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ARTICLE

Science Textbooks: Aids or Obstacles to Inquiry Teaching? Science Teachers' Experiences in Norwegian Secondary Schools

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Abstract
Textbooks have several important functions in science education. By interviewing six teachers, this study shows how secondary school science teachers perceive and use textbooks as resources, especially in inquiry teaching. The results show that textbooks aid inquiry teaching by offering teachers easily accessible suggestions for practical and inquiry activities in accordance with the curriculum to be implemented in science lessons in addition to presenting scientific content adapted to students' level in which they can use to easily link theory to their practical inquiry. However, the use of textbook inquiry activities can restrict the degrees of freedom in implementing inquiries, as textbooks are perceived to rarely include inquiry activities with many degrees of freedom. In addition, some teachers adjust their textbook inquiry activities to have fewer degrees of freedom to meet the challenges they experience, such as time pressure and uncertainty about students achieving curriculum content knowledge goals. These results build important knowledge about textbooks' role in planning and implementing inquiry teaching in science. They should be of interest to teacher education programme developers and textbook authors who desire to contribute to a more inquiry-oriented practice in school science teaching.

1 Introduction

Textbooks have held a strong position in school science and are important resources for science teachers (Chiappetta & Fillman, 2007; Kahveci, 2010; McDonald, 2016). Textbooks are used in different ways and for various purposes, such as '… to target and

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frame teaching, disseminate content, set assignments, supply scaffolding for student activities, provide homework, support and guide teachers and more generally regulate behaviour in different ways' (Hansen, 2018, p. 369). They can influence how teachers facilitate their teaching strategies and student learning in the classroom (Chiappetta & Fillman, 2007). A teaching strategy that has received a strong focus in science is inquiry teaching, in which learning through inquiry is an area of focus in international curricula (Abd-El-Khalick et al., 2004). Learning through inquiry has been shown to have a positive effect on students' achievements (Martin et al., 2016; Teig et al., 2021) and provide good opportunities for motivation and in-depth learning in science (Karlsen et al., 2021a; Kersting et al., 2021). Nevertheless, in Norwegian classrooms, less time is spent on inquiry and experiments compared with classrooms in other countries participating in the Trends in International Mathematics and Science Study (TIMSS) (Martin et al., 2016; Mullis et al., 2020), which can be related to many Norwegian science teachers' lack of confidence in inquiry teaching (Kaarstein et al., 2020). Textbooks are considered a factor that creates self-confidence in teaching (Waagene & Gjerustad, 2015) and can also support teachers' implementation of inquiry teaching (Dunne et al., 2013).

Few studies have investigated teachers' use of and experiences with using textbooks in connection with inquiry teaching (e.g. Barman, 1992; Biggers, 2018; Eltanahy & Forawi, 2019). Some studies' textbook analyses have examined the books' inclusion of inquiry principles and the nature of science (e.g. Andersson-Bakken et al., 2020; Campanile et al., 2015; Chakraborty & Kidman, 2022; Dunne et al., 2013; Kahveci, 2010). Several of these studies have pointed to textbooks' potential for inquiry teaching in science, although they are not fully in accordance with curriculum objectives. How science teachers grasp and utilise this potential is sparsely elucidated. In this study, we seek to reduce this knowledge gap by showing how secondary school science teachers (teaching years 13–16) experience using textbooks as resources, especially in inquiry teaching. Teachers' perceptions of inquiry teaching can be relevant to how they implement it in teaching (Lotter et al., 2007). Moreover, teachers' previous experiences can influence how they implement curriculum changes in the classroom (Fullan, 2015), including inquiry teaching (e.g. Biggers, 2018; Eltanahy & Forawi, 2019; Ramnarain, 2016). Therefore, we seek answers to the following research questions:

1. How do secondary school science teachers perceive and experience the concept of inquiry teaching?
2. How do secondary school science teachers explain their experiences in using textbooks to facilitate inquiry teaching?

1.1 Teachers' Use of and Experiences with Science Textbooks

The role of textbooks is changing, but they are still used by teachers as a structuring element (Açikalin, 2014; Furberg et al., 2014; McDonald, 2016; Trygstad et al., 2013). Teachers value textbooks because they are adapted to teaching in school, designed in accordance with current curricula and provide progression in a subject that is adapted to a secondary level course (Gilje et al., 2016; McDonald, 2016). Science textbooks present science content and can be used to prepare students' work on science texts (Penney et al., 2003). Therefore, they are used as reference points between teachers and students (Driscoll et al., 1994). They provide particular support for teachers with little to no teaching experience in science (McDonald, 2016). Regardless of their teaching experience, teachers

can adjust textbooks according to '… their (and their students') anticipated needs, their disciplinary culture, their political and cultural beliefs, and the wider societal contexts in which they are located' (Kolbeck & Röhl, 2018, p. 402).

1.2 Inquiry in Norwegian Curricula

Inquiry has been part of the Norwegian natural science subject curricula in recent decades and has received increased focus. In 2020, the new National Curriculum for Knowledge Promotion in Primary and Secondary Education and Training (LK20) (Ministry of Education and Research, 2019) was implemented in Norway. LK20 emphasises inquiry throughout the core element of *natural science practices and approaches*, which states that students shall experience science as a practical subject and understand the world around them from a natural science perspective through wondering, exploring and experiencing. Through this core element, students gain experience in natural science practices and ways of thinking. The curriculum also emphasises students' need for in-depth learning, in which gradual and durable understandings of concepts, methods and connections between disciplines are central together with critical and ethical thinking (Ministry of Education and Research, 2017). This underscores inquiry-based teaching of science concepts and socio-scientific issues as essential in fostering and supporting deep learning (Jablon, 2014; Metcalf et al., 2018; Salmi et al., 2023). The preceding LK06 curriculum (Ministry of Education and Research, 2013) highlighted inquiry throughout the main theme of *the budding researcher*, which focused on students' gaining experience in processes revolving around how scientific knowledge is developed. Against the background of the textbooks' intended use for students' attainment of curriculum goals (The Education Act, 1998), the curriculum transition from *the budding researcher* to *natural science practices and approaches* was anticipated to have consequences for how inquiry is discussed in textbooks. This study was conducted during Norwegian schools' implementation of LK20. New textbooks were designed and gradually implemented in schools.[1] This was an interesting time to undertake such a survey, as teachers pointed out that alignment with the curriculum is an important feature of textbook content (Gilje et al., 2016; McDonald, 2016).

1.3 Science Textbooks in an Inquiry Context

An important part of textbooks is the tasks, such as questions and activities, that often appear at the end of each chapter. These tasks are important to student learning because they regulate which information is presented and which strategies should be used to process this information (Doyle, 1983, p. 162). Therefore, textbook activities provide guidelines for what information is processed by students and how they work with it, for example, through inquiry strategies. In this way, textbook activities are important in safeguarding textbooks' intention to align with the curriculum regarding inquiry principles in science. In designing inquiry activities in textbooks, textbook professionals consider it essential to take into account teachers' understanding of inquiry (Chakraborty & Kidman, 2022). In inquiry activities, textbooks are used as data sources and references by using theories to aid in interpreting the data collected from experiments (Karlsen et al., 2021b).

[1] Norwegian teachers choose the textbooks purchased by schools. It may take time before schools update their textbooks based on the new curriculum.

Several studies have reported that Norwegian and international textbooks are sparsely inquiry oriented (Andersson-Bakken et al., 2020; Campanile et al., 2015; Chakraborty & Kidman, 2022; Dunne et al., 2013; Kahveci, 2010). For example, textbooks may use language that is too difficult with the extensive use of terminology, which can inhibit inquiry learning (Kahveci, 2010). Tasks and activities in textbooks have also been shown to be mainly closed and reproducible, with very few tasks requiring students to collect data in accordance with inquiry principles (Andersson-Bakken et al., 2020). Moreover, the inquiry process skills in *questioning* and *constructing arguments* are omitted in textbook lessons (Chakraborty & Kidman, 2022). For effective teaching through the use of textbooks, teachers should analyse and modify them (Kahveci, 2010). Dunne et al. (2013) showed that textbooks could support the implementation of inquiry in schools by offering teachers knowledge about science content and various student-centred pedagogical practices. Even though textbooks are generally not inquiry oriented, various textbooks have different capacities for promoting inquiry teaching, in which some textbook series are more inquiry oriented than others (Andersson-Bakken et al., 2020; Campanile et al., 2015; Dunne et al., 2013; Kahveci, 2010; Isaksen & Thorvaldsen, 2022). Moreover, Isaksen and Thorvaldsen (2022) reported that teachers' perceived potential for inquiry teaching in textbooks is not fully utilised, especially among teachers who follow textbooks closely.

To a small extent, Norwegian students are involved in asking questions, formulating hypotheses or planning investigations, but inquiry activities with many degrees of freedom are rarely carried out in Norwegian classrooms (Haugan et al., 2017; Karlsen et al., 2021b). Thus, science teaching has the potential to be more inquiry oriented if students are invited to participate more in these processes (Kersting et al., 2021). Similarly, Biggers (2018) found that inquiry questions are almost exclusively asked by teachers or textbooks, partly to save time. There is also the potential for more inquiry by changing teacher-centred questions and involving the students to a greater extent in this process (Biggers, 2018). Biggers (2018) also argued that teachers need training and strategies to adjust textbooks to gain more student participation in the process of asking inquiry questions.

2 Theoretical Perspective

2.1 Inquiry Teaching

The term *inquiry* has been ascribed multiple meanings in science education, causing some confusion about how to interpret it (Crawford, 2014; Furtak et al., 2012). In science education, inquiry has been used to describe the following ideas: (1) scientific ways of knowing—that is, the work of scientists, (2) a way for students to learn science, (3) an instructional approach and (4) curriculum materials (Furtak et al., 2012, p. 235). In this study, we use the term *inquiry teaching* to address inquiry as an instructional approach in science, and our understanding of inquiry teaching is based on Crawford's (2014) and Knain and Kolstø's (2019) works. In their stated characteristics of inquiry teaching, a common feature is the engagement of students in key elements, such as asking questions, collecting data and gaining a deeper understanding of science theory by interpreting data to evaluate and find answers. We also include communicating results in accordance with Crawford's (2014) work. Inquiry teaching is further operationalised through Pedaste et al.'s (2015) inquiry-based learning framework. The framework organises inquiry-based learning as a cycle composed of five phases, with the following areas of focus:

1. Orientation – stimulating curiosity about a topic and addressing a learning challenge through a problem statement.
2. Conceptualisation – generating theory-based research questions and/or hypotheses regarding the stated problem.
3. Investigation – planning and conducting exploration or experimentation based on research questions or hypotheses, respectively, in addition to interpreting collected data.
4. Conclusion – drawing conclusions from the data and comparing inferences (based on the data) with hypotheses or research questions.
5. Discussion – communicating/discussing inquiry findings to/with others and/or reflecting on the inquiry phases (p. 54).

In the conceptualisation phase, a question-driven approach, a hypothesis-driven approach or alternatively, their combination can be chosen. Exploration follows a question-driven approach, while experimentation follows a hypothesis-driven approach. After interpreting the data, students can also choose to ask new questions and/or formulate new hypotheses for further exploration or experimentation. By dividing inquiry into several phases, we include all cases in which teachers describe working with different phases.

The inquiry-based learning framework provides teachers with room for action on how much freedom should be given to students in their inquiry process (Pedaste et al., 2015). The guidance dimensions of inquiry provide a visualisation of the room for action in inquiry teaching, depending on the amount of structure and scaffolding given to students (Furtak et al., 2012). The degree of freedom granted to students in designing their inquiry process can vary along a continuum between two extremes. One is a closed approach in which questions and procedures are given and there is a predetermined outcome. This approach is often called expository instruction, structured or teacher-centred. The other extreme is an open approach in which students can decide on the questions and procedures themselves, possibly with guidance from their teacher, and no result is given in advance or is known to the students (often called open inquiry) (Gyllenpalm et al., 2010). In open inquiries, teachers alternating between giving students space and structure (scaffolding) in the inquiry phases can act as a 'driving force', supporting students in the different phases and providing direction for their own experiences, without limiting the degree of freedom (Bjønness & Kolstø, 2015, p. 235). Inquiry teaching also has different degrees, depending on the case complexity, and this is connected to how teacher-led the inquiry is around questions and procedures and how much room is given for the student learning outcomes (Knain & Kolstø, 2019). An activity with the aim of obtaining a single-faceted answer to a scientific content knowledge goal has a low-case complexity, whereas a higher case complexity provides increased breadth in students' knowledge output and training in inquiry process skills (Knain & Kolstø, 2019).

2.2 Sociocultural Perspective

The theoretical approach that provides the framework for this study uses a sociocultural perspective, with the aim of communicating content to learners through social interactions and tools (Vygotsky, 1978, 1986). In this study, we gain support from Säljö's (1994, 2006) theory of appropriation of cultural tools, which is a process in which humans learn to use these tools through contact with and repeated use of them. Cultural tools are developed and adapted by people to meet their needs in the contexts in which they are involved. Textbooks can be cultural tools that can contribute to creating meaning for users. The process of appropriation can be characterised by increased coordination between the tools

and the users through four phases: initial phase, in-depth exposure, partial mastery and independent mastery (Säljö, 2006) (for the characteristics of the phases, see Appendix A). During appropriation, users learn under which circumstances the tools work and do not work and become familiar with the tools until they appropriate or master the use of these tools. At the same time, tools are appropriated in specific practices and for different purposes, but users rarely master the tools fully. Users can return to the tools to learn something new (Säljö, 2017; Säljö, 2006). Textbooks are artefacts that teachers encounter and use in different learning contexts in schools. In this study, Säljö's (2006) theory of the appropriation of artefacts is used to understand the relationships that teachers have with textbooks as artefacts and how well they are perceived to work for various teaching purposes, especially inquiry teaching. The sociocultural perspective also has value in inquiry teaching, as social interaction is central to inquiry through discussion (Pedaste et al., 2015) and teacher support (Bjønness & Kolstø, 2015).

3 Methods

In this paper, we report a qualitative study in which teachers were interviewed to gain insights into their use of textbooks and perceptions of inquiry and to explore their connections with inquiry teaching.

3.1 Participants

The six teachers who participated in the semi-structured interviews were selected through quota sampling (Gobo, 2004) based on a previously answered survey. The online survey was distributed to science teachers in public lower secondary schools in two Norwegian counties, one in the north and one in the south ($N = 108$ or 47% response rate; Isaksen & Thorvaldsen, 2022). To obtain a broad selection of science teachers based on their affiliation with the textbooks of their choice, the survey respondents were grouped into three equally sized groups based on their scores on the construct *textbook orientation*. Two teachers were randomly selected from each group. The construct included items measuring how important the textbooks were to the teachers, how security-creating and time-efficient they were perceived, whether they needed to be supplemented, how often the teachers used them in various contexts and how satisfied the teachers were in doing so (Isaksen & Thorvaldsen, 2022).[2] Table 1 shows the teachers selected for the interviews, who were anonymised and assigned fictitious names. These teachers had 3–35 years of teaching experience and taught various grades (8–10) in lower secondary school. At this level, science is interdisciplinary, integrating chemistry, biology, physics and parts of the geosciences within 1 year. The current textbooks used by the classes the teachers taught were Tellus, Eureka! and Trigger (Table 1). However, it was likely that during their time as teachers, they also had experiences with other textbooks. The teachers in this study represented a range of the Norwegian teaching population, as both women and men with varied teaching experiences participated. In addition, they taught at different schools in urban and rural areas. However, they could not be considered representative.

[2] The selection of teachers to be interviewed was made at the early stage of developing the construct *textbook orientation* and is not completely identical to the construct in Isaksen and Thorvaldsen (2022).

Table 1 The table shows (i) the interviewed teachers who were recruited through quota sampling based on their survey response on the variable textbook orientation (ranging from 1–low textbook orientation to 6–high textbook orientation), (ii) the interviewees' teaching experience in general and in teaching science, (iii) which textbooks the teachers used when answering the survey and (iv) the curriculum in which they taught

Teacher	Textbook orientation	Years of teaching experience (in science)	Textbook	Curriculum
Berit	3.57 (medium)	23 (23)	Tellus	LK20
Jakob	4.14 (high)	9 (6)	Tellus	LK20
Nora	2.86 (low)	5 (5)	Eureka!	LK20
Espen	2 (low)	35 (35)	Eureka!	LK06
Anne	3.43 (medium)	3 (3)	Tellus	LK06
Filip	4.57 (high)	6 (6)	Trigger	LK06

3.2 Interviews

Individual interviews were conducted via Zoom and Teams due to the considerable geographical distances between the interviewees. Two pilot interviews were previously conducted to ensure the quality of the technical implementation of the online interviews and to optimise the interview guide. Each interview lasted about 1.5 h and consisted of three themes. Two of the themes—(1) teachers' work and experiences with science textbooks and (2) inquiry—are presented in this paper. We mainly study teachers' experiences with science textbooks as a general concept, not the various textbooks specifically. We have no intention of comparing the textbooks the teachers had experience with. We also highlight cases in which the teachers reflected on additional resources associated with textbooks. As an introduction to the discussion on inquiry, two activities from the textbooks *Tellus 8* (Ekeland et al., 2006) and *Tellus 10* (Ekeland et al., 2008) were presented to the teachers, who provided opportunities for inquiry in various ways (see Appendix B for details on the textbook activities). The teachers were asked if and why they would or would not use these activities in their teaching. At this point, inquiry was not mentioned in the interviews. The two activities emphasised different aspects of inquiry (cf. Pedaste et al., 2015) so that they could be compared and become a starting point for reflecting on the ways in which each of them was inquiry oriented or not.

The interviews were conducted during a period (autumn of 2020) when the compulsory school in Norway was in a transition phase between two curricula (LK06 and LK20), in which LK20 was introduced for grades 1–9 in the school year 2020–2021 and for grade 10 in the school year 2021–2022. All the teachers used physical textbooks in their teaching, and at that time, none of them had received updated textbooks in the new curriculum. The interviews were intended to shed light on the teachers' overall experiences with inquiry teaching and the use of textbooks during their entire teaching career, not only during the current year. This was a prerequisite for investigating how and whether the teachers had appropriated the textbooks as a tool to facilitate inquiry teaching and how this might have changed during their time as teachers. Reflections on the changes and comparisons between the prerequisites for teaching can illuminate how the textbooks are appropriated and possibly adapted accordingly.

The interview data were transcribed by two of the authors. The interviews were conducted in Norwegian, and all quotes were translated into English.

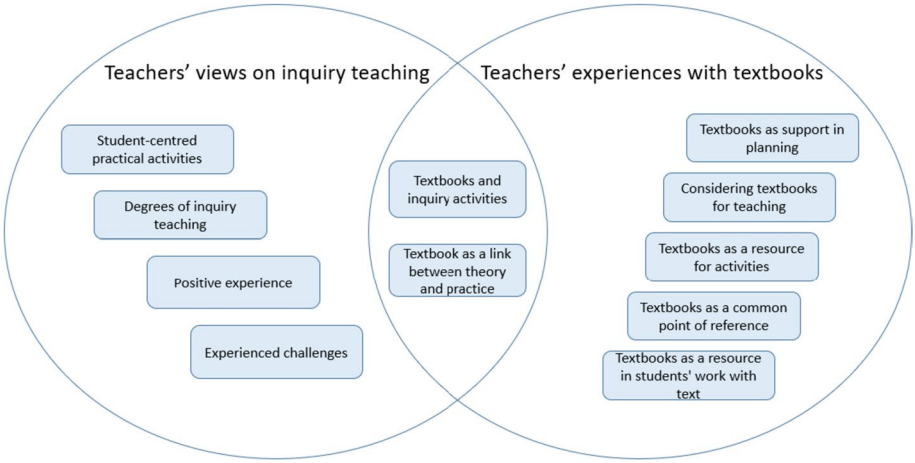


Fig. 1 Map of the themes developed under the focus areas of teachers' experiences with textbooks and teachers' views on inquiry teaching (the themes in the intersection belong to both focus areas and represent the connections between the textbooks and inquiry teaching)

3.3 Analysis

The data were coded and analysed using NVivo. The codes were sorted and organised into two areas of focus: *teachers' views on inquiry teaching* and *teachers' experiences with textbooks* (Fig. 1). A reflexive thematic analysis was conducted through a process of moving back and forth across the six phases of familiarisation, coding, generating initial themes, reviewing and developing themes, refining, defining and naming themes and writing up (Braun & Clarke, 2006, 2019, 2021). The analysis started with transcribing, reading through and getting to know the data. This was followed by inductive coding, in which the analysis used an open approach to grasp the essence of the teachers' statements. The analysis was conducted with an awareness of the theoretical framework against which the findings were discussed, and thus not in an epistemological vacuum (Braun & Clarke, 2006). Developed from the codes, the themes strived to show common features about concepts in the data while pointing out differences.

The teachers' experiences with and perceptions of the concept of inquiry teaching (research question 1) were gathered under the focus area of *teachers' views on inquiry teaching*. The teachers' accounts of how they perceived inquiry teaching were coded, and the codes were organised into two themes: *student-centred practical activities* and *degrees of inquiry teaching* (Fig. 1). The teachers' experiences with inquiry teaching were coded, and the codes were organised into two themes: *positive experience* and *experienced challenges*. Through the analysis, we seek to reveal the teachers' understanding of and how they experienced facilitating inquiry teaching.

The teachers' explanations of their experiences with using textbooks to facilitate inquiry teaching (research question 2) were analysed by initially coding the material in the focus area of *teachers' experiences with textbooks* by searching for practices in which textbooks were used and the teachers' experiences with it. The practices were further organised into five themes: *textbooks as support in planning*, *considering textbooks for teaching*, *textbooks as a resource for activities*, *textbooks as a common point of reference* and *textbooks as a resource in students' work with text.* We then searched both focus areas for cases in

which the teachers reflected on their use of textbooks in connection with inquiry teaching. These connections were inductively coded and organised into two themes: *textbooks and inquiry activities* and *textbooks as a link between theory and practice* (Fig. 1). The themes entailing teachers' general textbook practices are not presented as findings per se but are used to gain insight into how the teachers' general experiences with using their science textbooks can inform their textbook use in inquiry teaching.

4 Findings

4.1 Research Question 1: Teachers' Perceptions of and Experiences with Inquiry Teaching

The analysis of the material in which the teachers explained how they understood inquiry teaching resulted in two themes: *student-centred practical activities* and *degrees of inquiry teaching*. These themes give an account of what is important in the teachers' understanding of inquiry teaching. Analysing teachers' experiences with inquiry teaching resulted in two themes: *positive experience* and *experienced challenges*.

4.1.1 Student-Centred Practical Activities

There were some individual differences in how the teachers expressed their understanding of inquiry teaching. However, most of the interviewees addressed it as a student-centred process related to (1) practical activities that (2) originate from wondering, questions or hypotheses and (3) that aim to find answers. For example, Filip explained inquiry teaching as 'a way of working that requires students, in a way, to both formulate their own hypotheses and find their own answers'. The other teachers also emphasised that in inquiry teaching, the students should do things on their own, such as think, contribute, hypothesise, choose procedures and materials, try out, find theories and answers, and discover. These approaches were also interpreted as the teachers perceiving inquiry as a student-centred process.

The teachers mentioned different starting points for the processes of inquiry. Some mentioned curiosity as the main starting point, while others preferred to start with wondering about an everyday phenomenon. What remained the same for all the teachers, except Berit, was that they mentioned formulating a hypothesis as a main feature of preparing an inquiry but rarely specified what the hypothesis was based on and whether it was based on a question (as shown in Filip's quote above). Although some considered questioning to be part of an inquiry, only Berit stated that questions were the main starting point. The teachers' focus on making hypotheses rather than on asking questions may indicate that they have a hypothesis-driven approach, while Berit has a more question-driven approach.

All teachers shared the opinion that practical work is important in inquiry teaching, as their descriptions of inquiry often noted that students should find out something by conducting practical activities, experiments, tests or explorations. For Espen and Nora, inquiry is a combination of practice and theory. Nora explained:

… it [means] that they can do something practical, investigate a little and then link a little theory along the way. […] But inquiry is something practical, I think, not just theory. There must be something practically connected with it.

It seems that the interviewees' common perception about inquiry is that the students themselves should discover or find answers to something, as opposed to demonstrating the right answer. According to Filip:

The assignment does not suggest what you are going to find out and maybe, not even tell what the right answer is. […] There may not be one right answer, either.

Whether or not there is one correct answer, the teachers' descriptions focused on the students as the ones who should find answers and make discoveries.

4.1.2 Degrees of Inquiry Teaching

All teachers reflected on whether different activities were—and in what way they could be—more or less inquiry oriented. Espen pointed out that an increased emphasis on the theoretical aspect increases the degree of inquiry. Conversely, the others considered the degree of student involvement as a deciding factor in how inquiry oriented the activities are and described activities as more inquiry oriented if students formulate their own hypotheses and procedures than if these are given in their textbooks or by their teacher. Anne believed that there are varying degrees of inquiry teaching: 'I feel that there are different degrees of inquiry teaching'. She illustrated this through two extremes of how inquiry teaching could be arranged:

How open should you make it to the student? I see that many students are used to receiving recipes. 'This is how you should do the experiment'. And then, the inquiry is 'what do you find'? Whereas you can, for example, just place a non-stop[3] bag on the table and ask, 'What can you figure out with this'? So be completely open, then.

Anne classified experiments in which students were minimally involved in designing their inquiry process as closed experiments, as opposed to open experiments in which students were given the freedom to make all decisions in their inquiry activity. For Filip, open experiments are inquiry activities, while closed experiments with a recipe are not inquiry oriented and do not make nuances like the others.

4.1.3 Positive Experience

Except for Jakob, all teachers had a positive attitude about inquiry teaching because it activates, engages and motivates students. Berit, Nora, Anne and Fillip highlighted variety in teaching as a motivation for inquiry teaching. Motivation and variety are particularly justified by practical work, which the teachers considered important to inquiry. Anne, Nora and Fillip reported wanting to facilitate inquiry teaching because they liked it and found it educational. According to Filip, 'I think that learning happens best when students are allowed to inquire themselves'. Therefore, teachers' beliefs about teaching and learning in accordance with inquiry principles seem to promote inquiry teaching. Jakob had a more neutral attitude towards inquiry. 'I'm not really that interested in inquiry teaching as a concept. I am interested in the two things that the students should learn and that it should make sense to them'. He was also uncertain about the term inquiry. That Jakob did not have positive experiences with inquiry could be rooted in his uncertainty about the concept of inquiry teaching.

[3] A Norwegian version of different-colored chocolates, similar to Smarties.

4.1.4 Experienced Challenges

All the teachers pointed to the challenges in inquiry teaching. These challenges generally included inquiry being time-consuming, scarcity of materials, uncertainty about students achieving curriculum goals and teachers' knowledge and experience. Nora explained that '… access to materials is an important factor, and time. Is it possible to implement'? and considered that access to materials and time were limiting factors. Jakob and Anne mentioned time pressure as a limiting factor. Planning inquiry teaching becomes more time-consuming if teachers have limited expertise in the activities, whereas it becomes less time-consuming with increasing experience. Anne explained:

In the beginning, I needed a lot of time to think about and establish good plans. 'How does it work?', 'What should I do?' and so on. But when I've done it a few times and gained more experience, of course, it goes much more naturally, and it's much easier to get it done.

Several teachers were uncertain about student learning outcomes in inquiry teaching, in which uncertainty increases with more freedom granted to students. In inquiry teaching, the teachers' aim seemed to preferably increase students' understanding of science content to be able to assess students' knowledge against the curriculum content goals rather than the curriculum goals concerning process skills. Anne explained:

After all, we want what they learn not to be entirely on the side of the curriculum goals. […] So there is always such a struggle with [this question:] Should you let the students explore and work with what they are interested in and, in a way, really let them flourish? Or 'we have an exam and have to work towards it so that they will pass'. […] they engage when they work that way. At the same time, in a way, 'Can you answer what an organic substance is'? No, you may not be able to do that in this particular case.

Thus, there seems to be a dilemma between giving students freedom to explore and find their own answers, which all the teachers considered important in inquiry, and exercising control to reach the curriculum's knowledge goals. Nora, Espen, Anne and Filip touched on inquiry teaching with the aim of developing process skills, but it was less highlighted and downgraded because it was too time-consuming and uncertain in terms of achieving knowledge goals, which are emphasised in exam assessment.

Jakob, Nora, Espen and Anne reported that many students at the secondary level were not independent enough to make progress in student-centred inquiries. To enable students to carry out an inquiry process and arrive at an answer, all except Filip would restrict the students' degrees of freedom by setting limits, especially in textbook activities, in asking the inquiry question or in giving detailed descriptions of how the activities should be performed. However, this becomes a problem because doing this makes the activities less inquiry oriented. According to Nora:

Inquiry teaching is within clear limits, so it is not completely open. It is very teacher-led, so one can discuss how it becomes an inquiry. But the students in secondary school are so young, so you have to lead them in the direction you want them to go. […] When you have a class, you will probably get half of the class who has no idea where to start or what to do and may not learn so much after such a session.

The intention behind restricting the degrees of freedom seems to be to ensure that all students gain theoretical knowledge as a minimum. By contrast, few teachers thematise guiding students in their inquiry process, but Jakob and Anne asserted that such guidance requires self-confidence on the teachers' part. Anne stated:

When students have to perform inquiry-based work, they possibly do seven different things. You have to feel that it is okay, and you have to make it happen somehow. As

teachers, you are a little out of your comfort zone because you will never quite know if you will be able to guide them towards the goal. You have to be a bit confident in yourself, then.

This can be interpreted as science teachers needing a high level of self-efficacy to guide students in open inquiries.

4.2 Research Question 2: Teachers' Use of Textbooks When Facilitating Inquiry Teaching

Through the subsequent elucidation of research question 2, we show how the participating teachers' general use of their textbooks within five different practices in which the textbooks are used in science teaching form a prerequisite for their textbooks also being used in similar ways in inquiry teaching. We chronologically highlight two themes that are crystallised in the analysis of the teachers' reflections on using textbooks when facilitating inquiry teaching: *textbooks and inquiry activities* and *textbooks as a link between theory and practice*. We also show how the teachers' perceptions of and experiences with inquiry, as presented in Sect. 4.1, are important for whether and how general textbook practices are applied in inquiry teaching.

4.2.1 Textbooks and Inquiry Activities

All teachers made use of their textbook inquiry activities in varying degrees. The participating teachers who had positive experiences with inquiry and emphasised student learning and variety in teaching as motivations for inquiry (all except Jakob and Espen) considered their textbooks to be a resource for finding inquiry activities. Nora used her textbook as a '… reference book to get some ideas'. Berit explained how her textbook and the teacher's guide supported her use of inquiry-oriented activities:

… In each chapter [in the textbook], there are examples of activities—and also in the teacher's guide—that belong to books, right? Then there is 'Oh, here are extra experiments' and 'Here are extra activities you can include in your teaching then'. So you are, in a way, somewhat surrounded by it.

Berit's thoughts were confirmed by Anne and Filip, who also believed that their textbooks (Tellus and Trigger) and the teacher's guide partly contributed to their facilitation of inquiry teaching because of the textbooks' many suggestions for inquiry activities. Anne and Fillip noted that teachers' beliefs about teaching and learning, as mentioned in Sect. 4.1.3, could be more decisive than textbooks in determining whether teachers should facilitate inquiry teaching. They pointed out that such stimulating factors could make teachers more inclined to grasp the textbook's potential for inquiry teaching.

Using science textbooks as an inspiration and references to find inquiry activities seems to stem from the general textbook practice *textbooks as a resource for activities*, which indicates that textbooks are perceived as reliable, time-efficient, easily accessible and supportive in planning activities and therefore perform a central role as a reference for practical activities in general. As Filip expressed, '…I like it [the textbook Trigger] because there are many activities. […] that you can't do them all. You only have to pick the best ones that you think are good'. Thus, the textbook's many suggestions for activities are considered a positive aspect and contribute to its importance for several teachers. Berit, Jakob and Filip affirmed that the internet and other resources also contained many good activities that are occasionally used in teaching but that they still used activities from the textbook. As Berit explained, 'shopping' for inquiry activities on the internet is

time-consuming as opposed to using textbooks to find activities for science lessons. Anne pointed out that, given her initial minimal teaching experience, the teacher's guide that accompanies the textbooks provided good support when choosing textbook activities.

When I was unsure how long an exercise could take, in a way, it was estimated there. It was very specific: 'You can relate this exercise to the following basic skills[4] and the following curriculum goals'. So it was, in a way, a little help to understand why you did what you had done and the time you spent on it.

Thus, several positive aspects of using science textbooks are used to argue for teachers often searching textbooks for suitable practical and inquiry activities as the first step in planning. Furthermore, it seems that, over time, teachers develop experience in using textbook activities and activities from other resources. According to Berit, '…when you eventually have a few years' experience, you know, "Oh, that experiment works very well" or "that activity works well", so I have to remember to include it when we talk about this and that topic'. Similarly, Jacob and Filip revealed that activities considered to work well in teaching are often committed to memory and repeated when the teacher handles the same grade in subsequent years, usually with minor adjustments based on previous experiences. Thus, these teachers build up a resource bank for the good activities they experience and become less dependent on textbooks as a resource.

All teachers reported positive aspects of using their textbooks for themselves and their students. This led them to use *textbooks as support in planning*, which entails using them as a starting point for planning science teaching. This general textbook practice seems fundamental because science textbooks are also an important inspiration for inquiry activities, as noted above. In planning science teaching, the teachers reported using their textbooks to support content, especially on topics in which they were academically uncertain and operationalising the curriculum. Filip explained that using the textbook was considered a form of quality assurance in performing in accordance with the curriculum: 'I feel that less responsibility is placed on me then if I can only rely on the textbook and its chapters. Then I have, in a way, followed a plan, and I will reach the curriculum goals at that age level'. If resources other than textbooks were used, he must provide his own assurance that he would perform in accordance with the curriculum. Anne and Filip revealed that they were closely attached to their textbooks when they had little teaching experience. With more experience, they freed themselves more from textbooks when planning science teaching.

Even though only the teachers who had the most positive experiences of inquiry teaching considered their textbooks important for inquiry activities, all the participants reflected on using textbook inquiry activities and seemed to consider whether and how they should use them in teaching. Thus, the teachers' use of textbook inquiry activities also reflects the general practice of *considering textbooks for teaching*, which indicates that, despite experiencing the strengths of the textbook, the teachers also found their textbooks to be insufficient in some areas. Before teaching a topic, the teachers regarded their textbooks with a critical eye and, with time, experienced how good it was as a teaching aid in terms of student learning. In cases in which the teachers considered or experienced the inadequacies in their textbook, for example, outdated content of inquiry activities in relation to the curriculum or difficult text, its content would be adjusted, supplemented or substituted completely with other learning resources. Moreover, the teachers' perceptions of and experiences with inquiry teaching seemed to

[4] The Norwegian curriculum (LK20) defines the five basic skills as oral, reading, writing, digital and numeracy skills. These are fundamental for learning in school, work and social life. The basic skills belong to all curriculum subjects, and each subject, including science, has a description of how the basic skills are integrated into the subject (Ministry of Education and Research, 2019).

influence how they assessed textbook inquiry activities as appropriate, whether they would use them and whether they should be adjusted or supplemented. For example, Filip found that the activities in his textbook could have a controlling effect on how the activities would be implemented if they were not supplemented in case of inadequacies. As he put it:

It [the textbook Trigger] is a bit locked. Then, it is up to us, teachers, to find other activities that are open. […] I think it is quite controlling if you follow the textbook. And on topics in which I work closely with the textbook, I probably depend a little on the fact that there are good tasks. However, I feel that I am quite good at supplementing them with other types of tasks. Because I have gained some experience at certain grade levels, I have found some tasks that work well.

The teachers nuancing the degree of freedom in inquiry activities along an inquiry continuum saw an opportunity to adjust the textbook activities towards more degrees of freedom. They noted the sample activities' potential to be more inquiry oriented by involving students to a greater extent in asking questions, hypothesising, choosing materials themselves and adding a discussion of the results. Nevertheless, the teachers did not claim to make such adjustments in inquiry teaching. To overcome the challenges they faced in inquiry teaching, some teachers considered it necessary to adjust the inquiry activities to have less student participation, especially in the investigation phase, and thus fewer degrees of freedom. Despite being aware that this would weaken the inquiry process, Filip and Anne justified this by asserting that it would save time. Espen, who revealed that many students at the secondary level were not independent enough to make progress in student-centred inquiries, asserted:

The teacher must be the one who, in a way, leads and ensures that they stay within certain limits. Because if you don't have very clear limits and just let the students try, then it will go out of hand. […] So you must explain what you can use. It must be relatively detailed. […] Things you know can easily go wrong, even if you follow the instructions in the textbook. Such things are not described in the textbook. What mistakes can you make'?

Thus, to avoid students making procedural errors, Espen considered that teachers need to provide an additional structure to textbook inquiry activities because students are required to obtain a certain result. He explained further:

And then, of course, it is to demonstrate what we can easily see, that 'Yes, what is written in the textbook is true because we did it in the lab'. And then it is somewhat important that we see it in the lab instead of seeing that 'Yes, we got a green precipitate, but in the textbook, it says that it should be blue, so then it is correct'. I don't like that. […] There may be things that are difficult to achieve in the lab, so then I may select some nice things that are on YouTube [videos demonstrating the activity].

Indicating that Espen would be happy for the students to gain practical experience if it aligned with the scientific truths presented in the textbook. If some of the content in the textbooks was difficult to demonstrate through practical work, in the sense that small errors in the experiment would risk defying the truths in the textbook, then he would rather choose to illustrate this through less student-active methods.

Berit, the only teacher applying the question-driven approach, revealed that she would generally ask the inquiry question if the textbook did not.

In summary, science textbooks were easily accessible, time-efficient and reliable, thus supporting content and operationalising the curriculum, making them central in planning science teaching for all teachers. In planning science teaching, teachers who had most positive experiences with inquiry also used their textbook inquiry activities as an inspiration for finding suitable science inquiries, which could also stimulate more inquiries. Nevertheless, all teachers considered their textbook inquiry activities and used them to varying degrees. Textbook inquiry activities were adjusted or supplemented to be in accordance with the

teachers' perception of inquiry and to overcome the challenges in inquiry teaching, such as time limitations, the lack of materials and uncertainty in goal achievement.

4.2.2 Textbooks as a Link Between Theory and Practice

Some teachers revealed that they used textbooks as a text resource for students during inquiry mainly to connect theory with their practical inquiry, as textbooks are easily accessible and adapted to students. Jakob and Espen revealed that their textbooks could be used by their students when preparing to obtain an overview of a topic or acquire a basic understanding of concepts that would make it easier to communicate and interpret inquiry findings. Such use of the textbooks is related to the teachers' general experience of *textbooks as a resource in students' work with text*, in which teachers usually prefer the students' use of texts in the textbooks, as textbooks are adapted for school use. Therefore, the text and design are customised for students and make conceptual understanding and scientific knowledge accessible to them. For example, the teachers mentioned that the figures and tables were adapted to increase students' understanding and ease the link between theory and practice.

Nora used the class textbook as a reference during the activity or when reporting the inquiry process.

If you choose to follow an experiment that is already there in the book [textbook], then they will have something to browse. So, if they are going to write a report, you know that they will have something tangible to look at. Or, if there is some theory that needs to be connected, they can look it up in the book.

In this way, textbooks can serve as a link between practice and theory, in that the students use their textbooks to gain a theoretical understanding of the practical inquiry activity they have done or will do. Preparing for or writing reports on inquiry activities, as described by the teachers, is a task that students are often assigned to do at home. This is where *textbooks as a common point of reference* is particularly important because they are an important, easily accessible and tangible resource for students to read or consult when they need support. Some of the teachers also stated that using textbooks is safe for students and parents, as opposed to using the internet or other resources. Regardless of whether the teachers used their textbooks or other resources in teaching, many teachers tried to relate the teaching content to the textbook, either in teaching or in referring to chapters or activities in the textbooks in the lesson plans. In this way, the textbooks were used as a reference point for students and parents, making teaching recognisable when doing homework, studying for tests or writing a report on an experiment at home. This also applies to inquiry teaching.

In sum, considering the class textbooks as a common point of reference for students and using them as a good pedagogical tool in students' work with text are important when using the textbooks to link theory to practice in inquiry teaching. This was particularly emphasised by the teachers who understood inquiry as a combination of theory and practice.

5 Discussion and Implications

In this study, we present science teachers' experience in using their textbooks to facilitate inquiry teaching (research question 2) based on the teachers' experiences with and perceptions of inquiry teaching (research question 1). Figure 2 shows how the teachers' experiences with their textbook and inquiry teaching form their use of their textbooks in inquiry

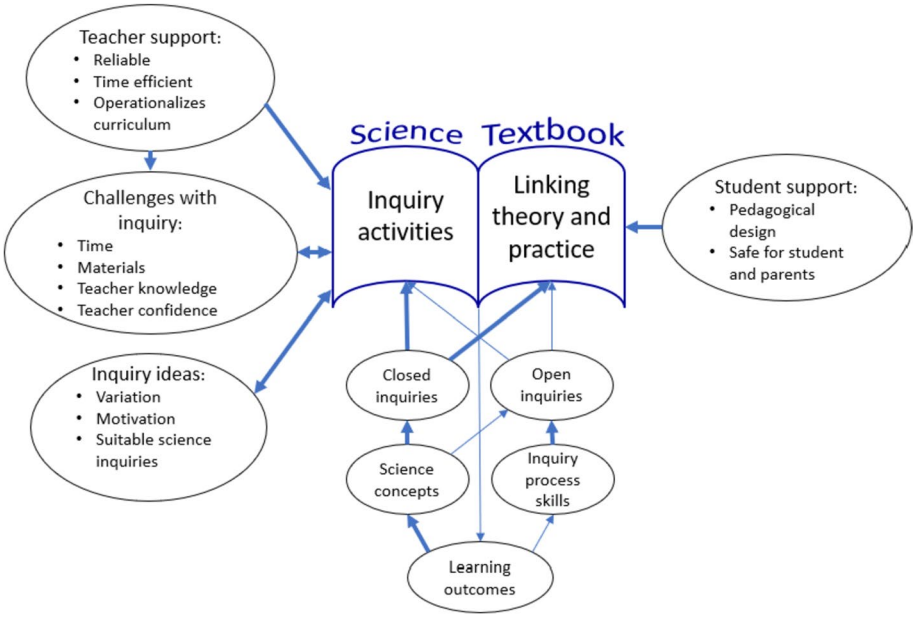


Fig. 2 The arrows pointing towards the science textbook show how the teachers' experiences with their textbook and inquiry teaching forms their use of textbook in inquiry teaching. The arrows pointing from the textbook indicate that using the textbook could also influence the degree of inquiry—and thus learning outcomes—and stimulate inquiry ideas. The thickness of the arrows indicates the degree of influence

teaching. All teachers used their science textbooks as support in planning science teaching, which enabled them to use the textbook's inquiry activities rather than other teaching materials. The textbook's inquiry activities are particularly important for teachers desiring to facilitate inquiry and gather ideas for inquiry activities. Using their textbooks for inspiration to gather inquiry ideas can have a self-reinforcing effect as the textbook inquiry activities stimulate more inquiries (arrows both ways). Using the textbook can also help meet challenges with inquiry, as it is time-efficient and supports teachers in areas where they feel that a lack of confidence and knowledge are obstacles to facilitating inquiry activities. On the other side, the challenges they faced in inquiry teaching enabled some teachers to adjust textbook inquiry activities to make them feasible in terms of time and materials. Textbooks are perceived as important support for students because they are adapted to the students and can serve as safe and tangible text references for homework. This also leads teachers who perceive inquiry as a combination of practice and theory to consider their textbooks as aids for students to link theory to their practical inquiry. As teachers gain experience in using their textbooks, they become familiar with its possibilities and limitations. Thus, they adopt a more critical attitude towards the use of the textbook. They use their experience and didactic competence to assess whether and how they should be used in teaching.

In the following subsections, we discuss the ways in which textbooks are perceived and used either as aids or obstacles to inquiry teaching, depending on the teachers' understanding of and experiences with inquiry teaching. This is shown based on how the teachers appropriate textbooks as a tool for science teaching. We also identify some potential for a more inquiry-oriented practice in teaching and textbooks.

5.1 Science Textbooks as Aids for Inquiry Teaching

At the start of their teaching careers, all the participants constantly tried out new activities from the textbook, and some considered the teacher's guide to be an important support in using textbook activities. This can be understood as the teachers being in an initial phase or an in-depth exposure phase of the appropriating process, which is characterised by trying out, systematically testing and partially needing external support (Säljö, 2006). The teachers highlighted the textbook's time efficiency, easy accessibility and reliability and noted that it should also be aligned with curriculum goals. These strengths of textbooks make them an essential tool for most teachers to find suggestions for practical activities and for teachers who have positive experiences with inquiry to find more inquiry activities. Some of the teachers found that their textbook's many suggestions for activities stimulated inquiry teaching by creating an expectation of how students should work with the subject matter. This confirms that using science textbooks can support the development of a more inquiry-oriented practice, as suggested by the textbook analyses of Dunne et al. (2013) and Eltanahy and Forawi (2019), which indicate that science textbooks could foster teachers' implementation of inquiry teaching by offering various student-centred pedagogical practices. Thus, our study's findings reveal that the teachers who had a desire to implement inquiry teaching recognised the textbook's potential. By virtue of their activity suggestions, textbooks can be a primary tool for teachers to facilitate inquiry teaching. Therefore, it is important to maintain a focus on textbook activities.

Specifically, the teachers who perceived inquiry teaching as a combination of practice and theory highlighted textbooks as valuable for students because they linked theory to practice in inquiry learning. This implies that teachers' understanding of inquiry has an effect on whether these general textbook practices are also used in connection with inquiry teaching. Previous studies have shown that science textbooks provide content for students (Penney et al., 2003) and are used as reference points between students and teachers (Driscoll et al., 1994). Our study shows that these functions of science textbooks also apply in inquiry teaching. Students can use their textbooks to prepare for a topic, as a reference to link theory to their inquiry and as support in writing reports, as they are easily accessible, tangible and adaptable to students. Therefore, textbooks can be suitable and outperform other curriculum materials when used as a link between theory and practice in inquiry activities. In this context, textbooks can be important for students in the conceptualisation phase of their inquiry by presenting relevant theory as a background for asking theory-based questions and/or formulating hypotheses; in the investigation phase, students use theories from textbooks to interpret collected data; and in the discussion phase, students can use it as support for writing reports to communicate their findings and conclusions drawn from their inquiry (cf. Pedaste et al., 2015). Ødegaard (2016) showed how students' use of different texts is important as an integrated part of their practical inquiries and contributes to their scientific literacy skills and how they view their use of text as meaningful. We showed how textbooks as textual resources could be a key learning tool for students to easily link theory, which is adapted to their level, to their practical inquiry. However, few teachers used the textbooks in this way, and we identify a greater potential for using the textbooks as a text resource in inquiry learning. Currently, as printed textbooks are seemingly being phased out in favour of digital textbooks and other digital tools (Gilje, 2021), this finding provides an argument for the retention of textbooks in printed format.

In sum, science textbooks can be aids for inquiry teaching by offering teachers easily accessible suggestions for inquiry activities and a tool for students to link theory to their practical inquiry.

5.2 Science Textbooks as Obstacles to Inquiry Teaching

Although we did not find many direct obstacles to using textbooks for inquiry, we did find that textbooks could limit opportunities for more open inquiries to some degree. For example, one of the interviewed teachers appreciated the many activities provided by his textbook while acknowledging that they were mostly closed activities that provided recipes, or the so-called 'cookbook experiments'. This is confirmed in other studies in which tasks and activities in textbooks were found to be mainly closed and reproducible, with very few explorative tasks requiring students to collect data in accordance with inquiry principles, such as questioning, planning procedures and constructing arguments (Andersson-Bakken et al., 2020; Chakraborty & Kidman, 2022). We suggest that the teachers' perceptions of the degrees of freedom may influence how they perceive and consequently handle textbook activities. Teachers who differentiate between open and closed activities and nuance, to a small extent, the degrees of freedom in inquiry activities deem it necessary to supplement the textbook's activities with open activities from other resources. The textbook deficiency in open activities seems to be a perception built up through the appropriation of the textbook. However, the teachers explained being less inclined to supplement open inquiry activities with other resources despite being aware of this deficiency in the textbook. This could be explained by the teachers' observation that using textbooks to find activities saves time. Research has also shown that time pressure leads teachers to rely heavily on curriculum materials (Biggers, 2018) or that textbooks are easily accessible and provide assurance to serve in accordance with the curriculum (Gilje et al., 2016; McDonald, 2016). These positive aspects of using textbooks can increase the threshold for using other resources, despite their limitations. Therefore, using the textbook's activities 'as they are' can have a moderating effect on the degrees of freedom when implementing inquiry activities. It is important that textbooks contain various inquiry activities across the entire inquiry continuum.

Only one of the textbooks included in this study was perceived to be an obstacle to inquiry teaching. This could be explained by the teacher using this textbook having the most student-centred perception of inquiry, even though there may be differences between the various textbooks used by the teachers in this study in terms of how they are perceived to stimulate inquiry teaching, as indicated by Isaksen and Thorvaldsen (2022).

All the teachers in this study considered their textbooks the main starting point in planning science teaching, especially as they had little teaching experience, because they are considered reliable and supportive. Previous studies have presented similar findings in which textbooks are valued as a structuring element in planning teaching (Furberg et al., 2014; Trygstad et al., 2013) and for being adaptable to teaching in school and consistent with the current curriculum (Gilje et al., 2016). Despite the textbooks' importance in planning, two of the teachers did not mention their textbooks as important in planning practical or inquiry activities. Nevertheless, they continuously referred to their textbooks while reflecting on inquiry activities, with one teacher wanting their students to experience the scientific facts presented in their textbooks. This could be partly explained by these teachers not being interested in inquiry teaching and by the science textbooks, possibly unconsciously, functioning as presenters of scientific facts. Moreover, these teachers could be in a phase of independent mastery of appropriation. They perceived their use of textbooks as so natural for them for being a reference for finding practical or inquiry activities or for presenting science content for student learning that they had become blind to their importance (c.f. Säljö, 2006). This assumption could be supported by the one teacher having a long teaching experience, and also his

low score on the construct textbook orientation, and the other teacher building up a resource bank for good activities and becoming less dependent on textbooks as a resource.

5.3 Difficulties in Exploiting Textbooks' Potential for Inquiry Teaching

In this study, the teachers found time pressure, scarcity of materials and uncertainty about their students' goal achievement in inquiry teaching to be limiting factors, especially in open inquiries, confirming previous research findings (e.g. Biggers, 2018; Eltanahy & Forawi, 2019; Ramnarain, 2016). These limiting factors can result in teachers not choosing textbook activities with many degrees of freedom or modifying activities by reducing their degrees of freedom. This is concerning because textbooks seem to contain few activities with many degrees of freedom in the first place (Andersson-Bakken et al., 2020; Chakraborty & Kidman, 2022), and activities with many degrees of freedom are seldom implemented in Norwegian classrooms (Haugan et al., 2017; Karlsen et al., 2021b). In this study, the teachers had a student-centred understanding of inquiry teaching, in which students should find answers or obtain results on their own. Moreover, the teachers found that their students were often incapable of progressing towards an answer or a result when performing inquiries on their own, thus showing the dilemma between giving students freedom and accountability versus controlling their achievement. Requiring students to plan and experiment through practice on their own is also considered particularly time-consuming and uncertain in terms of students' attainment of curriculum knowledge goals. To save time and ensure available materials and learning outcomes regarding content knowledge, some teachers modified the inquiry activities in their textbooks towards a more closed approach by deciding on which procedures or materials to be used rather than guiding the students in these processes. This is supported by previous research, which showed that teachers often provide the procedure (Kersting et al., 2021). According to Biggers (2018), teachers think that students are not always capable of engaging in open inquiries; thus, they do not modify textbook activities to become more student-centred. Biggers' study involved third-grade students, but the same argument applies to the secondary school students in our study. This indicates that it remains challenging to facilitate open inquiries regardless of students' ages. The limiting factors experienced by the teachers, with the resulting adjustment of textbook activities towards a more teacher-centred approach, can help explain why using textbooks does not lead to a more inquiry-oriented practice among teachers who think that textbooks stimulate inquiry teaching, as shown by Isaksen and Thorvaldsen (2022). In this study, we recognise that textbooks' potential for inquiry teaching is not fully utilised due to limiting factors, such as time pressure, lack of equipment and uncertainty about attaining curriculum knowledge goals. Is it possible that even if textbooks, to a greater extent, include activities with many degrees of freedom, teachers will still adjust the activities towards a more teacher-centred approach to be feasible, considering the challenges they experience with inquiry teaching? Thus, we argue that it is important that textbook activities are not only varied and student-centred but also that textbook authors and editors must be particularly aware of the activities' feasibility in schools in terms of time and equipment. For example, suggestions can be included in each chapter, in which students are encouraged to hold shorter inquiry sessions, so that textbooks can contribute better to a more inquiry-oriented practice.

How, then, can we address the challenge of teachers not choosing textbook activities with many degrees of freedom or limiting their degrees of freedom to exercise better control over students in achieving curriculum goals? We argue that textbooks have the

potential to provide explicit signals about the intended and possible curriculum goal relevance when implementing textbook activities and how and for what purpose they can be adjusted. The teachers in our study, to a small extent, perceived inquiry teaching as involving guiding students through the various phases of an inquiry activity. Self-efficacy also seems important for scaffolding students in open inquiries, in which we see indications that teachers lack confidence in guiding students in inquiries with several degrees of freedom. A recent TIMSS study showed that many Norwegian science teachers do not feel confident in inquiry teaching (Kaarstein et al., 2020). Other studies have indicated that teachers are more comfortable with inquiry teaching on the teacher-centred side of the inquiry continuum to better control the class (Eltanahy & Forawi, 2019; Kersting et al., 2021). Teachers can perform their role in contributing with progression and direction in open inquiries by alternating between giving students space for testing their own ideas and scaffolding them towards attaining goals during the inquiry phases, as proposed by Bjønness and Kolstø (2015). If students are given the freedom to decide on the procedure, teachers can provide structure by informing the students about the available materials in advance and allowing them space to assess and choose among them. Furthermore, teachers can support students by asking questions about feasibility in terms of time and approving their ideas (structure). Kersting et al. (2021) pointed out several aspects of inquiry activities in which minor actions are required to make such activities more student-centred.

Similar to the teachers in the Linking Instruction in Science and Student Impact (LISSI) study, the teachers in our study also found that the purpose of inquiry teaching was mainly to increase students' science content knowledge, not so much on developing their inquiry process skills (Kersting et al., 2021). This focus may partly be due to the emphasis on the curriculum's science content goals when conducting student assessments and to some teachers being concerned that their students were not trained well enough in attaining the curriculum's inquiry process goals. Such purposes in inquiries indicate the activities' low-case complexity (cf. Knain & Kolstø, 2019). Thus, we recognise the potential for increasing case complexity in inquiry activities. Based on one teacher's experience of benefiting from the teacher's guide in understanding the purpose of textbook activities in relation to curriculum goals, we suggest that curriculum materials should point towards possible actions to increase the case complexity and the degrees of freedom of textbook inquiry activities. The teacher's guide or textbook can also explicitly describe how these modifications can affect whether skill training or acquiring science content knowledge is in focus and relate this to curriculum goals. This can support teachers in adjusting activities along the inquiry continuum and in deciding on case complexity and degrees of freedom. Chakraborty and Kidman (2022) found that textbook authors and editors often designed activities to provide an implicit understanding of the key elements in inquiry teaching. For example, in a textbook activity, the inquiry question should provide teachers and students with an implicit understanding that asking questions is central to inquiry. However, this did not lead to teachers engaging students in asking questions (Chakraborty & Kidman, 2022). Moreover, our study showed that the only teacher who pointed out the textbook or asked about the inquiry question was also the only one who perceived students asking questions as central to inquiry. This is in accordance with other studies showing that few teachers have a question-centred conception of inquiry (Ireland et al., 2012; Kersting et al., 2021). This enriches the argument that textbooks can give more explicit signals about their inquiry activities, for example, by highlighting which inquiry skills are in focus while showing the relevance of inquiry skill goals in the curriculum. This makes it clear to both teachers and

students how engaging in inquiry activities with an increased degree of freedom and case complexity is aligned with science content knowledge goals and inquiry skill goals in the curriculum.

A limitation of this study is that the findings and implications were based only on the teachers' accounts, in which biases could have occurred. We suggest conducting observational studies that examine teachers' and students' use of textbooks in inquiry teaching.

6 Conclusion

In this study, we have shown that science teachers appropriate textbooks to be a primary tool in several practices, including inspiration for inquiry activities. Through this practice, textbooks can have a stimulating effect on inquiry teaching, especially for teachers who have positive experiences with inquiry. Nevertheless, science textbooks may have a controlling effect on inquiry activities if they mainly contain closed activities or if they function as presenters of scientific facts that students should demonstrate. Time pressure, scarcity of materials and uncertainty about students' goal achievement are the factors limiting inquiry teaching. They make it especially challenging to conduct textbook activities with many degrees of freedom. We recognise textbooks' untapped potential for a more inquiry-oriented practice, and textbook authors can make minor adjustments to textbook design to better meet these challenges. Textbook materials also have the potential to better support teachers' facilitation of inquiry teaching in clarifying possible learning outcomes in their inquiry activities, especially inquiry process skills, as teachers are uncertain about students' learning outcomes in open inquiries and emphasise content knowledge.

Appendix 1. Appropriation phases

Table 2 Appropriation phases, characterised by increasing coordination between the tool and the user (Säljö, 2006, p. 215)

Phases of appropriation	Characteristics of the phases
Initial phase	User introduced to a previously unknown tool Becomes acquainted with the tool by trying it out Dependent on external support
In-depth exposure	Systematic testing of the tool More intensive use in specific practices Increased insights into the circumstances under which the tool works and does not work (possibilities and limitations) Experiences with using similar (and other) tools Less dependent on external support
Partial mastery	Mastery of the tool in some practices and for specific purposes Use of the tool becomes normalised and an integrated part of the specific practice
Independent mastery	Tool is perceived as completely natural User masters the tool so well that it has become "the way we do it", and the user can become blind to actually using the tool

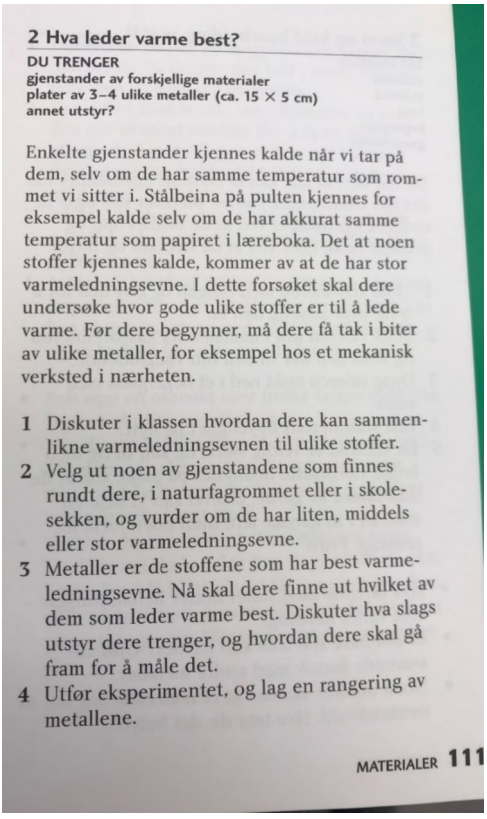
Appendix 2. Textbook activities used as an introduction to discuss inquiry teaching in interviews (with English translation)

What conducts heat best? (Fig. 3).

YOU NEED objects made of different materials, plates of 3–4 different metals (approximately 15 × 15 cm), other equipment?

Certain objects feel cold when we touch them, even though they have the same temperature as that of the room we are sitting in. For example, the desk's steel legs feel cold although they have exactly the same temperature as that of the paper in the textbook. Some substances feel cold because they have high thermal conductivity. In this experiment, you will examine how well different substances conduct heat. Before you start, you need to get hold of various metals, for example, in a nearby mechanic shop.

1. Discuss in class how you can compare the thermal conductivity of different substances.
2. Select some of the objects around you, in the science room or in your school bag, and assess whether they have low, medium or high thermal conductivity.
3. Metals are the substances with the best thermal conductivity. Now you have to find out which of them conducts heat best. Discuss what kind of equipment you need and how you will go about measuring it.
4. Carry out the experiment, and rank the metals.



2 Hva leder varme best?

DU TRENGER
gjenstander av forskjellige materialer
plater av 3–4 ulike metaller (ca. 15 × 5 cm)
annet utstyr?

Enkelte gjenstander kjennes kalde når vi tar på dem, selv om de har samme temperatur som rommet vi sitter i. Stålbeina på pulten kjennes for eksempel kalde selv om de har akkurat samme temperatur som papiret i læreboka. Det at noen stoffer kjennes kalde, kommer av at de har stor varmeledningsevne. I dette forsøket skal dere undersøke hvor gode ulike stoffer er til å lede varme. Før dere begynner, må dere få tak i biter av ulike metaller, for eksempel hos et mekanisk verksted i nærheten.

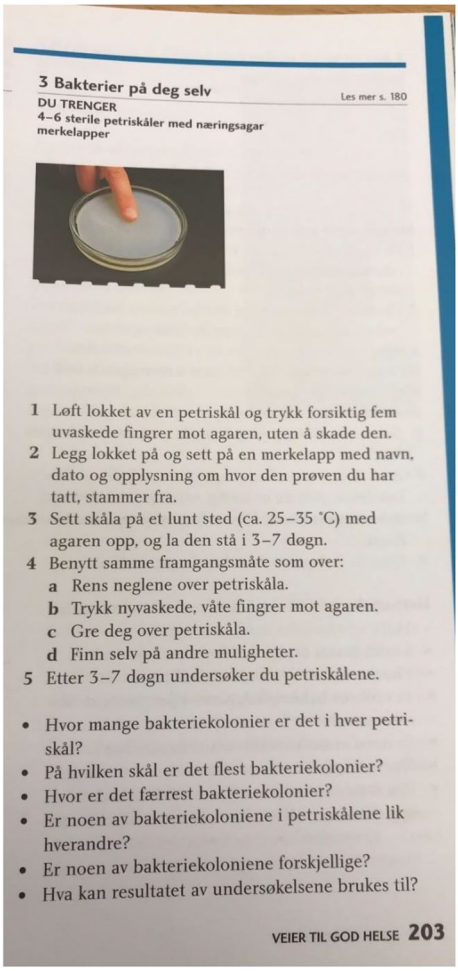
1 Diskuter i klassen hvordan dere kan sammenlikne varmeledningsevnen til ulike stoffer.
2 Velg ut noen av gjenstandene som finnes rundt dere, i naturfagrommet eller i skolesekken, og vurder om de har liten, middels eller stor varmeledningsevne.
3 Metaller er de stoffene som har best varmeledningsevne. Nå skal dere finne ut hvilket av dem som leder varme best. Diskuter hva slags utstyr dere trenger, og hvordan dere skal gå fram for å måle det.
4 Utfør eksperimentet, og lag en rangering av metallene.

MATERIALER 111

Fig. 3 Textbook activity (Ekeland et al., 2006, p. 111) discussed in interview

Bacteria on yourself (Fig. 4).
YOU NEED 4–6 petri dishes with nutrient agar labels.

1. Lift the lid of a petri dish and gently press your five unwashed fingers against the agar, without damaging it.
2. Put the lid back on and attach a label with name, date and information about the origin of the sample you have taken.
3. Put the dish in a warm place (approximately 25–35 °C) with the agar on top, and let it stand for 3–7 days.
4. Use the same procedure as above:
   a. Clean your fingernails over the petri dish.
   b. Press your freshly washed, wet fingers against the agar.
   c. Comb over the petri dish.
   d. Find other possibilities yourself.



3 Bakterier på deg selv

Les mer s. 180

DU TRENGER
4–6 sterile petriskåler med næringsagar
merkelapper

1 Løft lokket av en petriskål og trykk forsiktig fem uvaskede fingrer mot agaren, uten å skade den.
2 Legg lokket på og sett på en merkelapp med navn, dato og opplysning om hvor den prøven du har tatt, stammer fra.
3 Sett skåla på et lunt sted (ca. 25–35 °C) med agaren opp, og la den stå i 3–7 døgn.
4 Benytt samme framgangsmåte som over:
  a Rens neglene over petriskåla.
  b Trykk nyvaskede, våte fingrer mot agaren.
  c Gre deg over petriskåla.
  d Finn selv på andre muligheter.
5 Etter 3–7 døgn undersøker du petriskålene.

- Hvor mange bakteriekolonier er det i hver petriskål?
- På hvilken skål er det flest bakteriekolonier?
- Hvor er det færrest bakteriekolonier?
- Er noen av bakteriekoloniene i petriskålene lik hverandre?
- Er noen av bakteriekoloniene forskjellige?
- Hva kan resultatet av undersøkelsene brukes til?

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Fig. 4 Textbook activity (Ekeland et al., 2008, p. 203) discussed in interview

5. After 3–7 days, examine the petri dishes.
6. How many bacterial colonies are there in each petri dish?
7. Which dish has the most bacterial colonies?
8. Where are the fewest bacterial colonies?
9. Are any of the bacterial colonies in the petri dishes similar to each other?

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Declarations

Ethics Approval and Consent to Participate This study was reported to and approved by the Norwegian Agency for Shared Services in Education and Research (SIKT). All teachers gave their informed consent to participate.

Conflict of Interest The authors declare that they have no conflict of interest.

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