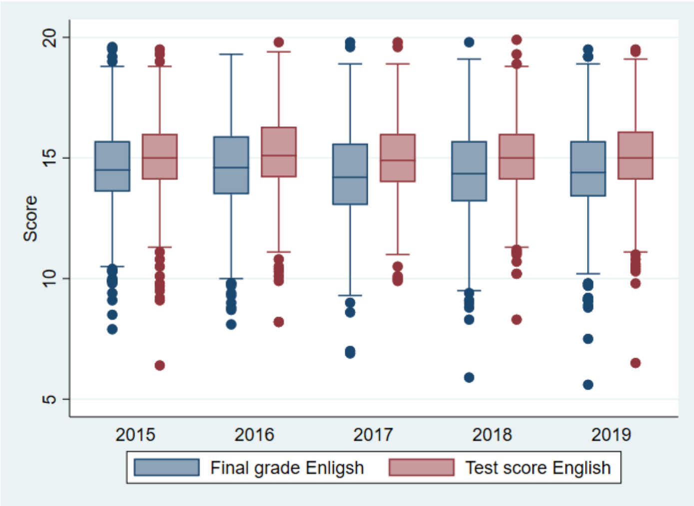
Figure A1: Equilibrium in a simple supply and demand model of the teacher labour market



Note: Q* and W* denotes the number of teachers and the teacher wage in equilibrium, respectively. With the budget constraint, E, present both Q and W become lower. The new levels of Q and W become W_g and Q_g. The difference between Q* and Q_g illustrates the teacher shortage. The government can interfere and affect demand and supply to overcome the teacher shortage.

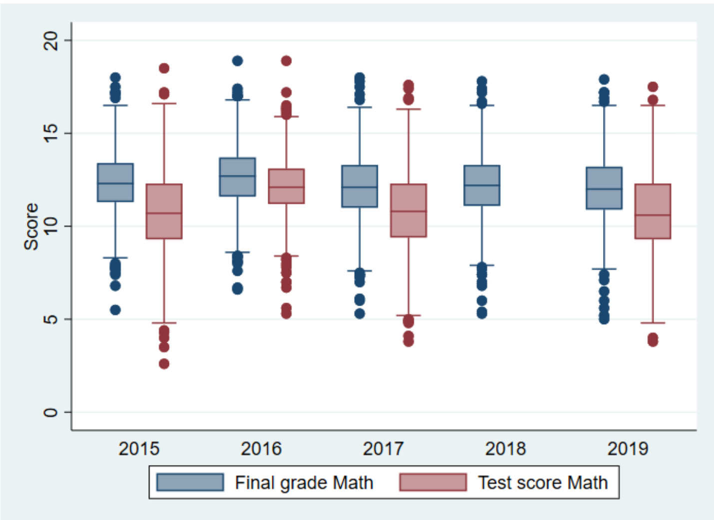
Appendix B – Summary statistics

Figure B1: *Distribution of test scores and final grade, English*



Note: B1 illustrates the distribution of the average final grades and the average test score over the period in English. The average final grade seems to be lower than the average test scores for all years.

Figure B2*: Distribution of test scores and final grade, Math*

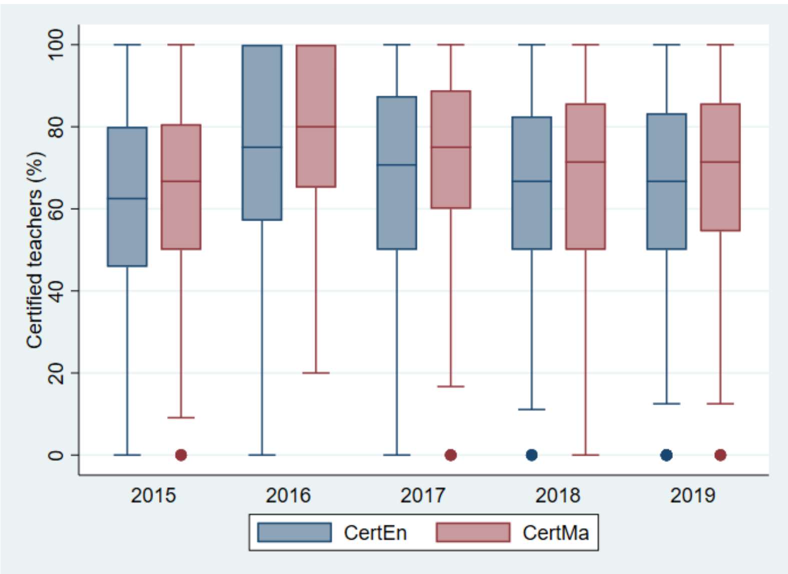


Note: B2 illustrates the distribution of the average final grades and the average test score over the period in English. The average final grade seems to be lower than the average test scores for all years.

__Table B1:__ summary statistics for the restricted sample: schools teaching 7th – 9th-grade only

VARIABLES	(1) Mean	(2) SD	(3) Min.	(4) Max.	(5) OBS.
Dependent variables					
Average test score, English	14.67	1.243	6.500	18.40	1,256
Average test score, math	10.83	1.775	4	15.90	1,023
Independent variables					
Share of certified English teachers	67.06	23.49	0	100	1,280
Share of certified math teachers	71.11	21.84	0	100	1,280
Control variables					
Average share of parents' education	2.245	0.192	1.320	2.860	1,280
Average share of newly immigrated	6.494	6.122	0	47	1,280
Average share of girls	47.59	6.794	24	78	1,280
Average share of STR (school level)	11.76	1.659	7.100	19	1,280
Number of schools	256	256	256	256	256

__Figure B3:__ Distribution of average share of certified teachers between 205-2019 for schools teaching 7th – 9th grade only.



Note: B3 illustrates the distribution of certified math and English teachers in schools teaching 7th – 9th grade over the period. The median shares of certified math teachers are higher than the median shares of certified English teachers for all years during the period. The

Appendix C – Regression Tables

Table C1: Regression results estimated effect of teacher certification on test score

	(1) English	(2) English	(3) English	(4) English	(5) English	(6) Math	(7) Math	(8) Math	(9) Math	(10) Math
Certified teachers in the subject	0.006***	-0.001	0.000	-0.000	-0.001	0.025***	0.011***	0.014***	0.007***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Newly immigrated		-0.031***			-0.025***		-0.032***			-0.024***
		(0.003)			(0.003)		(0.006)			(0.006)
Parents' education		4.361***			2.488***		5.323***			3.836***
		(0.120)			(0.163)		(0.182)			(0.313)
STR		0.084***			0.030***		0.022			-0.013
		(0.010)			(0.011)		(0.015)			(0.019)
Share of girls		0.006***			0.001		0.006			0.004
		(0.002)			(0.002)		(0.004)			(0.003)
Constant	14.673***	4.075***	15.061***	15.061***	9.165***	9.317***	-2.188***	10.113***	10.334***	1.767**
	(0.102)	(0.281)	(0.046)	(0.046)	(0.417)	(0.159)	(0.441)	(0.128)	(0.121)	(0.756)
Obs.	4758	4758	4758	4758	4758	3916	3916	3916	3916	3916
R-squared	0.010	0.630	0.000	0.010	0.104	0.054	0.451	0.023	0.256	0.312
Year fixed effects	NO	NO	NO	YES	YES	NO	NO	NO	YES	YES
School fixed effects	NO	NO	YES	YES	YES	NO	NO	YES	YES	YES

Note: Clustered standard errors are in parenthesis (cluster=school). Column (1) – (5) estimates the impact of certified English teachers on English test scores. Column (6) – (10) estimates the impact of certified math teachers on test result in math.
**** p<0.01, ** p<0.05, * p<0.1*

Table C2: Results, impact of teacher certification on final grade

	(1) English	(2) English	(3) English	(4) Math	(5) Math	(6) Math
Certified teachers	-0.000	-0.000	-0.001	0.001	0.001	-0.000
In the subject	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Newly immigrated			-0.070***			-0.039***
			(0.004)			(0.004)
Parents' education			2.589***			3.123***
			(0.174)			(0.200)
STR			0.014			-0.018
			(0.012)			(0.013)
Share of girls			0.005***			0.008***
			(0.002)			(0.002)
Constant	14.505***	14.582***	8.651***	12.179***	12.283***	5.275***
	(0.050)	(0.051)	(0.444)	(0.075)	(0.074)	(0.498)
Obs.	4910	4910	4910	4910	4910	4910
R-squared	0.000	0.029	0.211	0.001	0.077	0.186
Year fixed effects	NO	YES	YES	NO	YES	YES
School fixed effects	YES	YES	YES	YES	YES	YES

Note: Clustered standard errors are in parenthesis (cluster=school). Columns (1) – (3) estimates the impact of certified English teachers on final grades in English. Columns (4) – (6) shows results for estimating the share of certified math teachers on final grades in math.
**** p<0.01, ** p<0.05, * p<0.1*

Table C3: Regression results, impact of certified teachers on test score, 7th-9th grade school sample

	(1) English	(2) English	(3) English	(4) English	(5) English	(6) Math	(7) Math	(8) Math	(9) Math	(10) Math
Certified teachers in the subject	0.012***	0.001	0.002	0.001	0.001	0.022***	0.011***	0.015***	0.006*	0.006*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Newly immigrated		-0.030***			-0.022***		-0.041***			-0.023**
		(0.006)			(0.007)		(0.010)			(0.011)
Parents' education		4.260***			2.752***		4.435***			3.480***
		(0.247)			(0.279)		(0.370)			(0.615)
STR		0.043*			-0.028		0.022			-0.020
		(0.022)			(0.024)		(0.036)			(0.038)
Share of girls		0.000			0.002		-0.003			0.011*
		(0.004)			(0.004)		(0.007)			(0.006)
Constant	13.884***	4.695***	14.565***	14.600***	8.857***	9.271***	0.187	9.779***	10.206***	2.315
	(0.140)	(0.585)	(0.081)	(0.081)	(0.712)	(0.245)	(0.955)	(0.253)	(0.229)	(1.495)
Obs.	1256	1256	1256	1256	1256	1023	1023	1023	1023	1023
R-squared	0.048	0.591	0.002	0.017	0.114	0.072	0.379	0.039	0.354	0.398
Year fixed effects	NO	NO	NO	YES	YES	NO	NO	NO	YES	YES
School fixed effects	NO	NO	YES	YES	YES	NO	NO	YES	YES	YES

Note: Clustered standard errors are in parenthesis (cluster=school). Columns (1) – (5) show the result for estimating the impact of certified English teachers on test scores in English. Columns (6) – (10) show results for estimating the share of certified math teachers on test scores in math
**** p<0.01, ** p<0.05, * p<0.1*