Mathematical modelling in Norwegian schools

A study of teachers' conceptions and practices, and views on potentials and challenges

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This study explores Norwegian school mathematics teachers' (grade 5–10) conceptions and teaching practices regarding mathematical modelling, as well as their views on its potentials and challenges, following the inclusion of mathematical modelling in the current Norwegian national curriculum — The Knowledge Promotion Reform (LK20). Ten mathematics teachers took part in semi-structured interviews. The findings show that most teachers conceptualise mathematical modelling in line with the curriculum, however, the teachers lack understanding from a cognitive perspective. The teachers focus on student engagement in their teaching practices that also emerged as a significant challenge, in addition to finding good tasks and guiding and evaluating students' work.

Keywords: Mathematical modelling, lower secondary school teachers, primary school teachers

Mathematical modelling (MM) is being integrated as a compulsory component in mathematics curricula in many countries worldwide (Borromeo Ferri, 2021). In Norway, the latest curriculum reform in schools (LK20) (The Norwegian Directorate for Education and Training (Udir), 2019) has led to the inclusion of *Modelling and applications* as one of the six core elements in mathematics curriculum. After the introduction of the new curriculum, it is necessary to explore Norwegian teachers' experiences with teaching modelling as teachers play a central role in implementing MM in schools (Blum, 2015). Although some previous studies explored teachers' experiences globally (e.g., Xu et al., 2022) and in Nordic countries (Frejd, 2012), no research has yet examined how Norwegian teachers perceive and implement MM following the recent LK20 curriculum reform. This study is therefore the first to investigate Norwegian

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teachers' (grades 5–10) conceptions, practices, and views on the potentials and challenges regarding teaching of MM. The findings provide insights about implementation of modelling in schools and offer implications for teacher education and future curriculum development. The following research questions are addressed.

RQ1: How do Norwegian school teachers conceptualise mathematical modelling and practice its teaching?

RQ2: What potentials and challenges do Norwegian school teachers express regarding the implementation of mathematical modelling?

Theoretical background and prior research

The notion of mathematical modelling (MM)

Mathematical modelling deals with solving problems from real world situations (Blum & Niss, 1991). The cognitive perspective, the most influential approach to MM in international research literature, deals with the cognitive processes that take place during the modelling process (Schukajlow et al., 2023). The process of solving modelling problems is conceptualised as a cycle that involves many stages such as understanding the problem situation, structuring the problem, making assumptions, formulating and solving the problem mathematically, and interpreting and validating the results (Blum & Leiß, 2007; Borromeo Ferri, 2006).

The core element of Modelling and Applications in Norwegian curriculum describes modelling as "creating such [mathematical] models" and "to evaluate whether the models are valid and what limitations the models have, evaluate the models in view of the original situations, and evaluate whether they can be used in other situations" (Udir, pp. 2–3). Furthermore, it includes that the students "shall gain insight into how mathematical models are used to describe everyday life, working life and society in general" (pp. 2–3).

Teachers' conceptions and practices of MM

Teaching of MM requires working with real problem situations that allow students understand ways in which mathematics is relevant for the real world. The selection of modelling problems that provide opportunities for establishing connections between mathematics and real world is central to effective teaching of MM (Maaß, 2010). Dealing with real problem situations makes the orchestration of teaching demanding (Blum & Borromeo Ferri, 2009). Quality teaching of modelling also demands for an effective and learner-oriented classroom management where several methods are used flexibly while maintaining a balance between teacher guidance and student independence. Quality teaching of modelling thus demands a lot of different teacher competencies such as mathematical and extra-mathematical knowledge, ideas for tasks and teaching, and appropriate beliefs about MM and mathematics (Blum, 2015; Wess et al., 2021).

Prior research exploring teachers' conceptions and practices with MM in various global contexts has shown variations between the countries. In Nordic context, Frejd (2012) interviewed Swedish upper secondary school teachers and found that teachers had limited experiences with the notion of MM at that time. Most of the teachers described MM as "designing a mathematical model based on a situation (i.e. simplify and describe something with mathematics)" (p. 34). However, the situation may have changed over the past decade as modelling is no longer a new topic in the curriculum. In Norwegian upper secondary schools, Berget (2023) found that teachers lacked familiarity with the concept of MM, even though it had been explicitly included in the upper secondary curriculum for decades. The teachers relied on textbooks that portrayed modelling as regression analysis and solving functions where the relevant variables were identified and a single correct answer was expected. Given scarcity of research in this field, results from studies on pre-service teachers also provide a relevant context for this study. Norwegian pre-service teacher students are reported to consider active engagement of students crucial for MM activities (Hansen, 2021; Kacerja & Lilland, 2021). Globally, for example in Chile, Guerrero-Ortiz and Borromero Ferri (2022) found that pre-service teachers created word problems in which all information was provided, instead of realistic situations, preventing students' engagement with the full modelling cycle. While in China, the mathematics teachers emphasised a holistic view of teaching and learning of MM, that is working through all the stages of modelling cycle (Xu et al., 2022).

Potentials and challenges of MM

The integration of MM offers several potentials, as reflected in the literature. Niss and Blum (2020) outline two overarching goals for inclusion of MM in mathematics education. The first, *modelling for the sake of mathematics*, emphasises modelling as a tool to enhance mathematical understanding, referred also as modelling-as-vehicle by Julie (2002). The second goal, *mathematics for the sake of modelling*, emphasises modelling as a content area, referred also as modelling-as-content (Julie, 2002). Berget and Bolstad (2019) note that, in addition to these two goals, the Norwegian curriculum also emphasizes the value of modelling for developing students as critical and reflective citizens, referred to as the perspective of modelling-as-critic (Barbosa, 2006).

Blum (2015) presents four justifications for integrating MM in curricula and everyday teaching. *Pragmatic justification* is grounded in the view that modelling is useful in everyday life; *formative justification* emphasizes that engaging in modelling activities aids in the advancement of general mathematical competencies. *Cultural justification* regards connections to the extra-mathematical world essential for a comprehensive understanding of mathematics as a science. The last, *psychological justification* includes that real-world examples enhance students' interest in mathematics, exhibit relevance of mathematics, to motivate or structure mathematical content, facilitate better comprehension, and longer retention (Blum, 2015, p. 81).

Scholars have also highlighted several prospective challenges in the implementation of MM. Blum (1996) refers to four categories of obstacles: student-related, teacher-related, organisational, and material-related. Student-related obstacles refer to students' difficulties in carrying out modelling activities and inclination towards standard calculation tasks. Teacher-related obstacles refer to time aspects such as less time to prepare for the mathematical and teachers' skills, competencies (cf. Blum, 2015), and beliefs regarding MM. Organisational obstacles refer to the limited amount of time in mathematics lessons. Material-related obstacles concern limited resources such as knowledge about modelling tasks. Burkhardt (2006) highlights systemic barriers that hinder the effective implementation of MM. These barriers include insufficient professional development for teachers, difficulties in addressing real-world situations within modelling, a lack of organized research to support teaching of MM, and a general systemic resistance to change within educational institutions.

Empirical research shows that teachers around the world encounter different challenges in implementing MM. For instance, Norwegian preservice teachers find it challenging to balance student independence and teacher guidance during modelling activities (Hansen, 2021; Kacerja & Lilland, 2021). Manouchehri (2017) found that US school teachers enrolled in a professional development course faced mathematical, epistemological, and pedagogical challenges when implementing MM. These included difficulties with mathematical approaches and making assumptions, reconciling personal experiences with the modelling process, and managing classroom integration of modelling tasks. In a French Spanish context, Cabassut and Ferrando (2017) found that teachers across all levels, from primary to tertiary education, struggled with managing time, engaging students, and addressing lack of resources. Ferrando et al. (2025) reported that Spanish pre-service teachers experienced significant difficulties in designing MM problems and assessing their characteristics such as authenticity, openness, and complexity even though modelling is explicitly addressed in Spanish teacher education programs and after receiving specific training on modelling. German teachers' obstacles include lack of time, insufficient resources such as example tasks, and managing assessment processes (Schmidt, 2011). Yang et al. (2025) report Chinese upper secondary school teachers' obstacles as absence of modelling in teacher education as well as textbooks and teaching materials, students' limited prior knowledge and interest in MM, an unfavourable curricular tradition and school policies, and a strong traditional emphasis on examination culture. Xu et al. (2022) report that Chinese teachers perceived the absence of MM in the college entrance examinations as a challenge in devoting time to teaching of MM.

The study, participants, and data collection

This study is an exploratory case study (Yin, 2014) involving primary and lower secondary school mathematics teachers in Norway. We sent participation requests to the teachers through school principals and through our colleagues. The participants were informed about the topic of the interview in the participation request so that the teachers could make informed decision, however, the interview questions were not shared beforehand. Ten teachers from three different regions in Norway agreed to participate voluntarily. Two of the teachers worked at primary school while eight worked at lower secondary school level. The teachers had varying years of experience (see table 1).

Table 1. *The Ten Participant Teachers' teaching grade and years of experience.*

Teacher	Grade	Teaching experience	Teacher	Grade	Teaching experience
T1	5-7	14 years	T6	8-10	1 year
T2	8-10	25 years	T7	8-10	42 years
T3	8-10	10 years	T8	8-10	10 years
T4	8-10	5 years	T9	8-10	11 years
T5	5-7	10 years	T10	8-10	11 years

The data was collected through semi-structured interviews (Freebody, 2003) that involved questions regarding following seven topics: 1) education and previous experience with MM, 2) experiences with implementation, 3) understanding of the notion and role of MM, 4) selecting activities, 5) instructional strategies, 6) understanding of own teaching practices, and 7) challenges. The questions in these topics were interrelated (see interview guide in Appendix) and were included with the aim of prompting teachers to elaborate on different aspects of their teaching experience related to the teaching of MM. We did not necessarily pose all the questions from the interview guide when teachers had already reflected on those aspects.

The interviews were conducted in Norwegian language. Four of the interviews were held digitally because the teachers were located in regions different from those of authors. The interviews were audio-recorded using a mobile research application that encrypts the audio and stores the data on an online research server. Using the same tool, the transcripts were automatically generated in Norwegian language. The second author checked and adjusted the transcripts while listening through the audio-files.

Data analysis

The analysis of interview transcripts was inspired by techniques of grounded theory (Strauss & Corbin, 1998). The process started with *open coding* that provides "insights by breaking through standard ways of thinking about or interpreting phenomenon reflected in the data" (Corbin & Strauss, 1990, p. 12). The events and instances are given conceptual labels in open coding, and conceptually similar events are later grouped together in subcategories and categories. We assigned labels to the open codes that closely aligned with original statements in the data in order to prevent simplistic interpretations later, and we created new codes for slight variations from the existing ones to maintain proximity to the data. For example, in teachers' conceptions (RQ1), teachers mentioned specific links with mathematics and the codes reflect the words that teachers used such as apply, make models, find mathematical relationships (see table 2). Same excerpts of data were coded more than one time under different codes. For example, when T10 explained their conception of modelling as:

> Yes, modelling is when we look at a relation. We find a mathematical relation. [...] That there is something in reality that we model, describe in a mathematical language. One example is calculating how much something [e.g. apples] costs in the store. A such task can introduce modelling. The price of an item will change. The model is to multiply the price per kilogram with the amount of kilograms. That is the same as it is done in the store.

Table 2. *Codes and categories regarding teachers' conceptions of the notion of MM.*

Categories	Codes and frequencies	Frequency
Making connections between mathematics and real life	Describe reality using mathematics (7) Modelling reality (2)	9
Using mathematics in particular ways in real situations	Use mathematics to make models (3) Use mathematics practically (2) To find mathematical relationship (1) To apply mathematics (1) To connect mathematics with data from situations (1)	8
Relations with other themes in mathematics	Using concrete tools in mathematics (2) Functions (2) Problem solving (1)	5
Critical evaluation	Critical evaluation (3)	3
Don't know, not sure	I don't know, but make models in geometry (1) Show how to do things, but not sure (1)	2
Modelling is an interdisciplinary topic	Modelling is an interdisciplinary topic (1)	1

We interpreted this excerpt to mean that, while T10 focused on connections to reality explicitly, the teacher also focused on finding a mathematical relationship. Therefore, this excerpt was coded under *describe reality using mathematics* and *to find mathematical relationships*. For teachers' conceptions, we coded answers to the direct questions asked in the interview. Other aspects such as challenges were coded in the whole interviews since the teachers mentioned challenges before the question about challenges (question 7, see Appendix) was asked.

Next, we looked for emerging categories by comparing the open codes to check if the concepts and events in different codes aligned and if similar codes were grouped together (to achieve precision) in all instances (to achieve consistency) (Corbin & Strauss, 1990). We compared the open codes by revisiting the original transcripts to verify their distinctiveness and discern the nature of differences. The codes that were similar were merged, and the identified errors in the coded excerpts were rectified. For example, for the categories about teacher's conceptions of MM (table 2), the codes where teachers linked reality with mathematics generally were merged into the category *making connections between mathematics and real life*. The codes where the teacher specified the use of mathematics (such as apply, make models, find mathematical relationships) were merged together to form the category *using mathematics in particular ways in real situations*. The difference in these two categories is thus the emphasis placed on connections to reality in the former and on mathematics in the latter.

The coding was performed collaboratively keeping one unified code book in NVivo. For open coding, both authors coded the first two interviews individually, and discussed the results achieving a shared understanding before consolidating the codes. After that, we alternated open coding of every two interviews in a sequential manner. In the next step of identifying categories, we worked individually first and then we discussed emerging differences together to achieve shared categories reported in the results.

In Results section, we report identified categories and the respective frequencies in table 3–7, while we elaborate on the codes within the text. The frequency for each category is determined by counting frequencies of all open codes once per interview and summing up. In some instances, the frequency of a category surpassed the number of participants, which indicates that multiple open codes emerged from interviews with individual teachers. The examples of such categories are *plan*, *lead*, *and evaluate*, and *student-related* that emerged in the challenges (table 7). The frequencies are reported for the purpose of transparency (Maxwell, 2010), and the frequencies alone do not determine the importance of the categories (Hennink et al., 2017).

Results

Teachers' conceptions of MM and teaching practices (RQ1)

The lower secondary school teachers (eight out of ten, see table 1) expressed definite and multifaceted conceptions of the notion of MM.

Most common category of the conceptions from these teachers emerged as (see table 2) modelling involves *making connections between mathematics and real life* where teachers described modelling as a way to describe (or model) reality using mathematics. The second most common category in conceptions emerged as *using mathematics in particular ways in real situations* such as finding mathematical relationships in real situations, working with mathematics practically, and others. This shows that working with real life situations and working with mathematics are equally important and crucial elements in lower secondary school teachers' conception of MM. Moreover, links between MM and other areas in mathematics such as *using concrete tools*, *functions*, and *problem solving* were mentioned. *Critical evaluation* of models emerged only three times and *modelling is an interdisciplinary topic* emerged once. Two teachers who were uncertain about the concept of MM taught mathematics in primary school grades, and their responses revealed misconceptions, incorrectly viewing MM as simply demonstrating something visually and creating physical geometric models using manipulatives.

Out of the ten teachers, three described actively practicing teaching of MM, five as less explicit (indirect, or less integrated), and two as minimal (question 2a, appendix). Their teaching practices are organized around three dimensions that emerged from the data: teachers' selection or creation of tasks, characteristics of modelling task and activities, and classroom organisation. In the first dimension concerning teachers' selection or creation of modelling tasks (see table 3), the dominant practice involved teachers selecting or getting ideas about tasks and activities from the textbooks, by searching the Web, and on specific Web pages[1]. Some teachers mentioned keeping a collection of tasks for further use and making own tasks (not always successful). An experienced teacher, T7, mentioned that they had a collection of tasks they could choose from, and gained inspirations from the researchers they had collaborated with. Others mentioned that they collaborate and exchange ideas with teachers at same grade level in their school concerning selection of the tasks and activities.

Table 3. *Categories regarding the dimension of "teachers' selection or creation of tasks" in practices.*

Categories	Frequency
Choose activities and tasks from textbooks and internet	7
Teachers collect, store or make tasks	4
In collaboration with colleagues, companies and researchers	2

Concerning the second dimension, characteristics of a modelling task or activity (see overview in table 4), teachers placed most emphasis on engaging tasks that connect to specific interests of the student group in question and the tasks that ensure active participation from students across all achievement levels.

Table 4. *Categories regarding the dimension of "characteristics of a modelling task or activity" in practices.*

Categories	Frequency
Provide student engagement	12
Students must use mathematics	6
Allow for thinking students	4
Open tasks	4
Connections to functions and regression analysis	4
Practically possible to carry out	2

The next important characteristic identified is that the students must be able to use mathematics while solving modelling tasks. That is, students should be able to get or derive an exciting mathematical formula, show the mathematics they use, or show an understanding of mathematics. Further, open tasks and the tasks that allow students to think were mentioned. Some teachers mentioned the mathematical topics of functions and regression analysis explicitly while referring to modelling activities, and the associations with the topic of functions also emerged in some teachers' conceptions (see table 2). Furthermore, the tasks that are allowed to be carried out at school, keeping in mind resources and time involved, were least mentioned (table 4).

In the third dimension of practices, organisation of classroom (see table 5), most emphasis was placed on students' collaborative work in different forms including small group work, larger projects, Individual-Groups-Plenum, and pair work. The teachers mentioned that they use sufficient time while organising modelling activities to make the students get used to making mistakes, and some work over longer periods with modelling problems. The organisation of *student-led activities* was mentioned both positively and negatively. Some appreciated these activities for peer learning, even when the students were not experiences with working with open modelling tasks, while others mentioned that the student-led activities did not work in their classroom as the students could not handle the tasks on their own.

Table 5. *Categories regarding the dimension of "organisation of classroom" in practices.*

Categories	Frequency
Diverse student collaboration	12
Set aside sufficient time	5
Student-led activities (positive experiences)	3
Student-led activities (negative experiences)	2
Provide a safe learning environment	2

Teachers' views about potentials and challenges in implementing MM (RQ2)

Teachers recognised various potentials of MM (table 6). The most emphasized potential is *for practice-oriented teaching in mathematics*. In this regard, T4 expressed, "I think it [modelling] is a way to make it [mathematics] practical, and link mathematics, [and] topics that can be perceived as abstract to something close to reality". Several categories concerned students' understanding of mathematics, its relevance, and student engagement, which were almost equally emphasized. For instance, the teachers emphasized that modelling contributes to *students' mathematical understanding*, *student engagement*, allows *students see how they can use mathematics*, allows *students see why they should learn mathematics* (table 6). Concerning student engagement, teachers gave reasons such as modelling tasks possess the capacity to involve all students in classroom, despite the level of knowledge in mathematics modelling activities lead to inclusive classroom discussions and promote engagement in general. It should be noted that teachers recognize modelling' s potential for student engagement, but its role as a *motivating* factor is among the least acknowledged (see table 6).

Some teachers considered MM as way to work in line with *curriculum and [format of] examination* (table 6). T3 said, "application has become much more important, according to the curriculum, in the entire curriculum and in exams. So, understanding math is more than just memorizing math. So, we are pushed in that direction". Though sparingly, teachers mentioned to *solve problems in the future* and for *students' development as critical and reflective thinkers* as potentials of MM. T8 referred to critical thinking in the context of evaluating the appropriateness of mathematical models, "[the students] must use their knowledge to find: can this describe reality in a good way? They must learn to reflect on strengths and weaknesses. A mathematical model will not always fit a 100%. A model will have some strengths and some weaknesses".

Table 6. *Categories regarding teachers' views of potentials of MM.*

Categories	Frequency
1. For practice-oriented teaching in mathematics	8
2. Students see how they can use mathematics	6
3. For students' mathematical understanding	5
4. Student engagement	5
5. Curriculum and examination	5
6. Students see why they should learn mathematics	4
7. To solve problems in the future	4
8. For students' development as critical and reflective thinkers	3
9. Motivating	3

Teachers voiced several aspects of teaching of MM as challenging (table 7). The dominant category of challenges is *plan, lead, and evaluate* that involved aspects concerning teaching in classrooms. The most common challenge that emerged is teachers' difficulty in finding good tasks while planning for modelling, followed by challenges in conducting ongoing and final evaluation, managing application of advanced mathematics, and finding time to guide all groups in classrooms. T6's statement exemplifies some of the challenges:

> ...The challenge is to find good tasks that actually align with what they [the students] are supposed to work on and need to work on. They often want to choose the easiest way. So, they are not interested in generalizing or things like that ... It is very difficult to assess a modelling task. You can assess some kind of performance of the bungee jump task [a modelling task]. But on the other hand, as long as they solve it, they solve it. So, it is very difficult to do ongoing evaluation on it.

Next, teachers mentioned several *student-related* challenges pertaining to engagement, motivation and difficulty level. Some teachers mentioned that modelling is unusual for some students and linked this challenge with students' prior experiences. For instance, T2 explained that the students "are focused on producing a lot of correct answers" while T6 noted that "when they come from primary school, they are perhaps not used to open tasks (T6)". Some teachers mentioned that it is difficult to engage students to get started with modelling and to have student-led activities. Others mentioned that modelling is demotivating for students, is very difficult for some students, and that students are very different. T3 stated:

> I know the theory says that if you connect it [the modelling activity] to their everyday life, students can be motivated. But in my experience, this is not the case. What motivates them is knowing what to do, having a feeling that you can wrap things up. [...] And it is motivating because they believe they can succeed.

Another significant category emerged as *teachers' lack of experience and knowledge* (table 7), which involved aspects that individual teachers found challenging. The dominant of these aspects include uncertainty about the amount of time that should be used on MM and how modelling can be concretized. Teachers' personal views of what is effective teaching, difficulty in differentiating between problem solving and modelling, and difficulty in understanding the notion of modelling in general, were other challenges voiced in this category. *Curriculum-related* challenges refer to some teachers' difficulties with focusing on extensive number of contents in the new mathematics curriculum in the given time. T6's statement below exemplifies the challenges related to managing time and contents in the curriculum

> Because I have the competence aims in mind when I am planning my teaching. How I can cover all the competence aims over the course of a year. And then figuring out where modelling fits in. And yes, it does fit in everywhere. I do know that. But specifically, in a single lesson or a week, where can I actually fit it in? I find that difficult.

Other less mentioned challenges were *Covid-related*, pointing to disruptions due to the pandemic at the time of the introduction of new curriculum, and related to structural constraints pointing to fixed timetable in schools and few opportunities for off-campus modelling activities.

Table 7. *Categories regarding teachers' challenges in teaching of MM.*

Categories	Frequency
Plan, lead, and evaluate	18
Student-related	14
Teachers' lack of experience and knowledge	11
Curriculum-related	5
Covid-related	2
Structural constraints	2

Discussion

Teachers' conceptions of MM and teaching practices

The findings of this study show that the lower secondary school teachers had multifaceted conceptions of the notion of MM, which are in line with the description of MM in the Norwegian curriculum. The two primary school teachers, however, exhibited unclear conceptions. The discrepancies between the two teacher groups can be attributed to the fact that MM is included in the curriculum and examinations at the lower secondary level, but not at the primary level. Some teachers (e.g. T6) tend to align their daily teaching with competence aims and when modelling is not mentioned in competence aims for lower grades, the primary teachers might not emphasize it. Previous studies from Sweden and China also highlight curriculum and examinations as important factors influencing teachers' conceptions and practices respectively (Frejd, 2012; Xu et al., 2022; Yang et al., 2025). Given that there were only two participants from primary school, additional research is needed to investigate teachers' practices in primary school more thoroughly.

Regarding teachers' practices, the teachers reported collecting modelling tasks from a variety of sources (e.g., textbooks, resource websites such as Matematikksenteret) and storing them for future use. Their dominant criterion for selecting particular modelling tasks appeared to be student interest and engagement, whereas fostering students' cognitive activation in mathematics (cf. Blum & Borromeo Ferri, 2009), though still a concern, was given less priority (see table 4). Previous studies similarly report that Norwegian pre-service teachers emphasize student interest when planning modelling activities (Kacerja & Lilland, 2021). With respect to characteristics of modelling tasks, openness was the only feature explicitly mentioned by the teachers. While they emphasized the importance of real-world contexts in their conceptions of modelling, they did not refer to dimensions such as authenticity or realisticness when describing task characteristics. Thus, there remain unresolved questions regarding the nature and quality of the tasks actually implemented in classrooms, as well as about the extent to which teachers successfully adapt tasks drawn from the various resources they reported using.

In classroom organisation practices, teachers report using diverse forms of student collaboration including group-, project-, and pair-work, and allocating sufficient time for modelling activities, which suggest that the teachers practice flexible methods for engaging students in modelling activities (cf. Blum and Borromeo Ferri, 2009). Student-led activities, however, emerged as least frequently practiced and are perceived to yield minimal benefits. This indicates a potential imbalance between fostering student independence and providing teacher guidance (cf. Blum and Borromeo Ferri, 2009) — an issue that teachers themselves identified as a challenge (see below) and that has also been reported in previous research involving pre-service teachers in Norway (Hansen, 2021; Kacerja & Lilland, 2021).

Some teachers associated MM with specific topics such as functions and regression analysis, both in their conceptions and practices. Limiting modelling to only these topics, as has also been observed in the context of Norwegian upper secondary schools (Berget, 2023), presents a narrow view of modelling and restricts realising its broader potentials, particularly in highlighting the relevance of mathematics for everyday life and society in general. Moreover, None of the teachers mentioned the process aspect of modelling (Blum & Leiß, 2007; Borromeo Ferri, 2006) in either conceptions or their practices.

Teacher's views on potentials and challenges concerning teaching of MM

Teachers reported several potential benefits of MM, which relate to the goals and justifications for inclusion of MM outlined by Niss (2015) and Niss and Blum (2020). The potential of modelling activities for making mathematics teaching practice-oriented, which relates to Blum's psychological justification and the goal of *modelling for the sake of mathematics*, was most frequently mentioned. Student motivation, which is also included in Blum's psychological justification, was among the least mentioned.

Despite several perceived potentials, teachers in our study voiced many challenges in implementation of modelling, as also reported in international contexts (Manouchehri, 2017; Xu et al., 2022; Yang et al., 2025). Finding good modelling tasks, guiding students, and evaluating students' work emerged as major challenges. Concerning modelling tasks, the teachers reported that they actively search for, collect, and store tasks from multiple sources. However, as discussed above, they appear less aware of the characteristics that define high-quality modelling tasks, which may partly explain why they experience difficulties in finding suitable tasks. This points to both a lack of readily available materials (cf. Schmidt, 2011) and limited training to support teachers in adapting modelling tasks. Previous research also suggests that teachers struggle to adapt modelling tasks from textbooks even though modelling is emphasized in curriculum (cf. Ferrando et al., 2025), highlighting the need for curricular reforms to be accompanied by professional development and resources that enable teachers to select, adapt, and implement modelling tasks effectively.

Concerning guidance and evaluation of students' work, teachers linked their difficulties with large number of groups in class, variety among students, etc. However, this challenge also points to lack of teachers' professional development, which is well recognized in previous research (cf. Blum, 1996; Bukhardt, 2006). Individual teachers' lack of knowledge and experience of MM also emerged as a challenge in its own, also reported internationally (cf. Cabassut & Ferrando, 2017; Frejd, 2012). In the Chinese context, Yang et al. (2025) found that teachers did not view MM as relevant to curricula and examinations, in contrast to our findings where modelling is included in the curriculum and regarded as relevant by the teachers.

Engaging and motivating students in MM emerged as a significant challenge. Although Burkhardt (2006) suggested that real situations could enhance motivation, by contrast, recent studies indicate that students often perceive modelling problems as less interesting and report lower confidence compared to other types of problems (García-Cerdá et al., 2024; Krawitz & Schukajlow, 2018). The difficulty concerning student motivation is also reflected in teachers' practices regarding selection of modelling tasks and activities (table 4) where the most emphasized criteria emerged as student engagement. This might imply that teachers' focus on engaging students in modelling tasks is correlated with their perceived challenge of low student motivation. Some teachers linked students' lack of motivation with students' experiences in earlier grades in primary school. They argued that emphasis on finding single correct answers in earlier mathematics teaching presents a hinderance for modelling where multiple solutions often exist. This issue of transition between primary and middle school in Norway exemplifies the systemic resistance to change within educational institutions, as highlighted by Burkhardt (2006). One possible explanation for this split could be lack of learning goals explicitly mentioning MM in primary school grades, resulting in less emphasis by the teachers on modelling.

Conclusion and implications

The findings of this study suggest that the latest curriculum reform (LK20) has a positive role in implementation of MM in Norwegian lower secondary schools, as is the case worldwide (Borromeo Ferri, 2021). Primary school teachers, however, lack understanding of the notion of MM, which suggests a misalignment between primary and lower secondary school. Since our study included only two primary school teachers, further research is needed to gain deeper insight at the primary level. Overall, the teachers lack an understanding of cognitive perspective on MM aligned with international research literature, which are important to understand students' cognitive and metacognitive activities in modelling. There is a need to include cognitive perspective of modelling in the curriculum in general, and to make modelling explicit in the competence aims for better alignment between lower secondary and primary school in Norway.

In teaching MM, teachers emphasise students' collaboration, engagement, and mathematical thinking, but give less attention to student-led activities. They recognise modelling as valuable for making mathematics practice-oriented and relevant, and for supporting understanding and engagement. At the same time, they perceive modelling as less motivating for students and challenging to implement, particularly in finding suitable tasks and in guiding and evaluating students' work. These findings suggest that curriculum reforms in Norway should include support for teachers in planning and implementing modelling activities, with guidance on task selection, adaptation, and evaluation. Emphasising practical teaching strategies in teacher education could equip teachers with the skills and resources needed to enhance student engagement and motivation.

The findings of this study are based on interviews with 10 teachers who reflected on their teaching experiences with MM. The teachers were from different regions in Norway, which reduces the likelihood that the results reflect only a single local context. However, since the teachers were recommended by our colleagues, it is likely that they were already aware of or interested in modelling. We are confident that the results can be considered relevant for lower secondary school teachers, although participation from primary school teachers was limited. We have been careful in making interpretations from the data; nevertheless, our own prior experiences may have shaped both our analysis and our interaction with the dataset.

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Notes

1 Such as mattelist.no, matematikksenteret.no, nrich.maths.org and youcubed.org.

Appendix

Interview guide

1. Tell me about your education and previous experience.
    a) How many years of experience do you have as a mathematics teacher?
    b) Which grade level (s) do you teach mathematics to?
    c) Did you learn about mathematical modelling during your education?
    d) If yes, the program in which mathematical modelling was a part of.
    e) If yes, can you recall some content areas from your education in mathematical modelling?
    f) Did you solve mathematical modelling problems during your education?
2. Tell me about your so far experience with implementing mathematical modelling in your class.
    a) Do you use mathematical modelling in your class?
    b) If yes, can you state some reasons for using mathematical modelling in your class?
    c) Does new curriculum play a role in your implementation of modelling in any way?
3. Based on your teaching experiences, tell me how you think about the role of mathematical modelling.
    a) What do you think what mathematical modelling is?
    b) What do you think about role of mathematical modelling for students' learning?

c) What do you think about the role of mathematical modelling for students' development as modellers?

4. Tell me about selection of mathematical modelling tasks and activities for your teaching.

   a) How do you select the modelling tasks and activities to use in your classroom?

   b) Where do you get inspiration for modelling tasks?

   c) What are characteristics of a good mathematical modelling task in your view?

   d) How do you experience selection of modelling tasks and activities for your class?

5. Which instructional strategies do you believe are important for teaching of mathematical modelling?

   a) What activities do you use for mathematical modelling?

      i. Do you use group work during modelling activities?

      ii. Do you use project work in modelling?

   b) What do you think about the time and resource use during modelling activities?

   c) How do you experience managing students' activities during the modelling activities?

   d) Can you give an example of a good modelling activity that you used in your class?

   e) Are you familiar with modelling cycle? If yes, in what ways do you use modelling cycle in teaching of mathematical modelling?

6. How do you perceive your own teaching practices in mathematical modelling in relation to the following?
   a) Selection of modelling tasks
   b) Selection of modelling activities
   c) Managing students' activities
   d) Assessing students' work
7. Tell me about challenging aspects in implementation of mathematical modelling.

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