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TEACHING QUALITY, LIMITATIONS TO TEACHING, AND THEIR LINKS TO STUDENT ACHIEVEMENT:

Insights from Nordic Primary Schools

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SUMMARY

Classrooms with higher teaching quality were associated with higher learning outcomes in mathematics and science. Classrooms where teachers reported high degrees of limitations to teaching in the classroom—including disruptive students or students with language barriers—were associated with lower learning outcomes. These are two of the important findings of the Northern Lights book project examining the current state and trends in mathematics and science performance in Nordic primary schools using TIMSS (Trends in International Mathematics and Science Study) data from 2011, 2015, and 2019. The study also identified a worrying trend: a decline in aspects of teaching quality and increased limitations to teaching between 2011 and 2019. These negative changes were associated with decreased achievement over time. Fewer students perceived the teaching as supportive and clear, while teachers increasingly reported challenges in their teaching and learning, including students' lack of prior knowledge and absenteeism.

IMPLICATIONS

- Teacher support for students' learning and instructional clarity, as well as cognitive activation are related to mathematics and science achievement in Nordic countries. Highlighting the importance of incorporating these three aspects into teaching practice and teacher education to enhance student learning outcomes.
- Teaching quality, especially teacher support and instructional clarity has decreased over time in Nordic countries. The results imply that enhancing teaching quality through engaging teacher education and training, could improve student achievement over time.
- Nordic teachers struggle with increased classroom diversity, which may have contributed to decreased or stagnated student achievement since 2011. Implementing strategies to address these challenges may prevent the continued widening gaps between advantaged and disadvantaged students. Such strategies may include adaptations in teacher education and professional development toward more inclusive teaching strategies for diverse student populations.

INTRODUCTION

Student learning is deeply rooted in the daily practices and quality of teaching. While research has heavily focused on secondary education in Germany and the United States of America, there is a significant gap in our understanding of how teaching quality relates to student achievement in Nordic countries, particularly within primary education settings. While there are many video-based studies in the Nordic countries providing valuable knowledge (e.g., Klette, 2023), these studies do not have samples that are representative at the national level and findings may not be generalizable to the whole country. In addition, the gap in research is even more pronounced when considering longitudinal studies that track these dynamics over time.

Teaching quality is defined differently across studies. The present study is part of the Northern Lights book project, which uses a framework referred to as *The Three Basic Dimensions* to describe the teaching that takes place in the classroom (Klieme et al., 2009; Praetorius et al., 2018). These three dimensions are described in Figure 1 and have been found to have a positive impact on student learning outcomes (Baumert et al., 2010; Senden et al., 2021). The framework is validated and used extensively, in international large-scale studies: TIMSS, PIRLS, PISA, and TALIS (Klieme & Nilsen, 2022).

The Northern Lights book project specifically examines *teacher support and instructional clarity* within the aspects of *supportive climate* and *cognitive activation*.

Figure 1: Critical aspects of teaching quality

Classroom management	Supportive climate	Cognitive activation
• Focused and orderly learning environment • Lack of disruptive behavior • Effective time use • Clear routines, rules, and consequences	• Individual learning support • Teacher-student and student-teacher relationships • Instructional clarity • Engaging teaching	• Cognitively challenging learning tasks • Simulate cognitive engagement • Promote conceptual understanding • Engage in high-order thinking

► **Notes:** The figure was adopted from Klieme et al. (2009).

Teaching is inherently interactive and may be influenced by the compositions of students and their characteristics. For instance, if a large share of the students in the class do not speak the native language of instruction or interrupt class through disorderly behavior, the teaching quality may be limited. The importance of understanding such limitations to the instruction is underscored by immigration and societal shifts observed in Nordic countries, which have transformed classroom demographics and introduced complex challenges for educators. Teachers are tasked with accommodating diverse student needs, including variations in prior knowledge and language skills while addressing external factors affecting students' abilities to concentrate and learn, such as hunger and tiredness (Vik et al., 2022). Limitations to teaching caused by large shares of students with various challenges may be measured through the effect of classroom composition on teaching quality. However, teachers may vary in their opinion of what type of challenges they feel limits their teaching quality, and whether these challenges affect their teaching. Teachers' responses to what they believe limits their instruction may be a more valid measure than a direct measure of student composition.

In this brief, we investigate whether the changes in mathematics and science achievement in Nordic countries may be related to changes in *teaching quality* and *limitations to teaching* over time, focusing on three research questions:

1. To what extent do teaching quality and limitations to teaching relate to student achievement?
2. How have teaching quality and limitations to teaching changed over time?
3. How are changes in teaching quality and limitations to teaching related to changes in student achievement over time?

DATA & ANALYSIS

Data from fourth-grade students participating in TIMSS cycles between 2011 and 2019 from Denmark, Finland, Norway, and Sweden were analyzed. Note that Norway changed their target grade to fifth grade in 2015. *Student achievement* was assessed through standardized mathematics and science tests developed to align with the curricula in TIMSS-participating countries and designed to ensure comparability across countries. *Teaching quality* was measured through responses from both students and teachers regarding instructional methods, covering two of the three aspects of teaching quality, teacher support and instructional clarity (student reports), and cognitive activation (teacher reports). Classroom management in mathematics and science classrooms was first introduced in 2019 and had to be excluded.

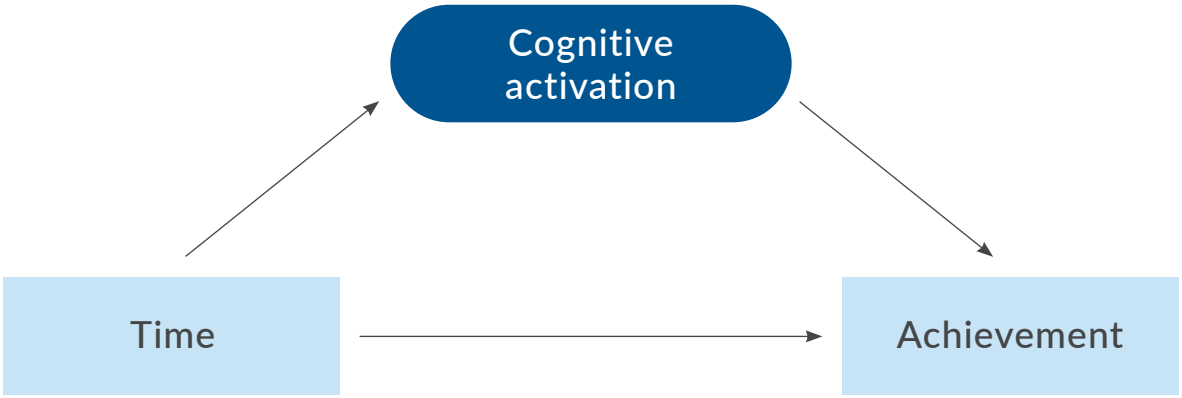
Limitations to teaching were measured by teachers' responses to whether the teaching was limited by: disruptive students, students with difficulties understanding the language of instruction, students lacking prerequisite knowledge or skills, students not getting enough sleep, or students with mental, emotional, or psychological requirements. The scale was turned so that higher values reflect less limitations.

The data was analyzed by using structural equation modelling. The regression coefficients reflect the strength of the relation between two constructs or variables. The analyses were conducted at the classroom level and accounted for the hierarchical design where students are nested within classrooms.

To analyze whether changes in relevant constructs, such as cognitive activation, are related to changes in achievement, we first create a variable called Time. Time is given the values of 0 for the 2011 cycle, 1 for 2015, and 2 for 2019. In other words, the values increase with each cycle. Next, we investigate the effect of Time on achievement in each Nordic country as illustrated in Figure 2. If a country's achievement has increased by 10 points, the regression coefficient will be approximately 10. We then investigate the effect of Time on cognitive activation. If cognitive activation has improved, this coefficient is positive, and if it has declined, it is negative.

Lastly, we investigate whether changes in cognitive activation can "explain" the changes in achievement over time. This is assessed through a statistical measure called the *indirect effect*. If the *indirect effect* coefficient is positive, for instance, with a value of 2, this suggests that 2 out of the 10-point increase in achievement is associated with an increase in cognitive activation. Other variables not included in the model may also explain the increased achievement.

Figure 2: A mediation model to investigate whether cognitive activation mediates (explains) the changes in achievement over time



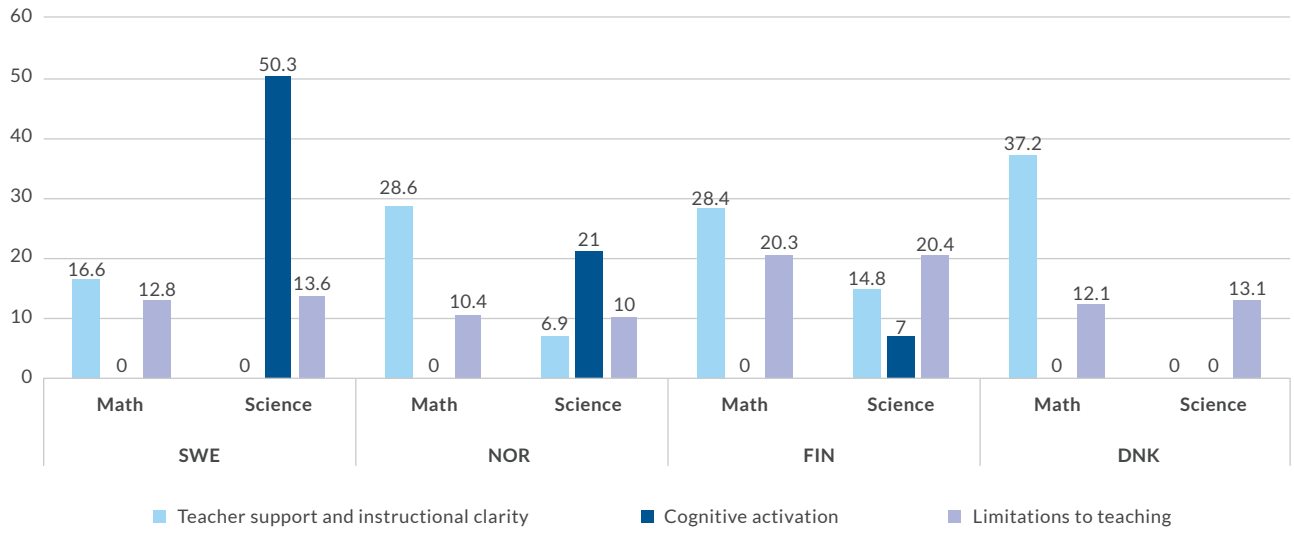
► **Notes:** Further details on the data and analytical approach can be found in Nilsen and Gustafsson (2024).

RESULTS

1. *The relationship between teaching quality, limitations to teaching, and student achievement.*

Figure 3 displays the significant relationship in terms of estimated regression coefficients for each of the Nordic countries included. The insignificant findings are denoted by a 0 in the figure. The regression coefficients reflect the strength of the relationship between the predictor (e.g., cognitive activation) and achievement.

Figure 3: Relationships between teaching quality and limitations to teaching with student achievements in mathematics and science



► **Notes:** The estimates in the figure are unstandardized regression coefficients based on the merged data between 2011, 2015, and 2019. A zero value indicates that no significant indirect effect was found. SWE = Sweden, NOR = Norway, FIN = Finland, DNK = Denmark

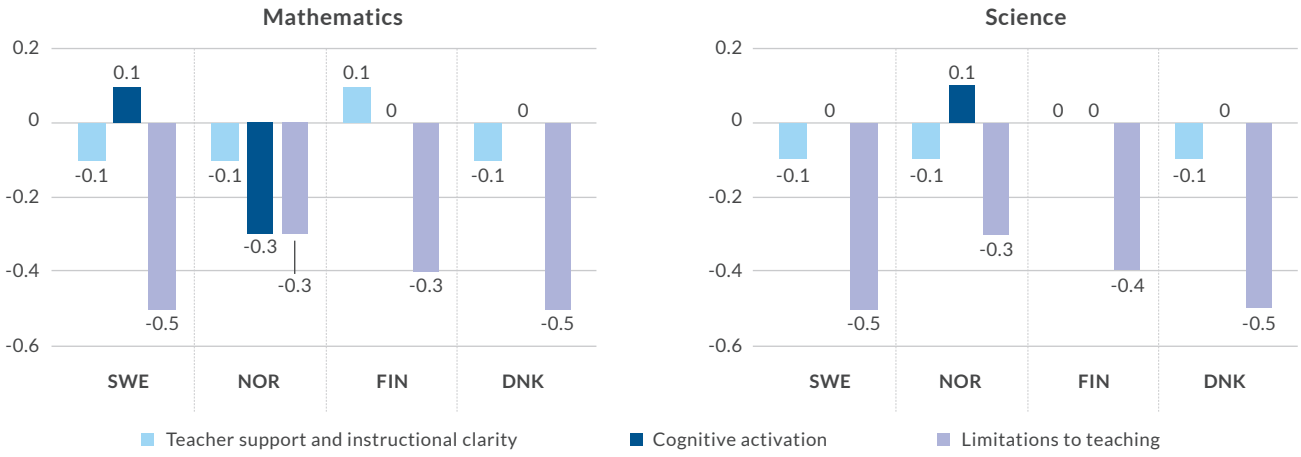
Findings for Science

In Sweden and Denmark, no significant relationship was observed between teacher support and instructional clarity with science achievement. Consequently, these are denoted by a 0 in Figure 3. In Norway and Finland, the relationship between teacher support and instructional clarity and achievement were 6.9 and 14.8, respectively. This means that enhancing teacher support and instructional clarity by one unit corresponds to an increase in science achievement of 6.9 points for Norway and 14.8 points for Finland. These are both small effects, albeit twice as large in Finland than Norway. For cognitive activation in science, there was a strong relationship with achievement in Sweden of 50.3. This effect size is considerable, exceeding half the standard deviation of international science achievement (the international standard deviation is 100). Limitations to teaching had a significant relationship to science achievement in all countries. Positive values of limitations to teaching reflect less limitations. Hence, less limitations were associated with higher achievements. The strongest relationship was found in Finland.

Findings for Mathematics

A consistent significant pattern emerges regarding the positive relationship between teacher support and instructional clarity with mathematics achievement in all Nordic countries. The strongest relationship is found in Denmark (37.2). In contrast, the results for science achievement display fewer significant findings and relatively weaker correlations. There were no significant findings for cognitive activation. Finally, limitations to teaching exhibits a significant relationship with mathematics achievement in all Nordic countries, with Finland demonstrating the most pronounced association. This means that less limitations to teaching are associated with higher mathematics achievement.

Figure 4: Changes in teaching quality and limitations to teaching in mathematics and science from 2011 to 2019



2. *Changes in teaching quality and teaching quality over time.*

This part of the study revealed a significant and concerning trend across Nordic countries: limitations to teaching as reported by the teachers increased over time, from 2011, through 2015 to 2019. This means that teachers in 2019 reported that their instruction, to a larger degree, was limited by various challenges (such as disruptive students) than in 2011. The changes were largest for Denmark and Sweden. The numbers are regression coefficients and may be interpreted as follows: a change in one unit in Time (i.e., from one cycle to the next) is associated with 0.5 in the value of limitations to teaching in Demark and Sweden. The coefficients are difficult to interpret, so we provide an example from Denmark using numbers from the international reports (e.g., Mullis et al., 2020). In Denmark, 43% of the students had teachers reporting that limitations were low in 2011, while in 2019, this decreased to 33%, and the change was significant. Meaning limitations to teaching increased from 2011 to 2019.

The changes in teaching quality were less pronounced. The largest change occurred in Norway, where cognitive activation during mathematics teaching decreased from 2011 to 2019. Teaching was less stimulating in Norway in 2019 than in 2011. Across all Nordic countries and both subjects, there was a consistent pattern of reduced teacher support and instructional clarity over time, except in Finland.

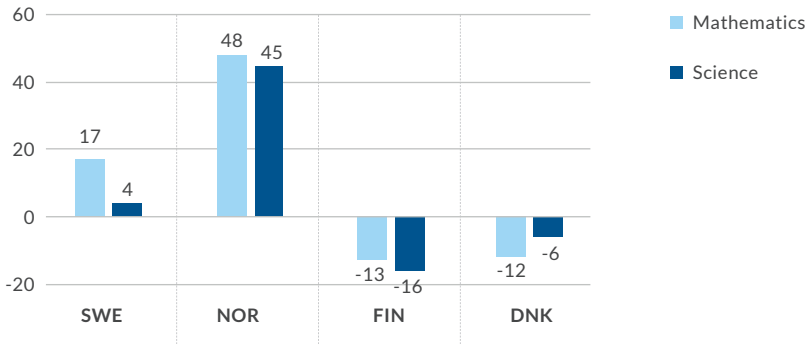
3. *The relationship between changes in teaching quality and limitations to teaching with the changes in student achievement.*

To be able to establish the association between changes in teaching quality and limitations to teaching with the changes in achievements, three criteria need to be fulfilled:

1. Teaching quality and/or limitations to teaching must exhibit changes over time
2. Achievement must also change over time
3. These two changes must be related

To facilitate the interpretation of the results, we present the changes in achievement in mathematics and science from 2011 to 2019 (Mullis et al., 2020), which are displayed in Figure 5. It may appear that Norway has improved its achievements since 2011. However, this apparent increase in achievement for Norway is most likely also caused by the change in the target grade from fourth to fifth grade in 2015. This change in target grade makes it difficult to interpret these changes in achievements. Apart from Norway, Sweden demonstrated the most substantial and significant improvement in mathematics achievement (a gain of 17 points) over the same period according to the TIMSS international report from 2019 (Mullis et al., 2020). The declines in mathematics for Denmark and Finland were significant. The decline in science achievement for Finland was significant, while the decline in science achievement for Denmark was not. The increased science achievement for Sweden was not significant.

Figure 5: Changes in student achievement from 2011 to 2019

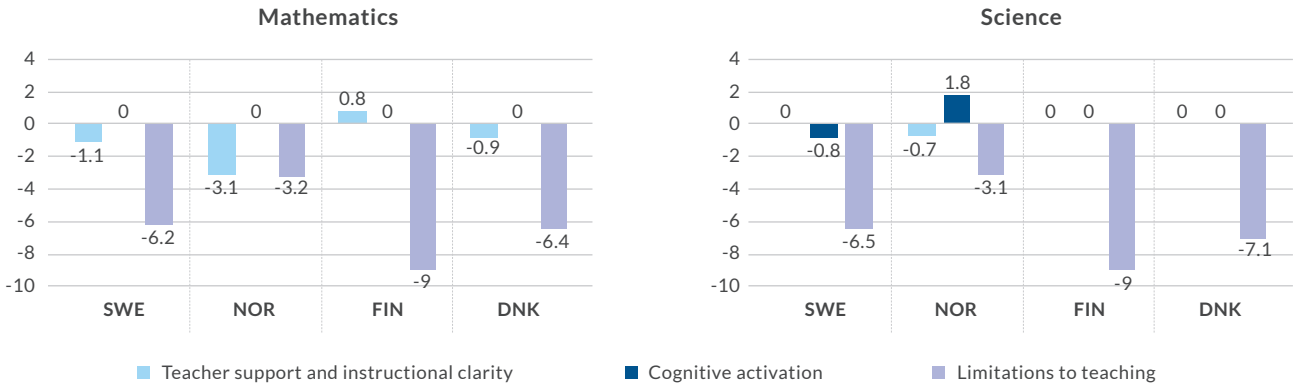


► **Notes:** Results are retrieved from Mullis et al. (2020), and the standard deviation is 100.

Figure 6 illustrates how changes in teaching quality and limitations to teaching are related to changes in mathematics and science achievement over time, respectively. The numbers in Figure 6 are the so-called indirect effects and reflect whether the effect of Time (from 2011 to 2019) on achievement is mediated (or "explained") by, for instance, cognitive activation. For example, the effect of Time on achievement in mathematics is 17 points for Sweden, as shown in Figure 5. The question is whether this change in achievement over Time is associated with the increased cognitive activation that took place during this period in Sweden. If the indirect effect is positive and significant, then there is a relation between the changes in cognitive activation and the changes in achievement over time.

Limitations to teaching exhibit the strongest findings. Across all countries, the indirect effect of limitations on teaching is negative. This implies that the changes in achievement over time are strongly related to the increased limitations to teaching. Finland's science achievement declined by 16 points from 2011 to 2019. The negative change in limitations to teaching is associated with a 9-point decrease in science achievement. It is possible that a large part of the declining achievement in Finland can be attributed to the increased limitations to teaching.

Figure 6: How changes in teaching quality and limitations to teaching are related to changes in mathematics and science achievements over time



► **Notes:** The figure shows the significant indirect effects of the aspects of teaching quality and limitations to teaching that mediate the relation between time and achievement.

Similarly, Norway's mathematics achievement was 48 points higher in 2019 than in 2011 (likely due to the change in target grade from fourth to fifth grade). Regardless of what caused the difference in achievement between these two timepoints, the relationship between increased limitations to teaching and increased achievement is -3. This might imply that the achievement would have increased more had it not been for increased limitations to teaching, although the change in target grade calls for caution of inferences.

The results are not as clear for the aspects of teaching quality. No consistent pattern emerges across the Nordic countries, and the relationship between changes in teaching quality and changes in achievement is weak. The strongest relation is observed in Norway, where the declining teacher support and instructional clarity in mathematics corresponds to a 3-point decrease in mathematics achievement. Interestingly, these results suggest that without the decline in clarity of instruction, the increased achievements may have been even higher.

DISCUSSION

The current findings reveal significant relations between teacher support and instructional clarity with mathematics achievement in all Nordic countries. Results on cognitive activation were more mixed, with more pronounced relations to science than mathematics achievement. This could be due to many of the items measuring cognitive activation in mathematics changing over time, resulting in a construct measured by few indicators, and potentially not fully covering the property of the concept.

Limitations to teaching emerged as a critical factor significantly related to student achievement in all countries. This finding corroborates previous research (e.g., Fauth et al., 2021; Vik et al., 2022), indicating that achievements will be reduced in classrooms where the teaching is limited by students facing challenges related to for instance, language barriers or prior knowledge.

Regarding changes over time, a consistent pattern of perceived decreased teacher support and instructional clarity was observed in both subjects and in all countries except Finland. These changes were small but significant. The reasons behind students' perception of their teachers as less supportive and instruction as less clear remain an open question. One

explanation could be that teachers found it more challenging to teach in 2019 than in 2011 due to the various challenges (e.g., disruptive, unmotivated, or tired students).

Another explanation is that the increased proportion of immigrant students in 2019, compared to 2011 as reflected, for instance, in the TIMSS international reports (Mullis et al., 2020). The immigrant students may perceive instruction as less clear due to language difficulties. Interestingly, this negative trend occurred in all countries except Finland. Finland's unique situation, with a significantly smaller proportion of students who do not speak the language of instruction at home (Mullis et al., 2020), could perhaps account for this difference.

The results also revealed significant relations between declines in teacher support and instructional clarity with changes in student achievement over time, especially in mathematics. However, the relations were weak, and the pattern was only consistent for all countries (except for Finland) in mathematics.

The strongest and most persistent pattern across countries and subjects were teachers' perception of limitations to teaching. The increased limitations on teaching was strongly associated with a significant decrease in student achievement. These findings are supported by previous studies (e.g., Vik et al., 2022) and point to the need for teachers and teacher education to adapt to more heterogenous classrooms in the Nordic countries.

The study highlights the importance of the various aspects of teaching quality for student learning outcomes. However, the increased limitations to teaching seen considering the future of educational equity in Nordic education systems is not positive. As teaching has become more complex and demanding, teachers today face more challenges, especially in heterogeneous classrooms compared to more homogeneous settings. Adaptations in teacher education and professional development are important to equip student teachers and teachers with effective and inclusive teaching strategies for diverse student populations.

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