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DOI: http://dx.doi.org/10.5617/adno.7946

Teacher Competence and Equity in the Nordic Countries. Mediation and moderation of the relation between SES and achievement

Abstract

The Nordic countries are known to have small differences between schools, and educational policies that promote equity. However, there are indications that in many Nordic countries, the influence of students' socio-economic status (SES) on achievement, has increased over the last decades. To promote equity, there is need to identify factors that may reduce this strong relation.

Teacher competence (TC) is the foundation of instruction and learning, and studies from the US and Germany have shown that competent teachers may reduce the strong influence of students' home background on achievement. However, few studies have investigated the relation between TC and equity in Nordic countries. This study investigates whether TC may mediate and/or moderate the relation between SES and achievement in these countries.

Analyses of TIMSS grade 8 data from Norway, Sweden and Finland (N = 13 345 students) were conducted using multi-group, multi-level mediation and moderation structural equation models.

Results across the three Nordic countries show that only in Norway were some aspects of TC (specialization in mathematics, and self-efficacy in mathematical pedagogical content knowledge and mathematical content knowledge) associated with higher levels of equity. In all three countries, there were indications of unequal distributions of competent teachers to high-SES schools. These findings could have implications for educational policy and are discussed in light of the context and previous research in each country.

Keywords: teacher competence, mathematics achievement, equity, TIMSS, moderation models, mediation models

Lærerkompetanse og likeverd i Norden. Mediering og moderering av sammenhengen mellom SES og faglige prestasjoner

Sammendrag

De nordiske landene er kjent for å ha små forskjeller mellom skoler og en utdanningspolitikk som promoterer likeverd. Likevel, forskning indikerer at betydningen av elevens hjemmebakgrunn eller sosio-økonomiske status (SES) for deres faglige prestasjoner, har økt de siste tiår i mange Nordiske land. For å kunne motvirke en slik utvikling, er det behov for å identifisere faktorer som kan redusere den sterke relasjonen mellom SES og faglige prestasjoner.

Lærerkompetanse danner grunnlaget for undervisning og læring, og forskning fra USA og Tyskland har vist at lærere med høy kompetanse kan redusere den sterke påvirkningen av elevers hjemmebakgrunn på deres faglige prestasjoner. Få studier har imidlertid undersøkt relasjonen mellom lærerkompetanse og likeverd i nordiske land. Denne studien undersøker om lærerkompetanse kan mediere og/eller moderere relasjonen mellom SES og prestasjoner i disse landene.

Analyser av TIMSS data fra Norge, Sverige og Finland (N = 13 345 elever) på åttende trinn ble utført med fler-gruppe, fler-nivå strukturelle ligningsmodellering med mediering- og modereringsmodeller.

Resultatene for de tre nordiske landene viste at aspekter av lærerkompetanse (spesialisering i matematikk og selvtillit i matematikkdidaktikk og matematikk) var assosiert med høyere likeverd kun i Norge. I alle tre land var det indikasjoner på en forfordeling av høy lærerkompetanse til skoler med høy SES. Disse funnene kan ha implikasjoner for utdanningspolitikk, og diskuteres i lys av konteksten samt tidligere forskning innen hvert land.

Nøkkelord: lærerkompetanse, matematikkprestasjoner, likeverd, TIMSS, modereringsmodeller, medieringsmodeller

Introduction

The Nordic countries are characterised by small differences among schools, and educational policies that promote equity (Hansen et al., 2014; OECD, 2016). However, the differences between schools in terms of achievement seem to be increasing in many Nordic countries, and the effect of socio-economic status (SES) on educational achievement seems to be growing (Gustafsson & Hansen, 2018; Hansson & Gustafsson, 2017; OECD, 2016; Nilsen, Björnsson and Olsen, 2018).

Although the relation between SES and educational achievement is weaker in the Nordic countries than in many other countries, it is nevertheless one of the strongest predictors of educational achievement (Hansen & Munk, 2012; Martin, Foy, Mullis, & O'Dwyer, 2013; Sirin, 2005). However, little is known about the mechanisms through which SES is related to educational achievement. These

mechanisms have received little attention in previous research, rather, SES has been used to control for selection bias (White, 1982; Gustafsson, Nilsen, & Hansen, 2018). If Nordic educational policies are aimed at reducing the effects of SES on educational achievement, school factors that reduce this relation, and that are within the control of educational stakeholders, need to be identified.

Based on several studies that found a relation between equity and teacher competence (i.e. the combination of teacher qualifications and teacher characteristics such as their self-efficacy), Wößmann (2008) concluded that teacher competence may have a positive effect on reducing inequity in education. Indeed, there is general agreement that teachers matter more than any other school factor and that teacher competence (TC) is the foundation of high-quality schools, learning and instruction (e.g. Baumert et al., 2010; Blömeke, Olsen, & Suhl, 2016). TC usually refers to teachers' qualifications (e.g. educational level and specialisation, mathematical content knowledge and pedagogical content knowledge) as well as characteristics (e.g. beliefs and self-efficacy) (Blömeke & Delaney, 2014; Goe, 2007; Kunter et al., 2013; Seidel & Shavelson, 2007; Wayne & Youngs, 2003). Many studies have found an indirect relation between TC and learning outcomes through instructional quality (e.g. Baumert et al., 2010). Some studies also indicate that TC and instructional quality may affect equity (e.g. Akiba, LeTendre, & Scribner, 2007; Darling-Hammond, 2006; Rjosk et al., 2014; Berkowitz, Moore, Astor, & Benbenishty, 2017). These studies either sought to determine whether TC exerted an *additive effect* by mediating the relation between SES and achievement (e.g. Darling-Hammond, 2006) or whether there was an *interactive effect* of TC (i.e. whether TC moderated the relation between SES and achievement) (Baumert et al., 2010; Hanushek & Rivkin, 2006).

Moderating and mediating mechanisms may operate simultaneously; consequently, they may sometimes reinforce or counteract one another (Gustafsson, Nilsen, & Hansen, 2018)). These mechanisms are complex, and few studies have investigated them. Most studies on equity and teacher competence have been conducted in the US and Germany (e.g. Baumert et al., 2010; Darling-Hammond, 2006). Few such studies have been conducted in the Nordic countries, and fewer still have utilised international large-scale assessments with representative samples. Therefore, it is important to investigate these matters also in the Nordic countries.

Thus, the overarching aim of the present study is to address this research gap by investigating the relations between TC and equity in the Nordic countries using data collected from the international large-scale assessment, the Trends in Mathematics and Science Study (TIMSS). More specifically, we investigate whether the relation between SES and mathematics achievement is strengthened or weakened (i.e. moderated) or mediated by TC.

Identifying how TC is related to equity is important in extending our knowledge about how to improve equity in Nordic countries.

Theoretical background

This discussion of theory is divided into three sub-sections. First, previous research and conceptualisations of equity are reviewed, with a focus on SES and its relation to educational achievement in the Nordic countries. In the second sub-section, previous research and the conceptualisation of TC and instructional quality are discussed. The third sub-section reviews previous research on the relations between equity, TC and instructional quality.

Equity

SES is one of the most powerful predictors of student learning outcomes. Previous findings reveal that the correlation between students' academic achievement and family SES in most countries is around .20– .40 at the individual level, and often above .6 at the class or school level (Sirin, 2005; White, 1982).

To explain the differences in educational achievement, the best approach to assessing student SES is to use a relatively broad measure of home educational resources that captures several aspects, such as the number of books at home, parental level of education and amount of study support at home (Hansen & Munk, 2012).

In the Nordic countries, the gap between high- and low-performing students has been observed to be lower than in many other countries (OECD, 2016). Measuring equity in terms of the dispersion of student achievement (e.g. using the standard deviations of achievement) or the amount of school differences in achievement, may reflect a form of egalitarian educational policy in which large differences in student achievement are considered unfortunate (Strietholt, 2016). Another type of measure of equity is the strength of the relation between SES (or other student characteristics) and achievement. This measure of equity reflects policies that accept differences between students as long as they are not caused by differences in home background, gender, ethnicity, or other student characteristics (Strietholt, 2016). This is the type of measure of equity used in the present study.

The strength of the relationship between SES and achievement seems to have grown stronger in many of the Nordic countries (e.g. OECD, 2016; Nilsen, Björnsson and Olsen, 2018). In the Programme for International Student Assessment (PISA), for instance, the score-point difference in science achievement associated with a one-unit increase in SES increased with 10 points in Finland from 2006 to 2015 (OECD, 2016). In the same period, it increased by 8 points in Sweden and by 1 point in Norway (the latter was not significant). Another study found that the relation between SES and mathematics achievement at the school level grew stronger in Norway between 1995 and 2015 for grade 8 (Nilsen, Björnsson and Olsen, 2018).

Teacher competence and instructional quality

Meta-analyses and other studies have divided teacher competence into teacher qualifications (e.g. educational level, specialisation and professional development) and teacher characteristics (e.g. beliefs, self-efficacy) (Blömeke et al., 2016; Goe, 2007; Kuger, Klieme, Jude, & Kaplan, 2016; Seidel & Shavelson, 2007).

Teachers' degrees and major academic disciplines (their specialisation) are indicators of their education, which have been found to affect teacher knowledge and skills (Ball, Thames, & Phelps, 2008; Blömeke & Delaney, 2014; Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009). These qualifications influence instructional quality and student learning outcomes (e.g. Baumert et al., 2010; Blömeke et al., 2016). Teacher experience may also be considered part of teacher qualifications, and has been found to influence student learning outcomes (Goe, 2007; Harris & Sass, 2011).

Previous studies, including meta-analyses, reveal that professional development is positively related to instructional quality and student learning outcomes if the activities meet certain characteristics of quality (Boyle, Lamprianou, & Boyle, 2005; Timperley, Wilson, Barrar, & Fung, 2007; Nilsen & Gustafsson, 2016).

In addition to teacher qualifications, teacher characteristics also form an important part of teacher competence (Goe, 2007). One of the most powerful predictors of student outcomes is the self-efficacy of mathematics teachers (e.g. Tschannen-Moran & Barr, 2004). According to Bandura (Bandura, 1997, p. 382), "Perceived self-efficacy refers to belief in one's agentive capabilities; that one can produce given levels of attainment". Bandura further states that self-efficacy refers to the strength of beliefs in *specific* capabilities. In the context of mathematics education, capabilities that are related to both mathematical content knowledge (MCK) and mathematical pedagogical content knowledge (MPCK) are vital for student learning outcomes (Baumert et al., 2010; Blömeke & Delaney, 2014). Hence, it is important that teachers have sufficient self-efficacy to teach algebra, geometry and other mathematics content. It is also important that they have sufficient self-efficacy in MPCK to, for instance, teach students problem-solving strategies and to engage students (e.g. Holzberger, Philipp, & Kunter, 2013).

Based on the above previous research, the present study uses the following indicators of teacher competence: teacher educational level, specialization, experience, professional development, self-efficacy in mathematical pedagogical content knowledge and in mathematical content knowledge.

Instructional quality

Teacher competence is rarely *directly* related to student outcome. Instead, it is related indirectly to student outcomes, through instruction (Baumert et al., 2010; Blömeke et al., 2016). Even though instructional quality is understood differently

within the research field, there is agreement that it includes several aspects that are associated with higher student learning outcome (Creemers & Kyriakides, 2008; Fauth, Decristan, Rieser, Klieme, & Büttner, 2014; Kane & Cantrell, 2012; Klieme, Pauli, & Reusser, 2009). These aspects are often labelled cognitive activation, teacher support and classroom management (Baumert et al., 2010)

Cognitive activation, which is regarded as subject-related, comprises in mathematics instructional activities in which students have to evaluate, integrate and apply knowledge in the context of problem solving (Baumert et al., 2010; Hiebert & Grouws, 2007; Klieme et al., 2009; Lipowsky et al., 2009). For instance, the teacher may ask students to work on problems for which there is no immediately obvious solution or may let students decide their own procedures for solving complex problems.

Teacher support reflects the support and clarity of instruction, and it often includes practices such as listening to and respecting students' ideas and questions, connecting new and old topics and providing a summary at the end of a lesson (e.g. Klieme et al., 2009).

Classroom management is also predictive of student outcomes (van Tartwijk & Hammerness, 2011), and is measured by items connected to efficient classroom and time management.

TC related to equity

Teacher factors can influence the relationship between SES and educational achievement in two ways (Gustafsson, Nilsen, & Hansen, 2018). First, teacher factors may mediate the relation between SES and achievement. This mechanism is referred to as an additive effect because the teacher factor may add to the already existing gap between low and high-SES students which is caused by their home background. For example, high-SES schools may have more qualified teachers than low-SES schools, and qualified teachers may cause higher levels of student achievement.

Such additive effects were identified, especially in the US where several studies showed the unequal distribution of competent teachers across schools (e.g. Darling-Hammond, 2006; Lankford, Loeb, & Wyckoff, 2002). Borman and Kimball (2005) explained such findings as follows: "Better teachers may be assigned, and seek out assignments, to classrooms with more advantaged, nonminority, and higher-achieving students".

Only a few studies have investigated the mechanisms through which SES is related to educational achievement in Nordic countries, perhaps because of the strong tradition of equity in educational policy. However, a study conducted in Norway revealed that certified teachers preferred schools with few minority students (Bonesrønning, Falch, & Strøm, 2005). Furthermore, there was a lack of certified teachers in schools with high proportions of minority students and students with special needs. The same pattern has been identified in Sweden (Hansson & Gustafsson, 2017).

Using data from PISA 2006, Willms (2010) examined the relationships among school SES, students' science literacy skills, and different school factors such as instructional quality in several participating countries. He found that the effect of school-SES on science achievement was mediated by instructional quality, it added to the effect of student home background. Furthermore, although the results varied across countries, students in high-SES schools were generally taught by teachers with higher instructional quality than students in low-SES schools.

Rjosk et al. (2014) investigated the mediation of SES via instructional quality in a longitudinal study conducted in Germany. The results indicated that cognitive activation mediated the effects of classroom-SES on achievement. This study also showed that students in high-SES schools were taught by teachers providing higher instructional quality than students in low-SES schools were.

The second way that school factors may influence the relationship between SES and achievement is by moderation. Specifically, teacher factors have differential effects on low- and high- SES students (e.g. Borman & Kimball, 2005; Gustafsson, Nilsen, & Hansen, 2018). For example, if teacher competence has a stronger positive effect on the achievement of low-SES students than on high-SES students, there will be a differential or interactive effect. In other words, teacher competence will then moderate the relation between SES and achievement.

Compared to mediation studies, fewer studies have examined the differential effects of teacher competence and instructional quality (Gustafsson, Nilsen, & Hansen, 2018). In a longitudinal extension of PISA in Germany, Baumert et al. (2010) investigated the effects of teacher competence. The results indicated that teachers' pedagogical content knowledge elicited higher learning gains in weak students than in high achieving students. In line with this finding, studies in the US found higher teacher effects on low-SES students than on high-SES students (e.g. Nye, Konstantopoulos, & Hedges, 2004). One interpretation of the interactive effect was that in schools lacking qualified teachers to compensate low-SES students for their lower competence, the outcomes were to a larger extent based on the students' family background (Wenglinsky, 1998; Gustafsson, Nilsen, & Hansen, 2018). However, in a recent longitudinal study of the association between teaching competence and student achievement among high- and low-SES students, findings were more diverse (Atlay, Tieben, Hillmert & Fauth, 2019). In this study, based on German PISA 2003/2004-data, classroom management was positively associated with student performance for both low and high-SES students. Cognitive activation and supportive climate, on the other hand, were found to positively moderate the association between socioeconomic background and achievement. Consequently, these aspects of teaching competence lead to larger achievement gaps between high and low SES students. One interpretation of these findings is that there might be a mismatch between the classroom culture and the home culture of students from low-SES families (Atlay et al. 2019).

Research questions

In lights of our review of previous research above, the present study seeks to investigate the relationship between TC and equity in the three Nordic countries, Norway, Sweden and Finland, by posing the following research questions:

RQ1: What is the moderation effect of TC on the relation between SES and student achievement in mathematics in lower secondary school?
RQ2: What is the mediation effect of TC and instructional quality on the relation between SES and student achievement in mathematics in lower secondary school?

Instructional quality is not needed in the first research question, as the focus is rather on the importance of TC for equity. Furthermore, including instructional quality in the moderation model would have made the model more complicated than necessary (moderated mediation analyses) and the results more difficult to disseminate. Instructional quality is, however, needed for the second research question, because TC rarely has a direct effect on achievement, but rather an indirect effect via instructional quality (e.g. Baumert et al., 2010).

Method

Data and sample

TIMSS is an international large-scale survey administered by Boston University under the International Association for the Evaluation of Educational Achievement (IEA). TIMSS measures students' competence in mathematics and science in grades four and eight using representative samples of students. TIMSS was first conducted in 1995, and it is repeated every four years.

TIMSS has a hierarchical design with students nested within classes and classes nested within schools (Martin & Mullis, 2012). Students in grade eight are tested in mathematics and science. In the present study, mathematics is in focus, and students were tested in four content domains (algebra, numbers, geometry and data) and three cognitive domains (knowing, applying and reasoning). In the achievement test, the mean was originally set at 500, with a standard deviation of 100. In addition to the test, students, teachers and school leaders answer questionnaires.

The aim of the present study is to investigate relations between TC and equity in lower secondary school. In TIMSS 2011, Norway, Sweden and Finland participated with students in grade 8, while in TIMSS 2015, only Norway and Sweden participated with grade 8 students. In order to gain a Nordic perspective, it is important to include all three countries. Hence, the data collected in the 2011 survey were chosen for the present study, as only Norway and Sweden

participated in 2015.This sample included Finnish (N = 4,194), Norwegian (N = 3,720), and Swedish (N = 5,242) eighth graders and their respective teachers.

The constructs

The teachers answered a questionnaire, and their answers are used to measure TC and instructional quality. In other words, TC was measured by the teachers' ratings of items pertaining to the following: *teachers' experience, educational level, specialisation, self-efficacy in mathematical content knowledge (MCK), self-efficacy in mathematical pedagogical content knowledge (MPCK)* and *professional development*. Instructional quality was also reported by teachers, and items measuring both supportive teacher and cognitive activation were included in the construct. All constructs are described in Appendix 1.

In a previous study (Nilsen & Gustafsson, 2016), the measurement invariance for these constructs in all countries participating in TIMSS 2011 was tested. The findings showed that the constructs were metric invariant. Hence, the relationships between these constructs and other variables (e.g. achievement) were comparable across the Nordic countries.

The scale for SES was created based on students' responses concerning number of books at home, number of home study resources and parents' education. TIMSS created this scale using IRT scaling, specifically the Rasch partial credit model (Martin & Mullis, 2012).

Method of analysis

Mplus 7.3 was used to specify two-level (students and teachers) mediation and moderation structural equation models (Muthén & Muthén, 1998-2014). A multiple-group approach was used to address the research questions. Confirmatory factor analysis (CFA) was employed to evaluate the reliability and validity of all the latent variables (i.e. professional development, self-efficacy in MCK and MPCK and instructional quality) prior to including any structure. If the factor loadings for one (or more) item in the construct is insignificant and too low (e.g. < 0.3), this means that the item measures something different, jeopardizing the construct validity. What our analyses do not capture though, is construct under-representation (i.e. there are too few items to cover the broadness of the construct). This may be the case for instructional quality, as this construct has too few items to investigate its different aspects (e.g. cognitive activation). Construct under-representation could produce results that may appear insignificant, but that may in fact be significant.

The chi square, root mean square error of approximation (RMSEA), comparative fit index (CFI) and the Tucker-Lewis index (TLI) were used to evaluate the fit of the models (Hox & Roberts, 2011). A multiple imputation procedure implemented in Mplus was employed to handle the five plausible values of achievement (Rutkowski, Gonzalez, Joncas, & von Davier, 2010). In the achievement test, the mean is 500, with a standard deviation of 100.

In building the models, the first step was to investigate the relation between SES and achievement (henceforth referred to as the reference model). Achievement was regressed on SES at the student and class levels simultaneously. The same model was also specified at the student and school levels. All other models were specified at the student and class levels.

The mediation models illustrated in Figure 1 were used to determine whether the relation between SES and achievement was mediated via teacher competence and instructional quality at the class level. We made a set of models, one for each aspect of TC (e.g. educational level), while instructional quality remained unchanged.

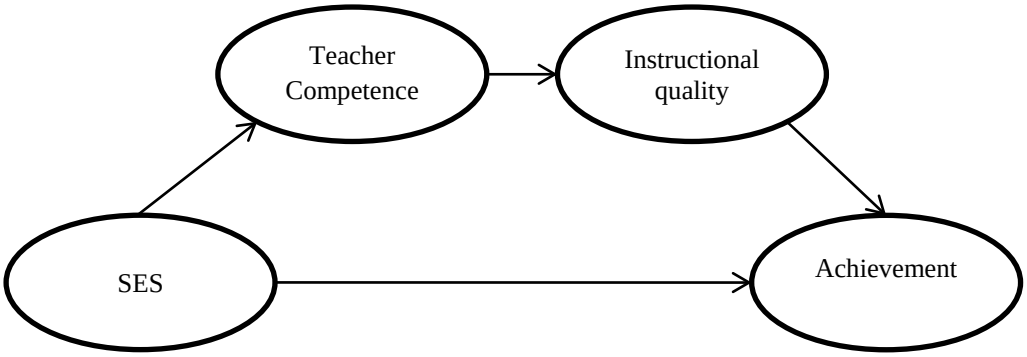

Figure 1 Mediation model at the class level

For the mediation models, SES was included also at the student level to control for individual students' SES.

The indirect effect of SES on achievement via teacher competence and instructional quality was tested statistically to determine its potential mediation. A positive indirect effect would mean that the relation between SES and achievement is mediated via TC and instructional quality. In other words, part of the effect of SES on achievement is accounted for by differences in TC and instructional quality between low- and high-SES classes. Thus, a higher class-SES is associated with higher teacher competence, which again is associated with higher instructional quality and in turn, higher achievement. In addition, the model assumes that there is a direct effect of class-SES on achievement.

The moderation model illustrated in Figure 2 was used to determine whether TC moderated the relation between SES and achievement. A random slope for the relation between SES and achievement was specified at the within level, which reflected the within-class variations in this relationship. This random slope was then regressed on TC (e.g. educational level) at the between level, which produced a moderation coefficient (β).

Here too, a set of models were made, one for each aspect of TC (e.g. educational level), while instructional quality remained unchanged. A positive and significant moderation coefficient would indicate a strengthening relation between SES and achievement with increasing TC (e.g. educational level), thus reflecting inequity. A negative moderation coefficient would weaken the relation

between SES and achievement, thus reflecting higher levels of equity with increasing teacher competence.

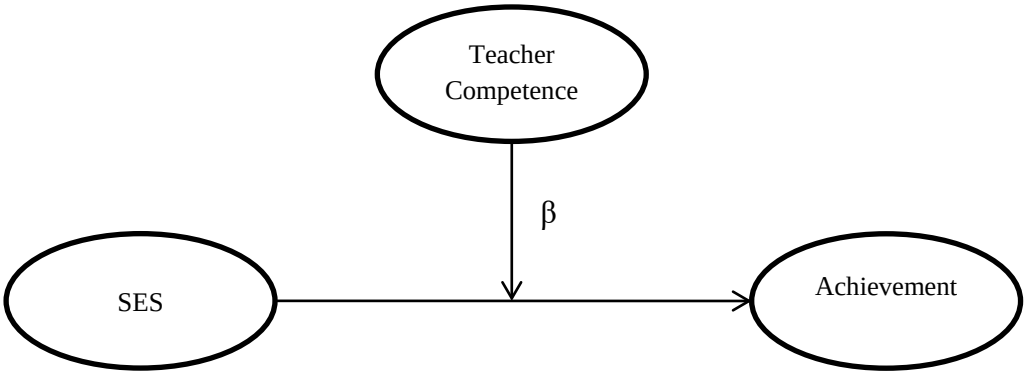

Figure 2. Moderation model at the class level. β is the moderation coefficient

As previously mentioned, the focus of this study is not on instructional quality, but rather on the importance of TC for equity. However, because TC is rarely directly related to achievement, instructional quality was included in the mediation models (RQ1) (e.g. Baumert et al., 2010). Instructional quality is not included in the moderation model as this would have made the model more complicated than necessary (moderated mediation would have to be investigated). This means that the two models are not directly comparable; rather the models provide two different perspectives of equity.

In all analyses, missing data were handled using the full-information maximum likelihood procedure under the assumption that they occurred at random, given the observed variables. Furthermore, we included the appropriate weights. Weights are created to account for the sampling design by adjusting unequal sampling probabilities. Large schools have more classes than small schools, hence students in small schools are more likely to have their class selected than students in large schools. The class weight accounts for this inequality in sampling probability. Hence, the mathematics class weight was included in the analyses (MATWGT) to account for the sampling design applied by TIMSS (for more information about this weight, see https://timssandpirls.bc.edu/publications/timss/2015-methods/chapter-3.html).

Results

In this section, the results of the reference models are presented, followed by the results of the mediation and moderation models. All results are reported at the class level and are presented in Appendix 2. The primary goal of this study was to investigate the relations between equity and TC, not between TC and achievement. Hence, the results concerning equity, i.e. relations between SES and TC as well as mediation and moderation effects, are emphasised. For descriptive

statistics of achievement, SES, and all other constructs see the international report by Mullis, Martin, Foy, & Arora, 2012.

The reliability and validity were high, as the factor loadings of all latent variables ranged between 0.71 and 0.86, and the model fit was for the most part good, and sometimes acceptable.

Reference model. According to the findings of the reference models reported in Appendix 2, in Finland, the relation (i.e. the unstandardised regression coefficient, B) between SES and achievement at the class level was 195.542 (standardised β = .699), meaning that for one unit increase in the SES variable, mathematics achievement increased with 195 score points. At the school level, this relation was significantly lower (B = 131.622, β = 0.593) and the difference between school and class-level was significant. This finding may have been caused by small differences between schools and large differences between classes (OECD, 2016).

In Norway, no significant difference was found between the regression coefficients at the class level (B = 137.622, β =.738) and school level (B = 138.134, β =.721). In Sweden, the regression coefficient at the class level was 182.462 (β =.825) and at the school level 154.702 (β=.870). In Sweden, the difference between the regression coefficients at the class level and school level was just barely significant. In Finland, however, this difference was significant.

The comparison of the standardised estimates derived from the multi-group approach across the three countries, revealed that Sweden had the strongest relationship and Finland had the weakest relationship between SES and achievement on both levels.

Finland. The results of the reference model, especially the large difference between the class and school levels in Finland, may shed light on the findings concerning equity. The results presented in Appendix 2 showed that in Finland, specialisation in mathematics (as one indicator of TC) moderated the relation between SES and achievement (B = 16.893, p <.05). The moderation coefficient was positive, which means that specialisation in mathematics was associated with a stronger relationship between SES and achievement. This result indicates that SES is of greater significance in classes where teachers are specialised in mathematics. Interpretation and discussions of these and other findings will be found in the next section.

Moreover, specialisation in mathematics and instructional quality partly mediated the relation between SES and achievement. The indirect effect and the difference between the total effect and the relation between SES and achievement in the reference model were both positive and significant. In other words, high-SES classes were associated with competent teachers and high instructional quality, which was associated with high student achievement. This result indicates that specialisation in mathematics and high instructional quality added to the strength of the relation between SES and achievement. Hence, the results indicate that the relation between class SES and achievement is the sum of two parts;

student home background and TC (and instructional quality). These results may indicate that the gap between high- and low-SES students increased because of TC. In this respect, the results of the mediation model may shed light on the results of the moderation models, which showed that TC strengthened the relation between SES and achievement. This result could have been affected by the unequal distribution of competent teachers in high- and low-SES classes.

Together the results of the mediation and moderation models strongly indicate that specialisation in mathematics is associated with larger gaps between high-SES and low-SES student achievement (inequity) in Finland. In contrast, specialisation in mathematics education neither mediated nor moderated the relation between SES and achievement although it was positively correlated with SES.

Self-efficacy in mathematical content knowledge (MCK) in all four domains (number, algebra, geometry and data) both mediated and moderated the relation between SES and achievement. All moderation coefficients were positive, thus reflecting inequity. Similarly, the results of the mediation models showed that self-efficacy in MCK was associated with a significant increase in the strength of the relationship between SES and achievement, which is another indication of inequity.

Norway. In Norway, teachers' educational level moderated the relation between SES and achievement ($B = 8.166$, $p < .05$). This result indicates that SES matters more to achievement in classes where teachers have high levels of education, than in classes with teacher with lower educational levels. Although the mediation effect was not significant, SES was positively related to teachers' educational level. This indicates that teachers with a high level of education teach high-SES classes. Hence, in Norway, teacher's educational level is associated with inequity.

In contrast, the results showed that specialisation in mathematics education and self-efficacy in CK (numbers and algebra) moderated the relation between SES and achievement. The moderation coefficients were negative, indicating that these teacher variables reduce the strength of the relation between SES and achievement, thus reflecting equity.

Sweden. In Sweden, specialisation in mathematics education moderated the relation between SES and achievement ($B = 6.615$, $p < .05$). The positive moderation coefficient indicates that specialisation in mathematics education strengthens the relation between SES and achievement. Hence, in Sweden, specialisation in mathematics education is associated with inequity.

Although the mediation effect of SES on achievement through professional development and instructional quality did not quite reach significance in Sweden, the regression coefficients of these variables were positive and significant. In other words, high-SES classes were associated with high instructional quality and teachers who participated in professional development, which again was associated with high student achievement. This finding suggests that teachers who

participate in professional development teach high-SES classes, thus reflecting inequity.

Table 1 provides an overview of the results shown in Appendix 2, but includes only the findings related to equity or inequity. In other words, only significant findings on moderation or mediation, as well as relations between the aspect TC and SES are included as these are indications of equity or inequity. Pink cells indicate inequity (positive moderation or mediation effects) while blue cells indicate equity (negative moderation or mediation effects). For example, for "Specialisation-math education", this is related to SES in Finland, but there were no significant mediation or moderation effects. Hence, this cell is not pink, as there is not sufficient evidence of inequity. In Norway, on the other hand, "Specialisation-math education" had a negative moderation effect on the relation between SES and achievement (i.e. reducing the effect of SES), thus indicating equity (blue cell). In contrast, there was a positive moderation effect in Sweden, indicating inequity (pink cell).

Table 1 Overview of findings indicating inequity (in pink) and equity (in blue)

	Finland	Norway	Sweden
Experience	Not significant	Not significant	Not significant
Educational level	Not significant	Related to SES, Positive Moderation	Not significant
Specialisation-math	Related to SES, Positive moderation and mediation	Related to SES	Not significant
Specialisation-math education	Related to SES	Negative moderation	Positive moderation
Self-efficacy PCK	Not significant	Related to SES	Not significant
Self-efficacy, CK-numbers	Mediation, Positive moderation and mediation	Negative moderation	Positive moderation
Self-efficacy, CK-algebra	Mediation, Positive moderation and mediation	Negative moderation	Not significant
Self-efficacy, CK-geometry	Mediation, Positive moderation and mediation	Not significant	Positive moderation
Self-efficacy, CK-data	Mediation, Positive moderation and mediation	Not significant	Not significant
Prof. development	Not significant	Not significant	Related to SES

The comparison of the results across the three countries shows that only in Norway were aspects of TC associated with higher levels of equity. In Finland, TC was demonstrated to have a stronger association with inequity than in the other two countries. These findings are discussed in the following section.

Discussion

The findings indicate that TC matters, not just in relation to learning outcomes, but also to equity. However, not all aspects of TC were related to equity, and the results varied across countries.

In Finland, the results of the mediation and moderation models were aligned, as both mediation and moderation effects pointed to inequity. For instance, self-efficacy in CK both moderated and mediated the relation between SES and achievement. Both the interactive effects and the additive effects were positive, indicating that TC was associated with a stronger relationship between SES and achievement. Since the data are cross-sectional, no causal inference may be drawn and positive moderation effects may be explained in terms of an unequal distribution of competent teachers in high- and low-SES schools (Wenglinsky, 1998; Gustafsson, Nilsen, & Hansen, 2018). It may also be explained in light of recent findings that high-SES students, as compared with low-SES students, seem to profit on certain aspects of instructional quality, i.e. cognitive achievement and supportive climate (Atlay et al. 2019).

In the current study, the Finnish results from the mediation models reveal an unequal distribution of competent teachers between low- and high-SES classes. This finding is supported by the results of the reference model, which shows that the relation between SES and achievement is stronger at the class level than at the school level. However, it is beyond the scope of the present study to provide an answer to why there is a skewed distribution of competent teachers in Finland. Nevertheless, previous research revealed a hidden tracking in which students attend either low- or high-ability classes (Kallio, Kauppinen, & Erola, 2016; OECD, 2016). On the other hand, Finland is still one of the most equitable and highest performing countries in the world and various studies have attributed this to a high degree of inclusion and competent teachers (Halinen & Järvinen, 2008; Mullis et al., 2012). Whether signs of decreasing performance and decreasing equity in Finland (OECD, 2016) may partly be explained by hidden tracking and unequal distribution of competent teachers requires further research.

The results show that Norway is the only Nordic country where aspects of TC are associated with higher levels of equity. Specialisation in mathematics education and self-efficacy in MCK reduced the strength of the relation between SES and achievement, thus reflecting higher levels of equity. This finding may be referred to as a compensatory effect as competent teachers in certain circumstances can compensate for the inadequate qualifications of low-SES students (Wenglinsky, 1998; Gustafsson, Nilsen, & Hansen, 2018), and thus reducing the performance gap. However, not all aspects of TC were associated with enhanced levels of equity in Norway; educational level and specialisation in mathematics were both associated with inequity. This finding may seem contradictory to the first finding. However, a recent study found that highly educated teachers more often teach in urban schools, and students in large cities

tend to have higher achievements than in rural areas (Nilsen & Bergem, 2016). The findings of the current study seem to strengthen and confirm this result. Generally, more research is needed in order to investigate under which circumstances highly competent teachers are able to reduce the performance gap between high- and low-SES student groups.

In Sweden, there were few significant findings, and no aspect of TC was associated with higher levels of equity. The findings show that TC (specialisation in mathematics and self-efficacy in MCK) is associated with a strengthening of the relation between SES and achievement. It is somewhat difficult to interpret this finding as there is no mediation effect to rely upon. However, in Sweden, the relatively recent implementation of students' "free choice of school" has been connected to an increasing achievement gap between schools (Gustafsson & Hansen, 2018; Hansson & Gustafsson, 2017), As suggested in previous research (Hansson & Gustafsson, 2017), an unintended consequence of the "free choice of school" has been that competent teachers to a larger extent than before choose to teach in high-SES schools. If this effect is strong, it could counteract moderating mechanisms (Gustafsson, Nilsen, & Hansen, 2018). However, further research is needed to investigate this issue.

Professional development was positively related to SES in Sweden. This finding requires further research, moreover, this situation could lately have changed because of the large-scale national program for teachers' professional development, which was implemented in 2013 (Hansson & Gustafsson, 2017).

Some of the results from the current study seem to be somewhat contradictory, and thus difficult to interpret. Specialisation in mathematics education is, for instance, associated with equity in Norway but with inequity in Sweden, while in Finland no association with equity can be found. Other aspects of TC show similar unsystematic patterns. Limitations in the design of the study may explain some of these discrepancies and further research is obviously required in order to better understand these different associations between aspects of TC and issues of equity.

However, even though the results varied across the Nordic countries, data from all three countries indicate a disproportionate allocation of competent teachers to high-SES schools. In the Nordic countries, teachers are free to choose the schools in which they teach, and this is a very plausible explanation for the skewed distribution of highly competent teachers. Competent teachers *choose* to teach in high-SES schools (Bonesrønning et al., 2005). However, as equal opportunity for all students to succeed in school is maybe the most prominent goal for the educational systems in all the Nordic countries, this finding is very problematic. If the Nordic countries wish to prevent that the significance of student SES for achievement increases in the years to come, they should find ways to stimulate highly competent teachers to choose low-SES schools as their work place. How this should be done, is of course a political issue. However, if one looks outside the Nordic sphere, the educational policies of some countries, such as Cyprus,

assign teachers to schools for a mandatory period (Kyriakides & Campbell, 2003). As a compensatory approach there is also the possibility of using economic incentives to encourage highly competent teachers to work in low SES schools.

Limitations

The main limitation of the present study is the cross-sectional design of TIMSS, which prevents causal inferences. Another limitation is the construct under-representation of instructional quality. In the current data-set, this construct included too few items to cover the broadness of the construct. This could possibly partly explain why there were few significant findings. Another explanation could be that the two mechanisms, mediation and moderation, counteracted one another (Gustafsson, Nilsen, & Hansen, 2018). In addition, there is a limited number of teachers in the present study, and this could reduce the statistical power and render many findings insignificant.

An additional limitation of this study is that the two approaches, the mediation and the moderation models, are not directly comparable since instructional quality was only included in the mediation models. Further research is needed that also include mediated moderation models.

Concluding remarks

A large body of research has demonstrated the importance of TC for student learning outcomes (e.g. Blömeke et al., 2016; Wayne & Youngs, 2003). The present study demonstrates that aspects of TC may both enhance and reduce the level of equity, but also shows that these associations are very fine grained and complicated and that further research is required. However, our findings are largely in line with previous studies conducted in other countries (e.g. Baumert et al. 2010; Darling-Hammond 2015; Gustafsson, Nilsen, & Hansen, 2018; Schmidt, Burroughs, Zoido, & Houang, 2015; Berkowitz et al., 2017; Atlay et al. 2019).

In recent years, Norway and Sweden have invested considerably in teacher education and professional development (Hansson & Gustafsson, 2017; Kunnskapsdepartementet, 2012). One important finding of the current study is that raising the level of TC does not automatically contribute positively to pronounced goals of equity; more research is therefore needed to investigate how TC relates to issues of equity. Furthermore, the allocation of highly competent teachers within countries is also of high importance. That competent teachers mainly choose to teach in high-SES schools is problematic, as this can counteract the overarching goals of providing equal opportunities for all students, regardless of socio-economic status. This skewed allocation of highly competent teachers may contribute to a stronger association between student SES and achievement and thereby increase the achievement gap between low-SES and high-SES student

groups. The results of the present study suggest that compensatory approaches may be needed to prevent this from happening.

Concerns about the rate at which inequity in school is increasing in some of the Nordic countries have been expressed (e.g. OECD, 2016; Nilsen, Björnsson and Olsen, 2018). To this end, our findings may support the conclusion of Wößmann (2008) that emphasising teacher competence and at the same time preventing a skewed allocation of competent teachers, may strengthen equity in the Nordic educational systems.

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Appendix 1.

The Constructs Included in the Analysis in Terms of Content and Scaling

Construct	Content	Scale
Experience	The number of years of teaching experience	Continuous
Educational level	*What is the highest level of formal education you have completed?*	From *not complete ISCED Level 3* to *finished ISCED Level 5A second degree, or higher*
Specialisation	Teachers were asked what area of specialisation (major or main area) they studied during their education. Mathematics and mathematics education were included in this construct.	Yes or no
Professional Development	In the past two years, have you participated in professional development in any of the following? • *Mathematics content* • *Mathematics pedagogy/instruction* • *Mathematics curriculum* • *Integrating information technology into mathematics* • *Improving students' critical thinking or problem-solving skills* • *Mathematics assessment* • *Addressing individual students' needs*	Yes or no
Self-efficacy, MPCK	In teaching mathematics to this class, how confident do you feel in doing the following? • *Answer students' questions about mathematics* • *Show students a variety of problem-solving strategies* • *Provide challenging tasks for capable students* • *Adapt my teaching to engage students' interest* • *Help students appreciate the value of learning mathematics*	Not confident, Somewhat confident, Very confident
Self-efficacy, MCK (Number, Algebra, Geometry, Data)	The following example pertains to algebra. Similar constructs were included for number, geometry and data. How well prepared do you feel you are to teach the following mathematics topics? • *Numeric, algebraic, and geometric patterns or sequences (extension, missing terms, generalisation of patterns)* • *Simplifying and evaluating algebraic expressions* • *Simple linear equations and inequalities* • *Simultaneous (two variables) equations* • *Representation of functions as ordered pairs, tables, graphs, words, or equations*	Not well prepared, Somewhat prepared, Very well prepared.
Instructional quality	In teaching mathematics to this class, how often do you usually ask students to do the following? • *Explain their answers* • *Decide on their own procedures for solving complex problems* • *Work on problems for which there is no immediately obvious method of solution* • *Summarise what students should have learned from the lesson* • *Relate the lesson to students' daily lives* • *Use questioning to elicit reasons and explanations*	*Never, Some lessons, About half the lessons, Every or almost every lesson*

Appendix 2.

Unstandardised and Standardised Regression Coefficients (in brackets)

Model		Finland	Norway	Sweden
Reference model	Math[1] ON SES (school level)	131.622** (0.593**)	138.134** (0.721**)	154.702** (0.870**)
	Math ON SES (class level)	195.542 (0.699)	137.622 (0.738)	182.462 (0.825)
Experience	Experience ON SES	7.717 (0.096)	-11.859 (-0.127)	-5.336 (-0.084)
	INQ[2] ON Experience	0.002 (0.115)	0.000 (-0.002)	0.002 (0.096)
	Math ON INQ	54.803** (0.286**)	-4.774 (-0.027)	36.939** (0.186**)
	Math ON SES	184.617** (0.659**)	134.488** (0.726**)	184.117** (0.830**)
	Model Indirect	NS	NS	NS
	Moderation[3] Experience	0.169	0.104	-0.011
Educational Level (Edu_level)	Edu_level ON SES	0.325 (0.059)	0.172* (0.089**)	0.075 (0.026)
	INQ ON Edu_level	0.010 (0.040)	-0.004 (-0.008)	0.043* (0.112*)
	Math ON INQ	52.983** (0.268**)	-2.889 (-0.016)	36.287** (0.178**)
	Math ON SES	183.124** (0.654**)	138.474** (0.741**)	183.383** (0.826**)
	Model Indirect	NS	NS	NS
	Moderation Edu_level	-0.038	8.166*	2.211
Specialisation in mathematics (Spec_Math)	Spec_Math ON SES	1.315** (0.370**)	1.227** (0.301**)	0.204 (0.066)
	INQ ON Spec_Math	0.110** (0.278**)	0.039 (0.153)	0.023 (0.063)
	Math ON INQ	55.473** (0.273**)	-5.872 (-0.033)	37.803** (0.188**)
	Math ON SES	204.116** (0.712**)	138.635** (0.744**)	184.178** (0.829**)
	Model Indirect	*	NS	NS
	Moderation Spec_Math	16.893**	2.373	2.106
Specialisation in mathematics education (Spec_Math_edu)	Spec_Math_edu ON SES	0.374** (0.190**)	-0.099 (-0.040)	0.127 (0.041)
	INQ ON Spec_Math_edu	0.047 (0.063)	0.033 (0.078)	-0.005 (-0.015)
	Math ON INQ	53.435** (0.280**)	-4.544 (-0.026)	36.048** (0.182**)
	Math ON SES	183.354** (0.656**)	137.871** (0.739**)	183.482** (0.827**)
	Model indirect	NS	NS	NS
	Moderation Spec_Math_edu	7.029	-6.006**	6.914**
Self-efficacy MPCK (MPCK)	MPCK ON SES	0.025 (0.035)	-0.202 (-0.304**)	-0.006 (-0.014)
	INQ ON MPCK	0.519 (0.227)	0.715 (0.398**)	0.839 (0.314**)
	Math ON INQ	47.396** (0.279**)	0.896 (0.006)	31.641** (0.177**)
	Math ON SES	183.066** (0.655**)	135.374** (0.730**)	183.525** (0.828**)
	Model indirect	NS	NS	NS
	Moderation MPCK	14.989	-17.080	20.304
Self-efficacy, Number, CK (CK_Number)	CK_Number ON SES	0.702** (0.373**)	-0.066 (-0.030)	0.098 (0.096)
	INQ ON CK_Number	0.324** (0.407**)	0.093** (0.182**)	0.211** (0.182**)
	Math ON INQ	48.860** (0.259**)	-5.209 (-0.032)	32.932** (0.175**)
	Math ON SES	192.168** (0.679**)	137.534** (0.738**)	183.060** (0.825**)

	Model indirect	*	NS	NS
	Moderation CK_Number	31.083**	-7.818**	20.881**
Self-efficacy, algebra, CK (CK_Algebra)	CK_Algebra ON SES	0.799** (0.459**)	-0.353 (-0.161)	0.121 (0.099)
	INQ ON CK_Algebra	0.327** (0.389**)	0.064 (0.122)	0.301** (0.309**)
	Math ON INQ	49.890** (0.255**)	-3.161 (-0.019)	32.874** (0.177**)
	Math ON SES	209.609** (0.732**)	138.922** (0.743**)	183.240** (0.825**)
	Model indirect	*	NS	NS
	Moderation CK_Algebra	53.575**	-10.123**	15.428
Self-efficacy, geometry, CK (CK_Geometry)	CK_Geometry ON SES	0.708** (0.361**)	-0.082 (-0.040)	0.103 (0.130)
	INQ ON CK_Geometry	0.285** (0.371**)	0.111** (0.200**)	0.286** (0.192**)
	Math ON INQ	50.308** (0.267**)	-3.118 (-0.019)	32.383** (0.172**)
	Math ON SES	193.917** (0.684**)	137.439** (0.737**)	182.832** (0.824**)
	Model indirect	*	NS	NS
	Moderation CK_Geometry	26.082**	-1.227	29.602*
Self-efficacy, data, CK (CK_Data)	CK_Data ON SES	0.782** (0.378**)	0.119 (0.069)	0.029 (0.022)
	INQ ON CK_Data	0.285** (0.408**)	0.119 (0.193)	0.112 (0.128*)
	Math ON INQ	47.496** (0.244**)	-4.287 (-0.024)	35.255** (0.179**)
	Math ON SES	184.614** (0.655**)	137.681** (0.739**)	183.475** (0.827**)
	Model indirect	*	NS	NS
	Moderation CK_Data	19.410**	-3.031	3.756
Prof development (ProfDev)	ProfDev ON SES	0.051 (0.036)	0.009 (0.004)	0.360** (0.190**)
	INQ ON ProfDev	0.158 (0.146*)	0.135* (0.303**)	0.127* (0.206**)
	Math ON INQ	50.783** (0.277**)	-0.906 (-0.005)	30.467** (0.160**)
	Math ON SES	182.609** (0.653**)	138.208** (0.740**)	181.137** (0.817**)
	Model indirect	NS	NS	NS
	Moderation ProfDev	2.197	1.780	5.748

Note. The standardised regression coefficients are in parentheses. All estimates are presented at the class level, and had acceptable to good model fit.
* denotes p<.05, ** denotes p < .001, [1] Math = achievement in mathematics. [2]INQ = Teachers instructional quality.
[3] Mplus does not estimate standardised moderation coefficients; hence, these are presented as unstandardised estimates. NS = not significant. Results for Model indirect are presented by either significance (*, p<.05) or non-significance (NS).