

Chapter 7

Teachers' Role in Enhancing Equity—A Multilevel Structural Equation Modelling with Mediated Moderation



Trude Nilsen, Ronny Scherer , Jan-Eric Gustafsson, Nani Teig, and Hege Kaarstein

Abstract Even though equity is an important aim for the Nordic countries, for many of these countries, the effect of a student's home background on their achievement seems to increase over time. If the aim is to reduce the effect of SES (socio-economic status) on student outcomes, there is a need to identify the factors that moderate this relation. One such factor could be teachers and their instruction because they have been found to be key to student outcomes. However, few have linked teachers and their instruction to equity, and fewer still have made this link in Nordic countries. The aim of the present study is to identify the aspects of teacher quality and their instruction that may reduce the relationship between SES and student achievement in the Nordic countries. Eighth-grade students from the only two Nordic countries participating in TIMSS 2015 (Norway and Sweden) were selected. Multigroup, multilevel (students and classes) structural equation models with random slopes were employed to investigate which aspects of teacher quality moderate the relation between SES and student science achievement via instructional quality. The findings show that teacher professional development and specialisation reduce the relation between SES and science achievement via instructional quality in Sweden, while there were no significant findings for Norway. This study contributes to the fields of equity and teacher effectiveness, demonstrating that teachers may make a difference in reducing inequity through their competence and instruction.

Keywords Equity · Teacher quality · Instructional quality · TIMSS

T. Nilsen (✉) · N. Teig · H. Kaarstein
Department of Teacher Education and School Research, University of Oslo, Oslo, Norway
e-mail: trude.nilsen@ils.uio.no

R. Scherer
Centre for Educational Measurement, University of Oslo, Oslo, Norway

J.-E. Gustafsson
Centre for Educational Measurement, University of Oslo, Oslo, Norway
University of Gothenburg, Gothenburg, Sweden

7.1 Background and Rationale

Educational systems around the world have long strived to increase educational equity, yet a large body of research has established a prevailing and substantial relation between socioeconomic status (SES) and student achievement (Kim, Cho, & Kim, 2019; OECD, 2016; Sirin, 2005), and this relation seems to have increased in the Nordic countries over time (Hansen, 2015; Nilsen, Bjørnsson, & Olsen, 2018; OECD, 2016). For Sweden, the level of equity is now below the OECD average, with a score point difference of 44 in science achievement associated with a one unit increase in the ESCS¹ (OECD, 2016). For Norway, the level of equity is not statistically different from the OECD average, with a score point difference of 37 in science achievement associated with a one unit increase in the ESCS (OECD, 2016). This development is unfortunate, as it threatens the idea behind the Nordic model which is based on an ideal model of a “School for All” (see Chap. 2).

However, researchers have paid little attention to investigating the possible *mechanisms* through which SES is related to educational achievement (Berkowitz, Moore, Astor, & Benbenishty, 2017). Rather, SES is mostly utilized to control for selection bias when investigating effects of predictors on educational outcomes (Broer, Bai, & Fonseca, 2019). However, if educational systems aim to reduce the strength of the relationship between SES and student outcome, which is often used as an indicator of educational equity (see Chaps. 2 and 3), there is a need to identify factors that *moderate* this relation (Atlay, Tieben, Hillmert, & Fauth, 2019). In fact, knowledge about these factors could support educational systems with reducing educational gaps by manipulating factors, such as school climate, instructional quality, and teacher quality.

Although existing research has shown that teachers and their instruction are crucial for student outcomes, few studies have linked these aspects to equity (e.g., Darling-Hammond, 2015; Hwang, Choi, Bae, & Shin, 2018; Teig, Scherer, & Nilsen, 2018), and even fewer studies have been conducted in the Nordic countries. However, some studies from Germany and the United States found that high-quality teachers may enhance equity by reducing the gap between high- and low-SES students (Baumert et al., 2010; Darling-Hammond, 2015; Rjosk et al., 2014). While parents may support high-SES students may in their schoolwork (e.g., Tan, Lyu, & Peng, 2019), high-quality teachers may compensate for a lack of such support in low-SES students (Jeynes, 2005). Improving teacher quality, competence, and instruction may result in more students reaching their full potential (Atlay et al., 2019; Rivers & Sanders, 2002; Rjosk et al., 2014).

Researchers have linked formal teacher qualifications, including educational level, specialization, and professional development (PD), to high-quality teaching (Blömeke, Suhl, Kaiser, & Döhrmann, 2012). Despite mixed evidence on the effectiveness of teacher educational level, several studies have shown a substantial effect

¹ESCS refers to the Program for International Student Assessment (PISA) index of Socio-Economic Status.

of teacher specialization on student outcomes and equity (e.g., Goe, 2007; Qin & Bowen, 2019). Research syntheses have also demonstrated a significant effect of teacher PD on student achievement (Goe, 2007; Kraft, Blazar, & Hogan, 2018; Timperley, Wilson, Barrar, & Fung, 2007). In the United States, some researchers have even suggested that increasing PD for teachers would contribute to closing the achievement gap between students (Darling-Hammond, 2015; Fischer et al., 2016).

To improve teacher quality, in 2013, Sweden implemented a massive teacher PD program in mathematics, which has since been extended to other subjects (Ringarp & Parding, 2018). Similarly, Norway has also made substantial investments in teacher PD (Regjeringen, 2014), albeit on a lesser scale than in Sweden. Given the decreasing levels of equity and the increasing emphasis on improving teacher quality in these Nordic countries (Hansen, 2015; OECD, 2016; Regjeringen, 2014; Ringarp & Parding, 2018), the question arises whether teacher quality may reduce the relation between SES and achievement.

However, teacher quality is rarely *directly* related to student outcomes; instead, it exerts an indirect effect via instructional quality (e.g. Baumert et al., 2010; Fauth et al., 2019). Hence, researchers that examine whether teacher quality may moderate the relation between SES and achievement should also consider indirect effects via instructional quality (i.e., a possible mediational path).

By taking into account these possible mechanisms of relationship between student SES and achievement, the overall aim of this study is twofold: (a) to identify the aspects of teacher qualifications and their instruction that may reduce the relation between SES and student achievement in Norway and Sweden (*moderation*) and (b) to examine whether the moderation effect of teacher qualifications is (partially) mediated via instructional quality (*mediated moderation*). More specifically, this study addressed these aims within the context of science education. Investigating educational equity in this context is of key significance as reforms in science education continue to promote scientific literacy as a fundamental goal of school science (Norris & Phillips, 2003). Despite considerable efforts in developing scientific literacy of all students, research has shown that those from underprivileged SES families are at a disadvantage when it comes to learning the language of science (Ryoo, 2009). Along this line, it is valuable to investigate the relationship between student SES and achievement, particularly by taking into account teacher qualifications and practices in science teaching.

7.2 Theoretical Framework

7.2.1 Educational Equity

One of the most important goals of most educational systems is to provide equitable opportunities and to enable all students to fully realize their academic potential, irrespective of their gender, ethnic belonging, or SES (Opheim, 2004). This has

been an especially important goal and the idea behind the Nordic model (see Chap. 2).

According to Espinoza (2007), equity and equality are interrelated and defined in a number of ways (see Chap. 2). One of Espinoza's definitions refers to "equality on average across social groups" and describes equal opportunities for all students to achieve high academic outcomes, no matter their social background (p. 353). To an extent, the present study belongs under this umbrella. However, the OECD and UNESCO have narrowed this broad concept (OECD, 2016; UNESCO, 2018). International large-scale assessments (ILSAs) and especially the OECD (2016) has had a significant influence on the conceptualization of equity. UNESCO has likewise had an impact on the conceptualization and measurement of equity and equality (2018). One of the most common indicators of educational equity is the strength of the relation between SES and student academic achievement. This indicator of equity is referred to as "impartiality" (UNESCO, 2018). While knowledge of this relation is important, it still does not answer whether and how schools may compensate for such inequity. "Redistribution" is a type of equity referring to compensating mechanisms for inequity (UNESCO, 2018). For example, low-SES schools may be allocated resources to compensate for students' disadvantage. In order for policy to enact compensatory approaches, it is vital to know what factors may reduce the impact of students' background (e.g., gender, ethnicity, etc.) on their academic outcome. This is exactly what the present study investigates by exploring how and if teacher quality and their instruction may reduce the impact of student SES on achievement.

7.2.2 *Teacher Quality*

Teacher quality is a broad concept and conceptualized somewhat differently across studies. Researchers have also used the concepts of teacher quality and teaching quality interchangeably. In this study, we separate the two concepts and refer to teacher quality as the skills, beliefs, and abilities the teachers bring into the classroom, whereas we define teaching quality, or instructional quality, as the teachers' behavior in the classroom and the quality of their instruction.

Goe (2007) suggested that the inputs of teacher quality include teacher *qualifications* (e.g., education, certification, experience) and teacher *characteristics* (e.g., self-efficacy, attitudes, beliefs). In a similar vein, Blömeke, Olsen, and Suhl (2016) proposed that teacher quality includes teacher qualifications (e.g., educational background, amount of experience in teaching, participation in PD) as well as personality characteristics, such as teachers' self-efficacy or beliefs. Focusing on ILSA studies, Klingebiel and Klieme (2016) applied a conceptual framework of teacher quality that consists of: (a) teacher qualifications including education and PD and (b) teacher competence involving teacher professional knowledge, beliefs, and non-cognitive or motivational factors. Despite using different labels to indicate some aspects of teacher quality, these studies have offered a similar conceptual

framework of teacher quality, which comprises both teacher qualifications and teacher competence/characteristics.

In the present study, we focus on teacher qualifications rather than their competence/characteristics for the following reasons. First, previous research has shown that teacher qualifications are related to educational equity (Darling-Hammond, 2015). For example, high-SES schools may have more qualified teachers than low-SES schools have (e.g. Darling-Hammond, 2006; Lankford, Loeb, & Wyckoff, 2002). In Norway, a study revealed a lack of certified teachers in schools with high proportions of minority students and students with special needs (Bonesrønning, Falch, & Strøm, 2005). Researchers identified a similar pattern in Sweden (Hansson & Gustafsson, 2017). Additionally, teacher qualifications (e.g., certification) may have larger effects on low-SES students than on high-SES students (e.g. Nye, Konstantopoulos, & Hedges, 2004), although studies including such moderation effects of teacher qualifications are rare.

Second, teacher qualifications—such as their specialization, educational level, and PD—are important factors that can be influenced through educational policy (e.g., through teacher education). Even though educational policy may influence teacher characteristics, such as increased self-efficacy through teacher education, this mechanism is difficult to establish or measure. Third, the present study emphasizes a Nordic perspective and comparison across the Nordic countries. Teacher competence measured by, for instance, a test within a certain domain has proven difficult to measure across countries (Blömeke & Delaney, 2014; Blömeke, Hsieh, Kaiser, & Schmidt, 2014). Due to the above-mentioned reasons, this study concentrates on the qualification aspect of teacher quality, more specifically on teacher education, specialization, and PD. The following sections discuss each of these aspect in detail.

Teacher Education Researchers conducting ILSA studies commonly measure teacher formal level of education using International Standard Classification of Education (ISCED) levels (e.g. Mullis, Martin, Foy, & Hooper, 2016). Of the Nordic countries, teachers in Finland have the highest education, where more than 90% of them have a master's degree or higher (Mullis, Martin, Foy, et al., 2016; OECD, 2016). While the effect of teachers' educational level has often been hard to establish and varies greatly from one country to another (Blömeke et al., 2016), some studies have demonstrated a significant effect of teacher's level of education on student achievement (Blömeke et al., 2016; Nilsen, Scherer, & Blömeke, 2018) and in enhancing equity (Heck, 2007).

Teacher Specialization Specialization in the content domain is an important part of teachers' qualifications as well as an indicator of their content knowledge and pedagogical content knowledge (Blömeke et al., 2014; Goe, 2007). Student learning depends to a large degree on teachers who have specialized in the subject they teach and whose content knowledge and pedagogical content knowledge are sound (e.g., Baumert et al., 2010; Blömeke et al., 2016; Goe, 2007; Nilsen, Scherer, et al., 2018).

Such teachers may also reduce the achievement gap between students (Baumert et al., 2010).

Teacher PD Research syntheses found that teacher PD may have significant effects on student achievement (Goe, 2007; Kraft et al., 2018; Timperley et al., 2007). However, for PD to have an effect on student learning, it needs to be of sufficient length and quality (Timperley et al., 2007). As such, sufficient teacher PD may be an important factor in reducing the achievement gap among different groups of students (e.g. Darling-Hammond, 2015).

7.2.3 *Teacher Qualifications in Norway and Sweden*

A natural point of departure for reviewing the teachers' formal qualifications in Norway and Sweden can be traced back to an important phenomenon known as the PISA shock in 2001 (Elstad, Nortvedt, & Turmo, 2009; Haugsbakk, 2013; Lundström, 2015; Tveit, 2013). Norwegian students produced results on the PISA 2001 that were so far below expectations that the Norwegian Minister of Education compared it with the failure to bring home any medals from the Winter Olympics (Elstad et al., 2009; Nortvedt, 2018; Tveit, 2013). Following the PISA shock in 2001, Norway implemented several policy changes, including reforming the National Curriculum for Grades 1–13 called the “Knowledge Promotion” and introducing a National Quality Assessment System that implemented national tests alongside participation in other ILSA studies, like TIMSS² (for more details, see Elstad et al., 2009). A similar line of events also took place in Sweden as the PISA shock had a profound impact on educational policy (Ringarp, 2016). The PISA shock may also have been an important factor that drove the implementation of national tests in both Norway and Sweden (Lundahl & Waldow, 2009; Lundström, 2015). In addition to these initiatives and actions that focused on improving student outcomes, the Norwegian and Swedish governments also reformed teacher education and made changes to employment regulations for teachers.

The teacher education practices and programs in Norway and Sweden are quite similar and are founded on the same principles, values, and traditions (Ringarp & Parding, 2018). Some large reforms in teacher education have had an impact on the current teacher education and qualifications in these countries. Norway implemented a large teacher education reform in 2010 that divided teacher education for Grades 1–10 into two types of programs: classroom teachers for Grades 1–7 and specialized teachers for Grades 5–10 that focus on one or two subjects (for more details, see e.g., Munthe, Malmo, & Rogne, 2011). Individuals interested in teaching Grades 8–13 have always had an alternative route to become a teacher in Norway by following a university program and specializing in one or two subjects. Since 2014, Norwegian teachers must have a minimum of 30 credit points (i.e., one full-time semester) in

²Trends in Mathematics and Science Study, see <https://timssandpirls.bc.edu/>

science in addition to the already required pedagogical education to be hired and teach the subject. This requirement was not included in the teacher hiring requirements before 2014. All science teachers in Norway now have until 2025 to fulfill the last extension of the requirements (Ministry of Education and Research, 2015).

Sweden implemented two large teacher education reforms in 1998 and 2011. Research became an integral part of education in the 1998 reform, as all teachers were required to attend the same educational program and educating students across different socioeconomic classes were specifically targeted to enhance equity (Ringarp & Parding, 2018). In the 2011 reform, the educational program was differentiated and split into four educational programs: preschool teacher, classroom teacher for primary school Grades 1–3 and 4–6, specialized teachers (e.g., science teachers for Grades 7–9 or upper secondary school), and teachers for vocational tracks (Ringarp & Parding, 2018). Since 2011, all Swedish teachers are required to obtain a teaching certificate, and science teachers who teach Grades 7–9 need at least 45 credit points³ to teach the subject.

The investments in teachers' PD gained more widespread recognition since 2009 in Norway (Lagerstrøm, Moafi, & Revold, 2014) and since 2001 in Sweden. In Norway, school administrators (i.e., municipalities or counties) are responsible for meeting their teachers' need for PD. The main focus has been to ensure that teachers have the minimum required study credits (Ministry of Education and Research, 2008). In Sweden, teachers' PD is more centralized and described as one of the national steering devices for the government (Kirsten & Wermke, 2017). Substantial amounts of resources are invested for improving teacher quality, including granting teachers with 13 days per year to attend PD (Kirsten & Wermke, 2017). In 2013, Sweden implemented an extensive teacher PD program in mathematics, which has also been extended to other subjects (Boesen, Helenius, & Johansson, 2015; Ringarp & Parding, 2018).

In Norway, the politically prioritized subject has been mathematics (OECD, 2019), which could be why only a very small number of Norwegian students in TIMSS 2015 had teachers who participated in PD in science in the last 2 years (Martin, Mullis, Foy, & Hooper, 2016). Only 4% to 12% of Norwegian students were taught by teachers who participated in PD in other different topics. Conversely, this number ranged between 23% and 35% in Sweden (Martin et al., 2016).

In spite of all the reforms to improve teacher quality in Sweden and Norway, research examining teacher education and PD in these countries has been limited. Few studies have investigated whether these reforms have had an impact on student outcomes and educational equity or whether teacher qualifications relate to students' science learning outcomes, especially by comparing the results in both countries. However, some studies have found that PD implemented by the government was associated with high performance in Sweden (Gustafsson & Nilsen, 2017; Nilsen, Scherer, et al., 2018).

³One semester of full-time study is 30 credit points.

7.2.4 Instructional Quality

Similar to teacher quality, instructional quality is a broad concept operationalized differently across countries and studies (e.g. Blömeke et al., 2016; Ferguson & Danielson, 2014; Kuger, Klieme, Jude, & Kaplan, 2016; Kyriakides, Creemers, & Antoniou, 2009; Nilsen, Scherer, et al., 2018; Pianta & Hamre, 2009). Despite these differences, researchers in Europe (Blömeke et al., 2016; Kuger et al., 2016) have extensively used the framework of instructional quality from Klieme, Pauli, and Reusser (2009). According to this framework, instructional quality includes three main aspects: classroom management, cognitive activation, and teacher support.

Classroom management is often considered to be independent of the subject domain (Klieme et al., 2009). All subjects would require effective classroom management, including clear rules and procedures about the time spent on tasks and disciplinary situations. Since this study focuses on the context of science education, investigating a generic aspect like classroom management has become of less interest. In addition, classroom management has been frequently studied in research on instructional quality; hence, its relation to student outcome has been well established (Kyriakides et al., 2009; van Tartwijk & Hammerness, 2011). Thus, this particular aspect of instructional quality is not included in the present study.

In contrast with classroom management, *cognitive activation* is the aspect of instructional quality that is most dependent on the subject domain (Klieme et al., 2009; Kuger et al., 2016). In the domain of science, cognitive activation includes engaging students with cognitively challenging lessons through inquiry activities, such as interpreting data from scientific experiments (Minner, Levy, & Century, 2010; Teig, Scherer, & Nilsen, 2019). In general, cognitive activation comprises instructional activities that challenge students cognitively and engage them with high-level thinking, for example, through evaluating, integrating, and applying knowledge in the context of problem solving (Baumert et al., 2010; Hiebert & Grouws, 2007; Nilsen & Gustafsson, 2016).

Teacher support refers to practices related to the teacher's response to students' needs, including listening to and respecting students' ideas and questions and encouraging classroom discussions among students. A supportive teacher would show an interest in every student's learning, provide feedback, and adapt practices to the individual student's needs (Blömeke et al., 2016).

In addition to these three aspects, some studies have included a fourth aspect of instructional quality, known as *clarity of instruction* (Bellens, Van Damme, Van Den Noortgate, Wendt, & Nilsen, 2019; Bergem, Nilsen, & Scherer, 2016). Clarity of instruction relates to a clear and comprehensive teaching practice. To achieve clarity of instruction, the teacher must set clear learning goals, provide a summary at the end of the lesson, and link new and old topics (Bergem et al., 2016; Cohen & Grossman, 2016; Raudenbush, 2008). Although clarity of instruction could be integrated into the aspect of teacher support, the present study separates these two aspects of instructional quality.

Some studies have investigated the relation between teachers' instructional quality and educational equity; however, most of these studies were situated in Germany and the United States. Rjosk et al. (2014) investigated language instruction in German classrooms and found that cognitive activation mediated the relation between SES and achievement. Willms (2010) analyzed data from PISA 2006 and found that instructional quality mediated the relation between SES and achievement at the school level. Using data from TIMSS 2011, researchers have determined that instructional quality moderates the relation between SES and achievement (Gustafsson, Nilsen, & Hansen, 2018). Although the findings varied across the 50 countries who participated in TIMSS 2011, this study shows that instructional quality reduced the strength of the effect of SES on achievement in some countries (Gustafsson et al., 2018).

The body of extant literature on the moderating role of instructional quality is diverse, as the following two examples show. In a recently published study of a large German student sample, Atlay et al. (2019) examined the moderating role of instructional quality on the relation between SES and achievement in mathematics. Atlay et al. (2019) found that cognitively activating classrooms and good teacher support were beneficial especially for high-SES students; surprisingly, this study found support for a positive rather than negative moderation effect. In contrast, a study of the TIMSS 2015 national extensions in three countries (i.e., Germany, Belgium, and Norway) could not identify any moderation effect for any of the three core dimensions of instructional quality (Bellens et al., 2019). Considering these findings, the role of instructional quality as a possible moderator of the SES–achievement relation remains unsettled and warrants further empirical investigation.

7.3 Methodology

7.3.1 Data and Sample

We utilized large-scale data from TIMSS, the only study with representative samples at the national level that collects data from students and teachers in mathematics and science. Furthermore, TIMSS is the only ILSA that samples entire classes within schools, enabling investigations of factors explaining variance between classes. As the factor of teacher qualifications seems to be of more importance for student outcomes in lower secondary than in primary school (Goe, 2007; Nilsen, Scherer, et al., 2018), we selected Grade 8 students from the only two Nordic countries participating in the last cycle of TIMSS in 2015: Sweden and Norway.

7.3.2 Measures

Teacher Quality Teacher qualifications were used to measure teacher quality through the following indicators: (a) *educational level* from ISCED level 3 to 8; (b) *specialization* as determined by the major or main area of study in science education and in physics, biology, chemistry, or earth science; (c) *content of PD* or teachers' participation in various PD activities in the last 2 years, including science content, science pedagogy/instruction, curriculum, integration of information technology into science teaching, improving students' critical thinking or inquiry skills, and science assessment; and (d) *hours of PD* as determined by the number of hours teachers spent in PD in the last 2 years.

Instructional Quality We measured this construct using teachers' ratings of how often they would do certain practices (measured on a four-point scale from *never* to *every or almost every lesson*). In accordance with the framework of instructional quality (e.g. Klieme et al., 2009), we included five items pertaining to cognitive activation (e.g., "Ask students to complete challenging exercises that require them to go beyond the instruction"), teacher support (e.g., "Encourage classroom discussions among students"), and clarity of instruction (e.g., "Link new content to students' prior knowledge"). Note that TIMSS 2015 did not measure classroom management.

In addition, the measurement models of teacher qualifications and instructional quality demonstrated metric invariance across the Nordic countries (Nilsen & Gustafsson, 2016; Nilsen, Scherer, et al., 2018), which implies teachers from these countries interpreted both constructs similarly.

SES TIMSS 2015 measured students' SES by their responses on questions about parents' education, the number of books at home, and the educational resources at home. A composite score for SES⁴ was estimated based on an item response theory model to represent students' individual socioeconomic background.

Science Achievement The TIMSS 2015 science assessment contained 250 items that covered topics in chemistry, physics, biology, and earth science. These items captured the breadth of the science domain as well as the range of cognitive dimensions (i.e., knowing, applying, and reasoning). Five plausible values were drawn from the achievement distribution to represent science achievement. The mean science achievement for both countries was slightly different; specifically, Swedish students had a mean of 522 with a standard deviation of 3.4, whereas Norwegian students had a mean of 509 with a standard deviation of 2.8.

⁴<http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/home-environment-support/home-resources-for-learning/>

Table 7.1 shows percentages of teacher characteristics and qualifications in Sweden and Norway. More detailed information on the questionnaires and descriptive statistics of the measures are available on the TIMSS 2015 website.⁵

Table 7.1 Percentages of teacher characteristics and qualifications in Norway and Sweden

Variables	Sweden (<i>n</i> = 706)	Norway (<i>n</i> = 225)
Gender		
Male	41.0	45.1
Female	59.0	54.9
Years of teaching experience		
<10 years	38.6	51.5
10–19 years	43.9	34.0
20–30 years	10.7	9.7
>30 years	6.8	4.9
Level of formal education		
Upper secondary	7.1	–
Short-cycle tertiary	2.4	2.4
Bachelor or equivalent	52.0	69.9
Master or equivalent	34.4	27.2
Doctor or equivalent	4.1	0.5
Major area of education		
Science and science education	47.7	17.2
Only in science	26.5	33.5
Only in science education	13.7	9.4
All other majors	5.0	39.9
No formal education beyond upper secondary school	7.1	–
The number of hours teachers attended PD in the past 2 years		
None	33.5	57.7
<6 h	27.3	18.9
8–15 h	22.2	10.7
16–35 h	7.1	4.6
>35 h	9.9	8.2
The content of PD teachers attended in the past 2 years		
Science content	32.0	19.4
Science pedagogy/instruction	27.2	15.8
Science curriculum	34.0	11.2
Integrating information technology into science	26.6	8.2
Improving student' critical thinking or inquiry skills	22.3	9.7
Science assessment	32.0	12.8
Addressing individual students' needs	30.3	8.2

⁵<https://timssandpirls.bc.edu/timss2015/>

7.3.3 Data Analysis

Two-group (i.e., Sweden, Norway) and multilevel (i.e., students nested in classes) structural equation modeling (SEM) with random slopes was employed. A random slope model allows each group (i.e., class) to have a different slope, which means that the explanatory variable (i.e., teacher qualifications and instructional quality) may have a different effect for each group.

SEM is a multivariate statistical analysis technique that includes confirmatory factor analysis (CFA). CFA generates factor loadings of indicators on an underlying latent factor. Along with the model fit indices, the factor loadings provide a measure for reliability and validity (Hox, Moerbeek, & Van de Schoot, 2017). SEM allows researchers to examine the relationships between multiple observed and unobserved variables, while providing explicit estimates of error variance parameters. It further enables complex modeling (e.g., multi-group and random slopes models) and complex patterns with intervening variables between the independent and dependent variables, and independent variables may also function as dependent variables (Preacher, Zyphur, & Zhang, 2010).

Furthermore, another great advantage of SEM is the possibility for multi-level approaches (MSEM) where it is possible to model at all levels simultaneously. MSEM with measurement models with multiple indicators is the most robust method for multi-level analyses with latent variables (Hox et al., 2017).

We specified cross-level interaction models with indirect effects to test which aspects of teacher qualifications moderate the relation between individual students' SES and science achievement via classroom instructional quality. All models were estimated using the software *Mplus* 8.3 with the robust maximum likelihood estimation (Muthén & Muthén, 1998–2017). Prior to adding any structural models, multilevel confirmatory factor analyses were conducted to ensure reliable and valid measurement models of each construct at both the student and the classroom level. Indirect effects that may indicate (partial) mediation were estimated using the MODEL CONSTRAINTS option in *Mplus*, with Wald 95% confidence intervals. It should be noted that the coefficients provided in the results section were not standardized. All models follow the latent decomposition approach for variables that were measured at the student level but aggregated to the classroom level, following an approach presented by Marsh et al. (2009).

Figure 7.1 shows the conceptual model for the overall aim in the present study. The black dot reflects the random slope of the relation between SES and achievement at the student level. The arrows pointing to the dot represent the relation between the classroom level predictors, teacher qualifications and instructional quality, as well as the variation in the slope. In other words, the model shows how teacher qualifications and instructional quality may moderate the relation between SES and achievement at the student level. Furthermore, the model shows a mediation path where instructional quality mediates teacher qualifications' moderation of the relation between SES and achievement.

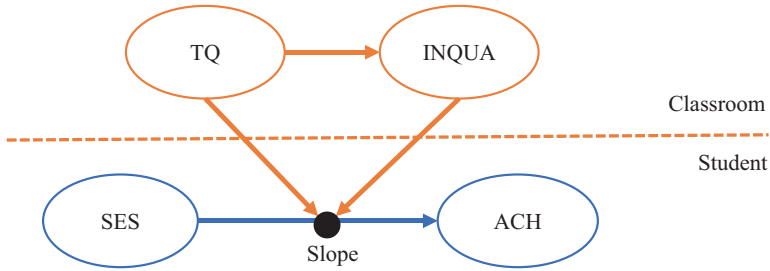


Fig. 7.1 The conceptual model of the overall aims in this study. TQ = teacher qualifications; INQUA = instructional quality; ACH = student achievement, SES = students' socioeconomic status

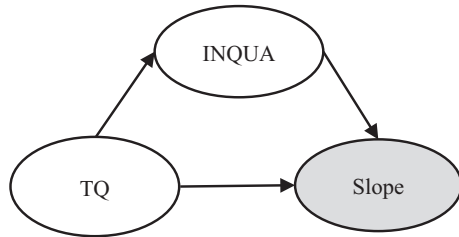


Fig. 7.2 The analytical model at the classroom level. TQ = teacher qualifications; INQUA = instructional quality; Slope = random slope of the relation between SES and achievement at the student level

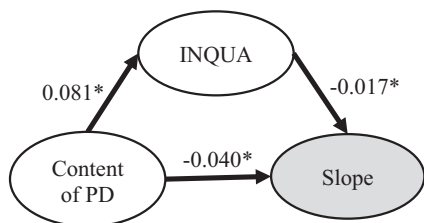
This model creates a latent variable for the slope between SES and achievement at the classroom level. Hence, in addition to the relations shown at the classroom level, we investigate the relation between the predictors of teacher qualifications and instructional quality and the slope, as shown in Fig. 7.2. We further control for the relation between SES and achievement at the classroom level. Figure 7.2 reflects the analytical model at the classroom level created in *Mplus*.

A direct moderation effect that enhances equity (by reducing the strength between SES and achievement) would require a negative, significant relation between teacher qualifications and the slope. A mediated moderation that enhances equity would require a negative, significant mediation effect from teacher qualifications to the slope via instructional quality.

7.4 Results

The purposes of the present study were to (a) identify various aspects of teacher qualifications (i.e., content of PD, hours of PD, teacher educational level, and teacher specialization) that may have contribute to reducing the relationship between student SES and achievement and (b) examine whether the moderation effect of teacher qualifications was (partially) mediated via instructional quality.

a) Content of PD: Sweden



b) Content of PD: Norway

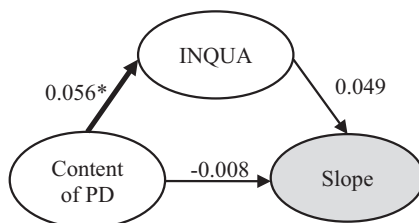


Fig. 7.3 Moderation model at the classroom level in (a) Sweden and (b) Norway. PD = professional development; INQUA = instructional quality; Slope = random slope of the relation between SES and achievement at the student level. * $p < .05$

Figure 7.3 presents the main results at the classroom level for teachers' participation in various PD activities (content of PD). For the Swedish data (Fig. 7.3a), all three relations between content of PD, instructional quality, and the slope were significant, along with a significant mediation effect. The moderation coefficient was negative and significant ($B = -0.040$), suggesting that content of PD reduced the strength of the relation between SES and student achievement via instructional quality. This may suggest good teaching quality—indicated by teachers who have participated in various activities of PD—reduces the importance of student home background for science achievement and hence, enhances equity among students. For the Norwegian data, on the other hand, only the relation between content of PD and instructional quality was significant, and neither mediation nor moderation effects were evident (Fig. 7.3b).

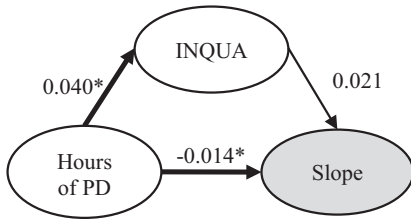
We further controlled for the relation between classroom SES and achievement. The results showed that the relation between SES and student achievement at the classroom level was $B = 2.04$ ($SE = .158$, $p < .01$) for the Swedish data and $B = 1.22$ ($SE = .141$, $p < .01$) for the Norwegian data. Hence, an increase of one unit in the classroom-level SES scale was associated with a 204-point score increase in Sweden. This change represents about twice the standard deviation of classroom-level achievement. In Norway, a one-unit increase of the classroom-level SES scale was associated with a 122-point score increase in classroom-level achievement.

With respect to the number of hours teachers spent on PD (hours of PD), we identified a direct, significant, and negative moderation effect in Sweden (Fig. 7.4a). The corresponding regression coefficient was smaller than for the model with the content of PD, and there was no significant mediation effect. These results indicate that the number of hours teachers spent on PD enhanced equity among students in Sweden. For Norway, no evidence for moderation and mediation surfaced (Fig. 7.4b).

For the teachers' educational level, we found no significant moderation effects in either country (Fig. 7.5).

With regard to the teacher specialization, we found a significant, direct, and negative moderation effect in the Swedish data (Fig. 7.6a), indicating that this aspect of teacher qualification enhances equity. Once again, no significant moderation and mediation effect surfaced for the Norwegian data (Fig. 7.6b).

a) Hours of PD: Sweden



b) Hours of PD: Norway

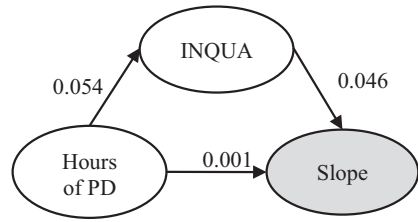
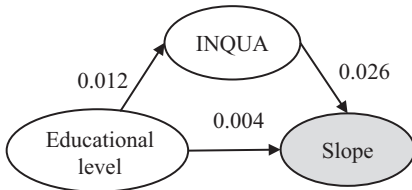


Fig. 7.4 Moderation model at the classroom level in (a) Sweden and (b) Norway. PD hours = hours of professional development; INQUA = instructional quality; Slope = random slope of the relation between SES and achievement at the student level. * $p < .05$

a) Teacher educational level: Sweden



b) Teacher educational level: Norway

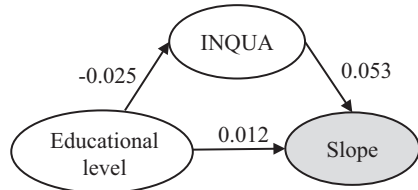
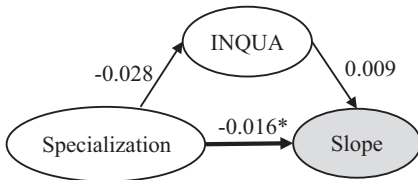


Fig. 7.5 Moderation model at the classroom level in (a) Sweden and (b) Norway. Educational level = educational level from ISCED level 3 to 8; INQUA = instructional quality; Slope = random slope of the relation between SES and achievement at the student level. * $p < .05$

a) Teacher specialization: Sweden



b) Teacher specialization: Norway

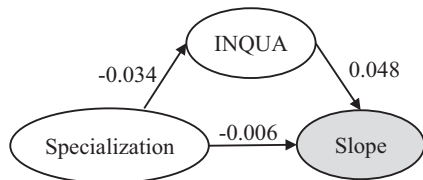


Fig. 7.6 Moderation model at the classroom level in (a) Sweden and (b) Norway. Specialization = teacher major or main area of study; INQUA = instructional quality; Slope = random slope of the relation between SES and achievement at the student level. * $p < .05$

7.5 Discussion

In this study, we investigated whether different aspects of teacher qualifications (i.e., content of PD, hours of PD, education level, and specialization) could reduce the strength of the relation between SES and achievement via their instructional quality. The results indicate that, in Sweden, teachers who participated in different PD activities helped enhance equity among students via their instruction. Moreover,

the length of these activities (i.e., hours of PD) also contributed to enhancing equity, although no mediation effect was detected. In Norway, we found no significant moderation or mediation effects for either teachers' participation in PD activities or the time they spent in these activities. With respect to teachers' educational level, we identified no significant effect for either the Norwegian or the Swedish data. For teacher specialization, conversely, there was a direct, significant, and negative moderation effect for Sweden. This finding indicates that teachers' area of specialization reduced the relation between SES and achievement and, thus, enhanced equity. In Norway, the moderation effect was insignificant for teacher specialization.

Both the content and number of hours teachers participated in PD contributed to enhance equity in Sweden. Given that Sweden has invested tremendous effort and resources into PD, these findings seem particularly promising. The findings were also in line with those from the United States (e.g. Darling-Hammond, 2015; Darling-Hammond, Hyler, & Gardner, 2017; Wilson, 2013), indicating that such efforts may reduce the performance gap between high- and low-SES students.

However, this study found no evidence that the number of hours teachers spent in PD contributed to enhancing equity in Norway, which could be due to several reasons. The number of teachers who participated in PD in Sweden was substantively larger than in Norway (Mullis, Martin, Foy, et al., 2016; Skolverket, 2016). In addition, relatively few Norwegian teachers participated in the TIMSS 2015 study; specifically, the study involved 225 teachers in Norway and 706 teachers in Sweden. The small sample in the Norwegian data could reduce the power of the statistical analyses, which might make it harder to detect findings that could in fact be significant. This explanation might be particularly true in the case of Norway, where fewer science teachers participated in the TIMSS study in comparison with Sweden. Among these participants, 57.7% of the Norwegian teachers stated they had never attended PD in the past 2 years in contrast to only 33.5% of the Swedish teachers (Table 7.1). Another possible explanation for the discrepancy might relate to how science teaching is delivered in both countries. In Norway, science is taught as an integrated subject whereas science is divided according to the subject domain (e.g., physics, chemistry, biology) in Sweden. Each subject domain would have a different teacher in Sweden. In other words, while only one science teacher is responsible for teaching a Grade 8 classroom in Norway, several subject-domain teachers are needed to accomplish similar tasks in Sweden. Taken together, the non-significant effects of PD in the Norwegian data might be attributable to the teachers' low participation in the PD activities and the small sample of teachers who participated in the TIMSS 2015 study.

Another plausible explanation could be due to differences in the quality of PD implemented in the two countries. For PD to have an impact on student learning, a certain level and type of quality are required (Boyle, Lamprianou, & Boyle, 2005; Timperley et al., 2007). Effective programs should be implemented for a considerable length of time and provide teachers with specific content focused on the curriculum and include active learning, collaborative activities, modeling of effective instruction, collegial collaboration, reflection, and continuous feedback (e.g. Darling-Hammond et al., 2017; Timperley et al., 2007). Sweden spent considerable resources and time

on PD for their teachers, and the courses were heavily based on research and structured planning (Gustafsson & Nilsen, 2017; Mullis, Martin, Goh, & Cotter, 2016; Ringarp & Parding, 2018). Conversely, the focus in Norway has been on mathematics teachers more so than science teachers, and even if the government in Norway has spent resources on teacher PD, it seems that few science teachers attended any programs (Martin et al., 2016).

While some studies have found a significant relation between PD and student outcome in Sweden (e.g. Gustafsson & Nilsen, 2017; Lindvall, 2017), no study has found a significant moderation of the relation between SES and achievement in Sweden. Although previous studies have investigated the moderation effects of PD on the relation between SES and achievement in Sweden and Norway, they did not include the *indirect* moderation effect via instructional quality (Nilsen & Bergem, 2020). This could be why this study found no significant moderation effect for Sweden or Norway. Including a mediated moderation model could then boost the power of the analyses as such a model to a large extent reflects the actual picture; in particular, teachers' qualifications in themselves are not valuable unless reflected in their teaching practices.

With regard to teacher specialization, the results showed that it contributed to reducing the importance of student home background in Sweden. Again, the findings for the Norwegian data were statistically insignificant. The aforementioned reasons for the lack of significant findings for Norway for content and hours of PD could also explain the insignificant effects of teacher specialization for Norway. Moreover, the Swedish data showed that 47.7% of the students had teachers who specialized in both science and science education, while only 17.2% of the students in Norway had access to such teachers (Table 7.1). Compared to the Norwegian teachers, Swedish teachers are required to take 50% more study points in science specialization to be formally qualified and allowed to teach this subject (Ministry of Education and Research, 2015; Skolverket, 2019). In addition, it is important to note that teacher specialization is only an indicator of teacher competence and not a direct assessment of teachers' knowledge and skills in science and science education. Such assessments are substantially more time-consuming for teachers and challenging to implement in ILSA studies. They require teachers to not only solve science tasks but also to answer the background questionnaire. Following this line of reasoning, the indirect assessment of teacher competence inherent in TIMSS could be one reason why the moderation and mediated moderation effects were not significant for teacher educational level in Norway or Sweden.

In summary, some possible explanations for why the content of PD, hours of PD, and teacher specialization reduced the strength of the relation between SES and achievement in Sweden and not in Norway may relate to the low statistical power (i.e., fewer teachers in the sample and fewer teachers who participated in PD activities in Norway) and the larger variations of students' SES in the Swedish data. Nevertheless, considering that previous studies have found that teachers' PD influenced student outcomes in Sweden but not in Norway (Gustafsson & Nilsen, 2017; Nilsen, Scherer, et al., 2018), it seems that the quality and length of the PD offered to the teachers in Sweden exceeded that of Norway. Perhaps improving the

quality and length of the training programs provided to science teachers in Norway could contribute to reducing the achievement gap between high- and low-SES students in Norway. Likewise, this suggestion could be applied to teacher specialization in Norway, as the average is substantially higher in Sweden than in Norway (Kaarstein, Nilsen, & Blömeke, 2016; Martin et al., 2016).

7.6 Limitations of the Study

As with all studies using ILSA data, no causal inferences can be drawn due to the cross-sectional design inherent in the studies. However, TIMSS has been repeated every 4 years since 1995, and the quality of this study has been enhanced for each cycle. TIMSS also implements a number of quality assurance procedures and pilots the survey in every cycle. In addition, this study's methodological approach of including multi-group and multilevel SEM is known to be the most robust and reliable analytical method for these types of research questions and offers higher levels of reliability and inferences.

Another limitation of this study relates to the low numbers of teachers who participated in TIMSS 2015, which may decrease the power in detecting significant findings. It may be argued that several of our findings would have been significant if more teachers had participated. This study could also suffer from construct underrepresentation when it comes to instructional quality. Although instructional quality is a multidimensional construct, TIMSS 2015 did not measure all aspects of instructional quality (e.g., classroom management). TIMSS 2019 has increased the emphasis on teacher practices by including all aspects of instructional quality. This change should consequently lead to higher validity and increase the power of the analyses in future studies.

7.7 Contributions and Implications

This study contributes to the knowledge base in the field of teacher quality and instructional quality. While it has been known for quite some time that instructional quality may mediate the relation between teacher quality and student outcome (Baumert et al., 2010; Blömeke et al., 2016), bringing together a mediation and moderation model represents a novel approach in this field. Although we found evidence only for the mediated moderation for teacher PD in Sweden, our findings indicate that researchers may want to examine such effects with teacher quality as the moderator. Teacher quality in itself (e.g., their specialization) is of little use unless it informs their classroom practices. For example, it is less likely that students achieve high learning outcomes from a teacher with a high educational level but with low instructional quality.

This study also contributes to the field of educational equity. While the number of studies examining equity is substantial, especially since the emergence of international large-scale studies, few have investigated the teacher's role in reducing inequity. Most of these studies have originated in the United States (e.g. Darling-Hammond, 2015), and very few have focused on the Nordic countries. It is especially interesting that professional development and teachers' specialization seemed to enhance equity in Sweden, given that Sweden has deviated from the Nordic model due to free school choice (Gustafsson & Yang Hansen, 2017, also see Chap. 2). In Chap. 3 there were strong indications that Sweden was an outlier compared to the other Nordic countries; regardless of how equity was measured and what methods were used, Sweden had a much lower level of equity. While Sweden's comparatively lower levels of equity is old news, our findings are uplifting, as Sweden's efforts to increase teacher competence may be a way back to the ideals behind the Nordic model.

One general implication of this study is that enhancing teachers' qualifications may increase the quality of their instruction and, ultimately, reduce the achievement gap between students. Providing PD for teachers and ensuring that teachers have sound qualifications may indeed reduce the effect of student home background on their achievement.

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