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Textbook tasks in the Norwegian school subject natural sciences: what views of science do they mediate?

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ABSTRACT

This study aims to investigate textbook tasks in the Norwegian school subject Natural sciences and the views of science that the tasks mediate to the pupils. Natural science is an interdisciplinary subject taught in Years 1–11 that includes chemistry, physics, biology and parts of the geosciences. We conducted a qualitative content analysis of 2,927 tasks from three Year-11 textbooks. The results showed that most of the tasks in all three textbooks were closed and asked the pupils to reproduce facts from the textbook or other information sources. However, findings also indicated that there are differences between and within the different chapters of the textbooks. In the topics that include socio-scientific issues, the tasks are more open for the pupils to both explore and evaluate evidence. Furthermore, all the three books have an introductory chapter focusing on scientific methodology, and the tasks in this chapter are much more diverse than in the remaining chapters. It therefore seems that the aim of the textbooks is to shed light on the nature of science, but the tasks embedded in the textbooks do not support scientific inquiry and perpetuate the traditional approach of asking learners to provide already determined answers to scientific issues.

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Textbook analysis; inquiry-based learning; nature of science

Introduction

Textbooks play a significant role in science education (Chiappetta & Fillman, 2007; Kahveci, 2010), and research has shown that they are used in several different ways: to supplement instruction, for pupils' discussions, as a source of activities, for assigned readings, and as a basis for the lectures or instruction (Davey, 1988). Thus, textbooks greatly influence learners' understanding of a school subject like science, both *indirectly*, by influencing the strategies teachers employ in the classroom and the sequence in which teaching and learning occurs (Almendingen et al., 2003; Chiappetta & Fillman, 2007; DiGiuseppe, 2014; Kesidou & Roseman, 2002; Mullis et al., 2012; Stern & Roseman, 2004), and *directly*, by putting forward 'the content

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students are to learn' and advocating 'what students should be able to do with that content' (Valverde et al., 2002, p. 125).

Important parts of textbooks are the tasks, that is, the many questions, directives, activities, and investigations that can be found throughout the book and especially at the end of the chapters. According to Doyle (1983, p. 162), tasks play a vital role in pupils' learning: 'Students will learn what a task leads them to do, that is, they will acquire information and operations that are necessary to accomplish the tasks they encounter'.

Even though tasks are important in developing pupils' understanding and learning of a subject, few studies have been conducted concerning tasks presented in science textbooks, and the existing research is still limited. Most studies have analysed only a small selection of tasks, and the purpose has been to evaluate rather than describe the tasks (Chinn & Malhotra, 2002; Germann et al., 1996; Herron, 1971; Yang et al., 2019); they have evaluated the tasks according to certain standards, but have not thoroughly described the different types of tasks. The aim of the present study, therefore, is to investigate what characterises the textbook tasks in science textbooks and to discuss the views of science that are conveyed through the tasks. We conducted a qualitative content analysis of all tasks in three Norwegian science textbooks for Year-11 students (16-year olds) to answer the following research questions:

- How frequent are different types of tasks presented in the science textbooks?
- How does the frequency of types differ across science topics?

Theoretical background

Theoretical learning perspective on tasks

In a socio-cultural perspective, learning is regarded as a form of socialisation into a particular society, and this socialisation does not take place primarily through teaching, but through participation in activities and as an outcome of participation (Säljö, 2005). The pupils' understanding of what science is, therefore, will be a result not only of what the teacher or textbook tells them, but also of the pupils' participation in various activities in science lessons and homework. In the pupils' encounters with the science textbook, the tasks may function as what socio-cultural learning theory calls mediating tools (Säljö, 2005). Mediating tools are physical or intellectual tools that have been developed within a culture and that shape people's understanding of and interaction with the objects around them. Textbook tasks therefore mediate pupils' understanding of science; they show pupils how to think, act and reason within the science subject. As Doyle (1983, p. 162) states, 'Tasks influence learners by directing their attention to particular aspects of content and by specifying ways of processing information.'

Research on textbook tasks has shown that, over time, a school subject may develop a specific task culture; that is, a system of norms for how to formulate, use and solve tasks (Bakken & Andersson-Bakken, 2017; Dahl, 1997; Valverde et al., 2002). The task culture is part of the subject culture, and, as with the subject culture in general (Höttecke & Silva, 2011), the task culture can only change gradually. The task culture may be particularly resistant to change because the members of the subject culture are often unaware of the norms regulating the tasks, and they can therefore be reproduced even if the national curriculum and theories and research on education change (Bakken & Andersson-Bakken, 2017). We are interested in investigating the views of science that are promoted through the textbook tasks, and how this socialises the students' perceptions and conceptions of science.

The educational context

During recent decades, research on science teaching and learning has called for improvements in science education including more emphasis on historical and philosophical perspectives related to science, and more pupil-active teaching and learning practices (Bøe et al., 2018). Major reforms in science education have also emphasised the nature of science (NOS) and engaging pupils in inquiry-based learning (IBL) (Abd-El-Khalick, 2013).

The way in which science is taught influences learners' capacity for lifelong learning and for solving real-life problems (Valanides et al., 2013). This is particularly relevant in the rapidly changing world in which we live, facing sustainability issues and other socio-scientific issues (SSIs) without definite answers and demanding complex reasoning and argumentation practices (e.g. Kolstø, 2001; Sadler & Dawson, 2012; Sadler et al., 2007). Globally, the focus has shifted from an emphasis on science for future scientists to the education of future citizens (e.g. Aikenhead, 2003; Osborne & Collins, 2001; Osborne et al., 2003), aiming to educate scientifically literate citizens who are able to make informed decisions in a democratic society (Zeidler et al., 2002).

In Norway, IBL has been on the educational agenda in recent decades and has been included in the science curricula since the 1990s. The current curriculum emphasises both IBL and NOS, and states that pupils should become aware that science is constantly evolving and that scientific laws and theories are models of a complex reality that can change or be further developed through new observations, experiments and ideas (Norwegian Directorate for Education and Training, 2013). In the curriculum, these perspectives are addressed through *the Budding Researcher* – one of six main subject areas in the Norwegian science curriculum (Norwegian Directorate for Education and Training, 2013):

> Teaching in natural science presents natural science as both a product that shows the knowledge we have acquired thus far in history and as processes that deal with how the knowledge of natural science is developed and established. These processes involve the formulation of hypotheses, experimentation, systematic observations, discussions, critical assessment, argumentation, grounds for conclusion and presentation. The budding researcher shall uphold these dimensions while learning in the subject and integrate them into the other main subject areas.

The Norwegian curricula are currently undergoing reform; school subjects are being renewed to meet future competence needs in both working life and society (Ministry of Education and Research, 2016). In the new science curriculum, the focus on IBL has increased, and science as a practical and inquiring subject is emphasised and linked to the need for inquiry skills in future working life and society (Norwegian Directorate for Education and Training, 2019).

IBL and NOS in science education

IBL is considered to reflect a quality science education (Anderson, 2002; Kahveci, 2010) and is one of the few overarching themes in precollege science curricula in countries around the globe (Abd-El-Khalick et al., 2004). Inquiry can be defined as 'an approach to learning that involves a process of exploring the natural or material world, and that leads to asking questions, making discoveries, and rigorously testing those discoveries in the search for new understanding' (National Science Foundation, 2000, p. 2). However, it is important that the understanding of inquiry does not become too narrow; it is not enough for pupils to just 'do science' (Crawford, 2000).

Osborne (2010, p. 67) states that science for citizenship should emphasise how science works and not only the facts of science since '"to know science" is a goal involving knowledge not only of *what* a phenomenon is, but also *how* it relates to other events, *why* it is important and *how* this particular view of the world came to be. Osbourne argues that currently practised science education 'uses evidence to persuade students that the *singular* account offered by the teacher is self-evident and "true"' and he points to the contrast between *science-as-practiced* and *science-as-taught* (Osborne, 2010, p. 61). Furthermore, Osborne argues that pupils occasionally should be given opportunities to study *science-in-the-making*, and be allowed to interpret data and examine arguments that involve uncertainties.

IBL can facilitate the development of pupils' understanding of both content knowledge and how to do inquiry and develop epistemological understandings about NOS (Abd-El-Khalick et al., 2004). NOS is considered essential for the education of future citizens and is linked with the characteristics of scientific knowledge being tentative, empirically based, subjective (and therefore influenced by the scientists' beliefs, knowledge and experiences), involving human interference and creativity, and being socially and culturally embedded (Lederman & Lederman, 2012). Insufficient understanding of NOS gives pupils naïve conceptions of science (Driver et al., 1996).

Even though research on science teaching and learning has called for improvement of science education, science education still suffers from transmissive teaching and little time for reflection (Höttecke & Silva, 2011; Lyons, 2006; Osborne & Collins, 2001). Höttecke and Silva (2011) reported results from German studies, revealing that physics teachers believed their role to be to convey the truth and express definite knowledge. Their lessons were therefore typically teacher-centred. Physics and chemistry teachers have been accused of being more receptive to the character of science as 'standing pure and separate from all involvement with society' (Ravetz, 1973, p. 9) compared to biology and environmental science teachers (Witz & Lee, 2009), and chemistry as an academic subject has been criticised for being irrelevant and fragmented, making the pupils struggle with transfer to new contexts (Gilbert et al., 2011). However, others have also found that science teachers in general regard the subject as referring to truths about nature that must be conveyed to pupils, emphasising the importance of memorising facts (e.g. Aikenhead, 2003; Lie et al., 2010; Lyons, 2006; Osborne et al., 2003). It is known that teachers who have an epistemological belief about science as a body of knowledge tend to favour instructional strategies (Jones & Carter, 2013). Furthermore, many science teachers have a vague understanding of NOS. They often lack education in NOS and will therefore rely on how NOS is conveyed in textbooks (Abd-El-Khalick et al., 2008; Höttecke & Silva, 2011).

Textbooks in science education

Knain (2001) studied Norwegian Year-8 science textbooks and claimed that the textbooks 'create (and are part of) a discourse which focuses on the end products of science' (p. 322).

This is in line with international research revealing that science textbooks traditionally, and still today, tend to focus on isolated facts and the reproduction of subject matter (Gilbert et al., 2011), and the end products of science and established scientific facts rather than IBL (e.g. Irez, 2009; Knain, 2001; Stinner, 1995). A focus on the end product leads pupils to emphasise the act of memorising rather than inquiry, and pupils perceive school science as the transmission of decontextualised, factual knowledge from expert sources, such as the teacher or the textbook (Lyons, 2006).

The number of publications on textbook analysis in science has been increasing rapidly in recent years (Vojíř & Rusek, 2019), and these have focused on different aspects. Some researchers have explored how the textbooks represent scientific methodology (Binns & Bell, 2015; Blachowicz, 2009; Knain, 2001) and NOS (Abd-El-Khalick et al., 2008; Chiappetta & Fillman, 2007; Niaz & Maza, 2011; Ramnarain & Chanetsa, 2016; Vesterinen et al., 2013). Others have investigated different levels of inquiry in the science textbooks (Chinn & Malhotra, 2002; Dunne et al., 2013; Park et al., 2009). Additional research on science textbooks has been investigating how well the textbooks support pupils' learning in certain topics (Stern & Roseman, 2004).

In their study of how eight US secondary school science textbooks described scientific methodology and how the textbooks' examples and investigations were consistent with this description, Binns and Bell (2015) found that broader views of scientific methodology were explicitly communicated to the reader compared to earlier studies. However, the textbooks still implicitly presented a narrow and traditional view. Other research has also found NOS to be insufficiently addressed in textbooks (Abd-El-Khalick et al., 2008; Ramnarain & Chanetsa, 2016).

Some research has also been conducted with regard to textbook tasks. This research has mainly addressed one of the following two aspects: (1) how cognitively challenging the tasks are or (2) how authentic the inquiry-based tasks are. In 1991, Shepardson and Pizzini published a study analysing the cognitive level of eight middle school science textbooks and found that low-level cognitive questions were predominant in the textbooks (Shepardson & Pizzini, 1991). Some 30 years later, Kahveci (2010) emphasises the role of questions in IBL and claims that questions posed to pupils have to reflect higher order thinking. In order to develop higher order thinking skills, '[pupils] need opportunities to apply, analyse, synthesise, and evaluate information obtained during chapter activities in order to construct meaning from the activity' (Pizzini et al., 1992, p. 77). Textbook questions that stimulate pupils to identify relationships and use the knowledge in new ways are more likely to lead to a deeper cognitive understanding (Kahveci, 2010).

Addressing the authenticity of IBL tasks, several studies have been conducted since Herron conducted the first study in 1971. However, the results seem to be the same: the investigations in textbooks rarely engage pupils in authentic investigations, and the epistemology of inquiry tasks were, in fact, incompatible with the epistemology of authentic science. Furthermore, most tasks failed to relate the inquiry-based tasks to lesson content (and therefore became activities rather than practices), failing to provide the pupils with opportunities to establish an understanding about scientific inquiry (Andersen, 2019; Chinn & Malhotra, 2002; Yang et al., 2019). These findings are in line with other research in science, indicating a certain task culture. A typical conclusion is that the tasks have to change (Chinn & Malhotra, 2002; Germann et al., 1996; Yang et al., 2019), but the results are repeated decade after decade.

A limitation in the previous research is that researchers tend to either analyse a selection of chapters (cf. Kahveci, 2010; Overman et al., 2013) or primarily focus on the inquiry-based tasks exclusively (cf. Chinn & Malhotra, 2002; Yang et al., 2019). Our contribution is that we have categorised all tasks in a sample of textbooks in which we have sought to find patterns in terms of how frequently different types of tasks occur. This gives a more nuanced picture of the tasks. We have also compared several textbooks to see if the same pattern is evident across the different textbooks and between different topics. A repeating pattern across textbooks may indicate that there is a task culture in the science subject, meaning that conventions and norms exist for formulating tasks in the subject.

Methods

We analysed three Norwegian textbooks from Year 11 in the subject Natural sciences (an interdisciplinary subject taught in Years 1–11 that includes chemistry, physics, biology and parts of the geosciences). The reason for choosing Year 11 is that this is the final year during which all pupils study this subject as part of their compulsory schooling in Norway. Furthermore, they have attained a relatively high cognitive level and can therefore be expected to have developed different strategies for solving tasks.

The three textbooks selected were *Kosmos 5th ed* (Heskestad et al., 2015), *Senit 3rd ed* (Van Marion et al., 2013) and *Nexus 2nd ed* (Ekeland et al., 2013). *Kosmos* consists of eleven chapters and 940 tasks, *Senit* has seven chapters and 1,257 tasks, and *Nexus* has nine chapters and 732 tasks. Since each textbook contains many tasks, we found it necessary to limit the number of books. Analysis of three textbooks was feasible, while at the same time ensuring a breadth in the selection. The books were published by the three major Norwegian publishing companies (i.e. Aschehoug, Cappelen Damm and Gyldendal); these publishers have long traditions in textbook production and choosing one book from each of the three publishers gives a representative sample. All textbooks were written for the 2006 curriculum and were later adapted to accommodate a minor curriculum revision in 2013. References to these three books will hereafter be given by the name of the book plus the page number, for example 'Kosmos, p. 155'. The tasks have been translated from Norwegian to English by the authors.

Data analysis

The tasks in the three textbooks were analysed using qualitative content analysis (cf. Fauskanger & Mosvold, 2014; Hsieh & Shannon, 2005; Krippendorff, 2013). All tasks in the three books were coded, and we compared the prevalence of different categories of tasks. Qualitative content analysis is a proven method within the study of textbook tasks, and it is well suited to our purpose because it enables us to identify any systematic differences in the specific tasks given in the different parts of the textbooks (Hsieh & Shannon, 2005; Strijbos et al., 2006).

In this study, we define a textbook task as a paratext that performs a directive addressed to the pupil. A paratext is a textual element that surrounds the main text (Genette, 1997), and a directive is a speech act in which the recipient is encouraged or required to perform a particular action (Searle, 1976). A directive is usually realised in the form of a question, such as: 'What is the difference between a community and an ecosystem?', or as an imperative: 'Explain the words species, population and community' (Kosmos, p. 59). In most cases, it is unproblematic to identify tasks such as these because, by virtue of being paratexts, they are separated from the text and clearly marked with a number, a letter, framing or another visual signal. However, certain textbook tasks are complex and comprise several questions and/or imperatives, and there may be doubts as to whether they should be regarded as one or more tasks. In our analysis, we followed the following rule: If several questions and/or imperatives follow one another in the same section, we count these as one task, for example: 'Find arguments in the text that justify why you should buy "nuke pills" (authors' comment: word used in the textbook for Potassium iodine). Select three arguments and assess their reliabilities' (Senit, p.156).

If the questions and/or imperatives are separated from each other graphically (for example, by numbering, line breaks or paragraph marking), we count these as more than one task. For example, the following are considered as two separate tasks:

a) Radioactive radiation is also called ionising radiation. Why?
b) What can happen to the cells in our body when they are exposed to ionising radiation? (Nexus, p.115)

The categories for coding the tasks were developed through what Hsieh and Shannon (2005) designate as a directed approach to content analysis. Based on theory and previous textbook studies, we defined a set of preliminary categories from which we attempted to encode the tasks and, in terms of the empirical material, these categories were adjusted and supplemented with new ones.

The categories placed in a science context

We ended up with a categorisation on two levels, as illustrated in Figure 1. At code level 1, the tasks were categorised according to the degree of freedom given to pupils with regard to answering the task. Closed tasks are tasks that have a definitive answer, such as 'What is mutation?' (Senit, p. 188), and: 'Both batteries and solar cells are sources of energy. What are the similarities and differences between batteries and solar cells?' (Kosmos, p. 196). For this category, we also counted tasks where the pupils are required to reproduce some examples from a clearly delimited selection of options – for example: 'Name some examples of oxidations' (Nexus, p.66). Open tasks are tasks that can be answered or solved in different ways, such as these three tasks from Nexus (p. 24):

a. Use the internet to search for genetically modified food and observe what hits you get.
b. Classify the various web pages into those you believe to be credible sources of information and those of which you are sceptical. How do you justify your classification?
c. Compare the lists you have created, and discuss the classification.

Distinguishing between closed and open tasks has proved to be fruitful both in textbook research (Skjelbred et al., 2005) and in studies of teachers' questions for pupils (see, for example, Nystrand et al., 1997). Closed tasks are important in science education since they direct the pupils' attention towards what Osborne (2014, p. 580) refers to as 'existing,

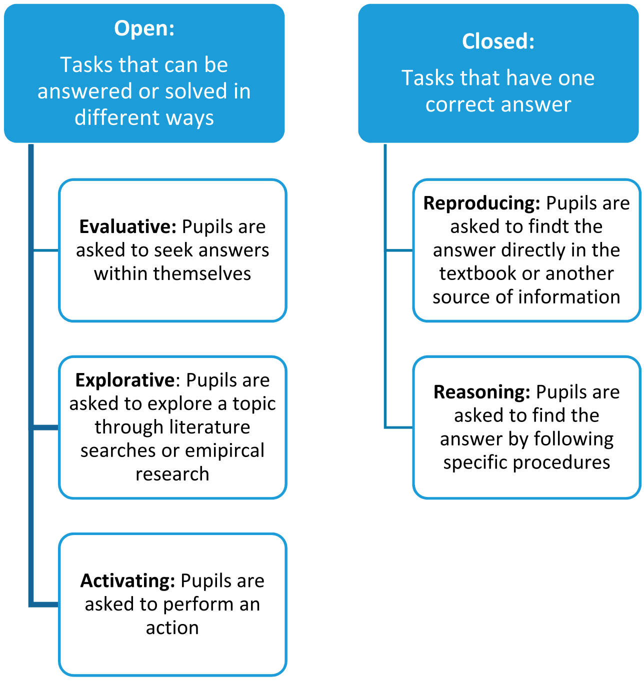

Figure 1. Categorisation at two levels: Code level 1 (open and closed) and code level 2 (evaluative, explorative, activating, reproducing and reasoning).

consensually agreed and well-established *old* knowledge'. Open tasks, on the other hand, are more directed towards *science-in-the-making* (Osborne, 2010) and allow the pupils to interpret data and make arguments. Thus, both kinds of tasks are important in understanding science, as they have different functions in the process of learning.

At code level 2, the tasks are divided into subcategories according to how the pupils are asked to solve them. Closed tasks are divided into reproducing tasks and reasoning tasks. Reproducing tasks are tasks where the answer is explicitly expressed in the textbook or in another source of information. Such tasks are important in learning the language of science and allowing the pupils to demonstrate their knowledge (Schneider & Stern, 2010). However, the tasks may also be answered based on syntax rather than understanding (Wellington & Osborne, 2001) and do not necessarily imply more than a passive conceptual understanding (Bravo et al., 2008). Examples of reproducing tasks are, 'What do we mean by key species?' (Nexus, p. 45), and 'What is cloning?' (Kosmos, p. 254). Reasoning tasks, on the other hand, are tasks where the learners are required to find the correct answer by applying their knowledge or following specific procedures described in the textbook. Being able to solve such tasks implies an active conceptual understanding (Bravo et al., 2008). Examples of reasoning tasks are 'What does not belong here? Justify your answer with scientific knowledge. Iodine – Calcium – Fluorine – Selenium' (Senit, p. 80), and 'How is it possible for two rats with black coloured fur to have offspring with white coloured fur?' (Kosmos, p. 229).

The open tasks are divided into evaluative tasks, explorative tasks and activating tasks. In evaluative tasks, the pupils are required to arrive at the answer by evaluating, interpreting or taking a position, and are, hence, in line with *science-in-the-making* (Osborne, 2010). An example of an evaluative task is 'What would it look like where you live if there were no decomposers?' (Kosmos, p. 59). In explorative tasks, the pupils are required to explore a topic by means of a literature search or empirical research (such as inquiry-based experiments with either question, methodology and/or answer not given). Examples of explorative tasks are: 'Use the internet to find ways to better utilise the energy in our homes. Examples of keywords: energy houses and energy saving' (Kosmos, p. 195). Finally, activating tasks are tasks where pupils must perform a specific action, such as writing a text, discussing with a fellow pupil or conducting 'cookbook' experiments. Cookbook experiments are placed in this category since experiments where the pupils are supposed to follow a recipe are considered activities rather than explorative inquiries. An example of an activating task is the following task from Nexus (p. 245): 'Insulin is used in the treatment of diabetes. Use encyclopaedias or the internet to find out how insulin was produced in the past and how it is produced today. Give a short lecture to the class'.

The rationale for categorising the tasks according to how the pupils are going to solve them lies in the socio-cultural theory basis of this study. The tasks are understood to be tools that mediate the understanding of science for the pupils – among other things, by showing them activities scientists engage in. It is therefore relevant to investigate whether there are differences in the activities the tasks invite the pupils to perform, both within individual textbooks and across textbooks.

Although the categories are defined so that they are mutually exclusive, some tasks were difficult to categorise. Particularly, there are certain tasks in our material that are composed of several questions and/or imperatives, and, in some cases, the various parts of the tasks can be placed in different task categories, such as this task from Senit (p. 73): 'How much energy does one kilogram of fat contain? Use the table above and create an exercise programme that allows us to use the corresponding amount of energy contained by one kilogram of fat'. The first sentence points to a reproducing task, and the last towards an activating task. To make the coding consistent, we coded compound tasks based on the ending of the task (i.e. the last paragraph). This example was therefore coded as an activating task.

Since the tasks were so numerous (2,927 tasks in all), we divided the tasks between two of the authors. To investigate the reliability of the coding, we made a control selection of 347 tasks, which the two authors coded independently. As a statistical measure of how these tasks were coded, we calculated Cohen's kappa. Code level 1 had a kappa value of 0.83, and at code level 2 the value was 0.78. Landis and Koch (1977, p. 165) consider values above 0.80 as 'almost perfect', while Fleiss (1981, p. 218) refers to values above 0.75 as 'excellent'. Based on this, we may consider the coding of the tasks reliable. As we are analysing texts that are publicly available, it will also be possible for others to test the reliability of our analysis (cf. Silseth, 2013).

Results

To answer our research questions, we will start by presenting the kinds of tasks that are included in the science textbooks and how they differ between the books. We will first present *how frequently the different types of tasks occur* (research question 1) on code level 1 and then on code level 2. Thereafter, we will present *how the frequency of types differ according to the science topics* (research question 2).

As we see in Figure 2, the majority of tasks in all three textbooks are closed, amounting to about 80% of the tasks. There are some small differences between the books; Kosmos has fewer open tasks, while the other two textbooks are quite similar in the proportion of open and closed tasks.

In Figure 3 below, we can see the distribution between the different tasks at code level 2, where the closed tasks were analysed according to whether they are reproducing or reasoning, and the open tasks according to whether they are evaluative, explorative or activating. As we can see from the diagram, there is a predominance of reproducing tasks – that is, tasks asking the pupils to reproduce answers that they can either find directly in the textbook or easily look up in other information sources (such as Wikipedia, Google, etc.). The second most frequent tasks are the reasoning tasks, where the pupils have to reason or deduce the correct answer.

As illustrated in Figure 3, there are some differences between the textbooks. Senit and Nexus, once again, are quite similar when it comes to the distribution of closed tasks. Both textbooks have approximately 47% reproducing tasks, whilst Kosmos differs from the two other textbooks, with 69.6% of the tasks being reproducing. As the number of closed tasks is quite similar in all the books, this also means that Kosmos has fewer of the reasoning tasks with only 12.7%, whilst Nexus and Senit have approximately 27% of tasks that are reasoning.

When it comes to the open tasks, the categories are relatively equally distributed among the three categories. In Nexus, 11.1% of the tasks are activating, whilst Senit has 9.7% and Kosmos only 5.5%. The tasks in Kosmos that are predominant are in the category of evaluative tasks, with 7.6%. In Senit, 10.3% of the tasks are evaluative, whereas Nexus only has 6.0% evaluative tasks. Two of the three textbooks have fewest tasks in the category of

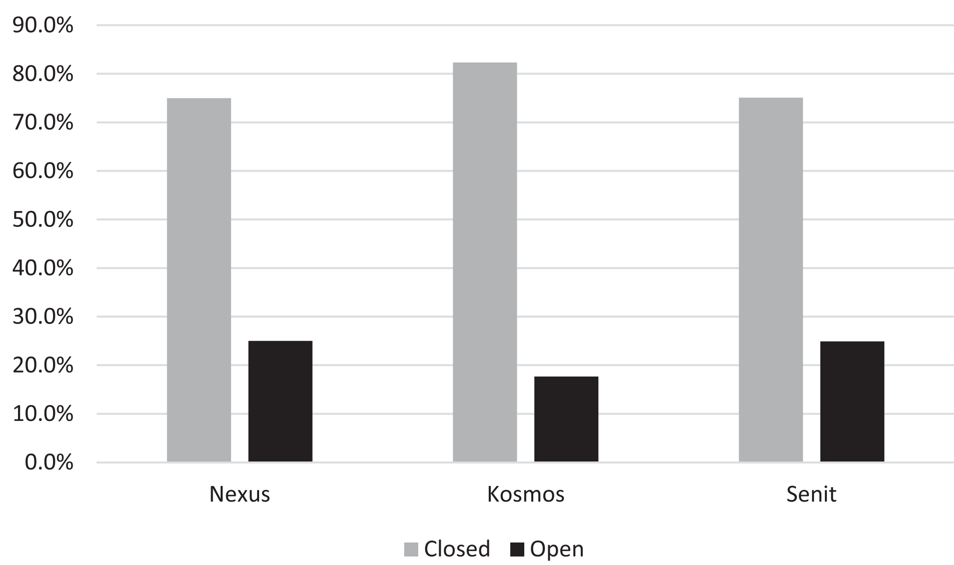

Figure 2. Distribution of open and closed tasks in the three textbooks.

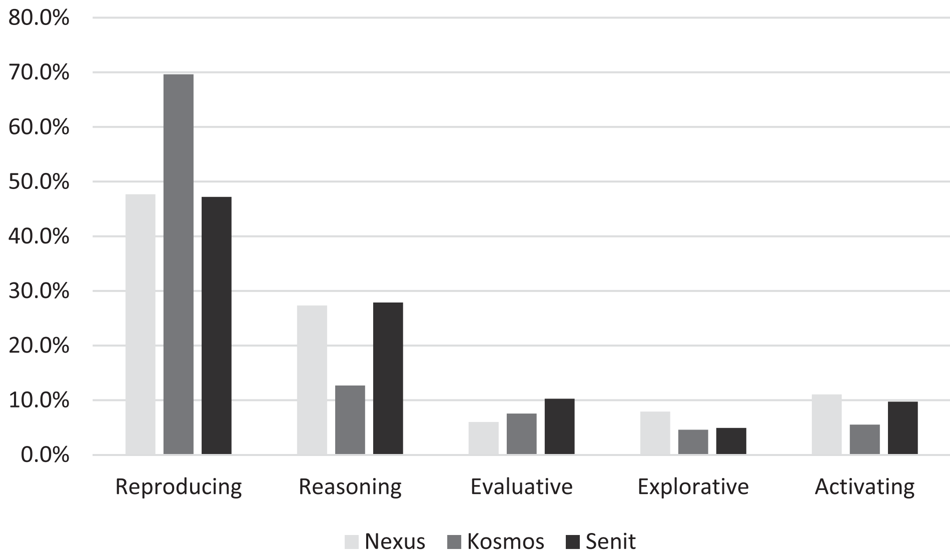

Figure 3. Distribution of different tasks at code level 2 in the textbooks.

explorative tasks. Here, Kosmos and Senit have 4.6% and 4.9% of the tasks, respectively, whilst Nexus has slightly more exploratory tasks with 7.9%. The two latter categories (i.e. evaluative tasks and explorative tasks) are those in which Nexus and Senit differ the most, with Nexus having more explorative tasks.

With regard to how the different tasks are distributed between the different topics of the books, we begin by looking at code level 1. As we can see from Figure 4, the introductory

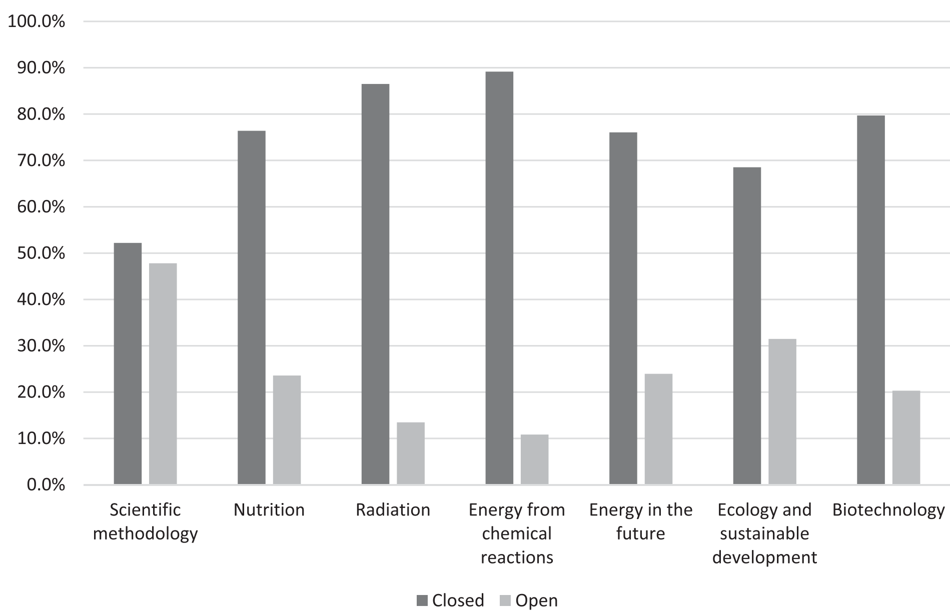

Figure 4. Distribution of tasks at code level 1 in the different chapters of the textbooks.

chapters focusing on scientific methodology as a topic have significantly more open tasks than the other topics. In these chapters, almost half the tasks are open, compared with the other chapters, where 10–32% of the tasks are open.

In the chapters focusing on *ecology and sustainable development*, a third of the tasks were coded as open. At the other end of the scale, the chapters concerning *radiation* and *energy from chemical reactions* were the ones with the fewest open tasks. This could be related to the subjects to which these topics belong – physics and chemistry, respectively. The topics that are closer to what the pupils face in their everyday life (e.g. nutrition and sustainable development) seem to have more tasks that are open. This can be also be revealed within a single chapter in which the types of tasks tend to vary. One example in this respect is the topic of *energy in the future*. The tasks that deal with solar cells and heat pumps are almost exclusively closed, whilst tasks related to energy and the environment are more mixed. Here we find several open tasks of all types – activating, evaluative and exploratory.

In Figure 5, we can see the distribution of different types of tasks in the chapters in the three textbooks. The results clearly indicate a greater variation in tasks in the introductory chapters concerning scientific methodology than in the other chapters. In the chapters concerning scientific methodology, fewer tasks ask pupils to reproduce (reproducing) than in the other chapters. Instead, there are more tasks that ask pupils to evaluate (evaluative) or perform some activity (activating) than in the other chapters. Furthermore, the category of explorative tasks is slightly more recurrent here than in the other chapters.

We can also see that the different chapters have a variation of tasks depending on the topic of the chapter. In the chapter concerning *energy from chemical reactions*, the pupils are asked to reason more than in any of the other chapters. Figure 5 also shows that

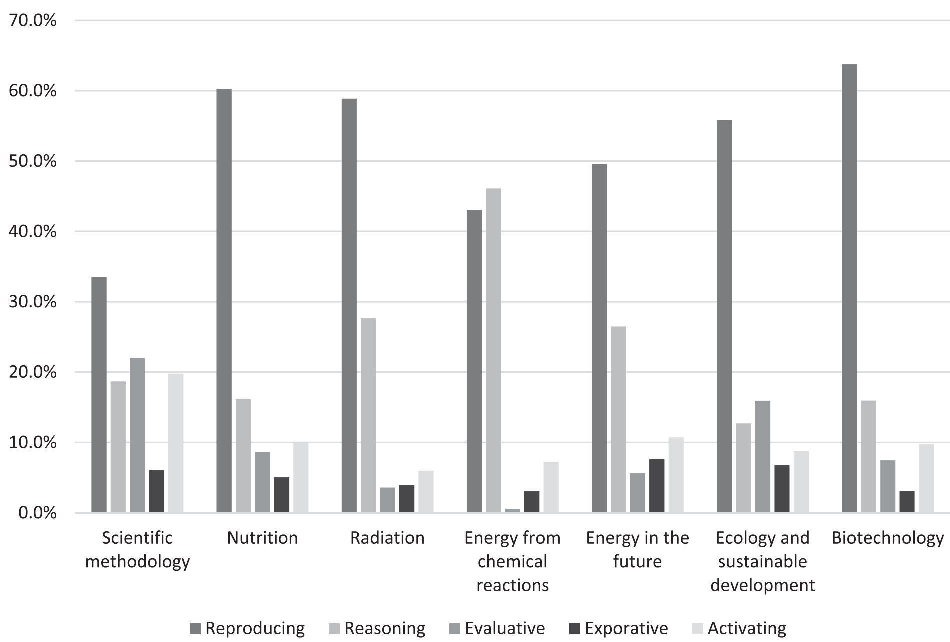

Figure 5. Distribution of tasks at code level 2 in the different chapters of the textbook.

chapters with topics in physics (i.e. *radiation* and *energy in the future*) have more reasoning tasks than do chapters with topics involving biology. Furthermore, there are few evaluative tasks, except in the chapters focusing on scientific methodology and sustainable development, and few explorative tasks in all chapters. The *energy in the future* and *nature of science* chapters have almost double the number of explorative tasks compared to the other chapters, and these mostly involve the exploration of a topic online. Many experiments were coded as activating rather than explorative since the pupils are supposed to follow a recipe towards a given answer rather than engage in inquiry. Most experiments coded as explorative ask the pupils either to follow a recipe towards an open answer or to design a procedure towards a given answer and were, hence, only partly explorative.

The variations revealed within a chapter in code level 2 are similar to those in code level 1, where the types of tasks within those topics that are closer to everyday life are more open. One example of this is the topic of *nutrition*. The tasks that deal with nutrients and the digestive system are typically reproducing, whereas the tasks that deal with diet and exercise are typically evaluative or activating.

Discussion

The aim of this study was to investigate the views of science that are portrayed through the textbook tasks in three Norwegian science textbooks for Year 11. In this section, we discuss our findings from a socio-cultural perspective on learning, in which learning is understood as enculturation through gradual participation in certain activities, social practices or discourses in society (Säljö, 2005; Vygotsky, 1978). We argue that the pupils are socialised into an understanding of science through the tasks in the science textbooks. In this sense, the textbook tasks can be regarded as mediating tools for the cultures of science and science learning in school. They convey to pupils the types of knowledge, values and practices that are important and relevant. By means of these tasks, pupils are confronted with ways to encounter and understand science.

Textbooks often present methodology and NOS explicitly in an introductory chapter, and implicitly in the remaining chapters (Abd-El-Khalick et al., 2008; Binns & Bell, 2015). This is also the case with these Norwegian textbooks, all of which have an introductory chapter aimed at giving the pupils an understanding of science and how scientific knowledge is created. The analysis of the introductory chapter in the three textbooks showed that the tasks are evenly distributed between open and closed tasks, as well as among the five categories, with somewhat more reproducing tasks and fewer explorative tasks. An even distribution where the pupils have to reason, evaluate and perform activities corroborates the view of scientific knowledge as tentative, empirically based and subjective (Lederman & Lederman, 2012). The remaining chapters, however, feature another distribution of the tasks, with a predominance of closed tasks, implying a perspective of science as self-evident and true (Osborne, 2010) – and, hence, being part of the discourse focusing on the end product of science (Knain, 2001).

Looking at the distribution of the closed tasks across the remaining chapters, there are most closed tasks in topics that can be linked to 'pure' chemistry and physics (such as *radiation*, *energy from chemical reactions* and parts of the *energy for the future* chapters). This is in line with the literature stating that physics and chemistry teachers consider science as being pure and separate from involvement with society (Witz & Lee, 2009) and presented as isolated facts (Gilbert et al., 2011). Looking further into the distribution within the closed tasks, there is an overweight in most topics of reproducing tasks allowing the pupils to display their knowledge, but at the same time encouraging memorisation rather than conceptual understanding (Kahveci, 2010). There are many reproductive tasks in topics within biology in particular. The only topic with a predominance of reasoning tasks, thereby demanding active conceptual understanding (Bravo et al., 2008), is the chemical topic *energy from chemical reactions*. Prior analyses of tasks in chemistry have also revealed a considerable number of tasks focusing on application (Overman et al., 2013). Furthermore, there is a larger proportion of reasoning tasks in the physics topics than in the biological topics.

The open tasks in the three textbooks are mainly evaluative and activating. An examination of the distribution of open tasks within the topics reveals a predominance of evaluative tasks only in the topic *ecology and sustainable development.* These are tasks connected to SSIs and without a given answer, which allows the pupils to evaluate and draw their own conclusions (Kolstø, 2001; Sadler et al., 2007; Zeidler et al., 2002). Elsewhere, activating tasks are prevalent, implying that the pupils are supposed to carry out an activity. The fact that there are few explorative tasks and many experiments not in line with inquiry principles shows that the pupils may be socialised into an understanding that science is not open for exploration, implying that there still is a contrast between *science-as-practiced* and *science-as-taught* as pointed to by Osborne (2010).

Comparing the introductory chapter on scientific methodology with the remaining chapters illustrates that what science is said to be (i.e. in chapter 1) differs from how science is implicitly presented in the other chapters. This is similar to the findings of Binns and Bell (2015), who found that the introductory chapters explicitly communicated broad views of scientific methodology, whereas the implicit message presented narrow and traditional views. The only exceptions are the chapter on *ecology and sustainable development* and sections of other chapters relevant to sustainable development (e.g. *energy for the future)*, indicating that the textbooks present established and uncertain knowledge differently. The tentative character of SSIs is more clearly in line with the tentative character of NOS (Lederman & Lederman, 2012), and the books tend to undermine the tentativeness of all scientific knowledge.

The emphasis on NOS has changed during the most recent decade(s) (Ministry of Education and Research, 2016), with a clearer focus on NOS in both the national curriculum and in the research community. The similarity between the distributions of tasks in the three books indicates that there is a culture of norms in the development of tasks in natural sciences. However, as stated earlier, the task culture takes a long time to develop and change, and in the case of the Norwegian textbooks, the task culture does not seem to be in line with the current curriculum. Furthermore, this culture is also often reproduced because of a lack of awareness around the norms that regulate the tasks (Bakken & Andersson-Bakken, 2017; Dahl, 1997). Here, content analysis has a value, as it can reveal patterns that are not visible at first sight. Through a descriptive analysis of *all* tasks in the three textbooks, rather than a selection of tasks, which has been common practice in prior research (e.g. Chinn & Malhotra, 2002; Germann et al., 1996; Herron, 1971; Yang et al., 2019), we have been able to go deeper into the culture that lies behind developing tasks in textbooks. We can thereby shed light on the kinds of understandings of science that pupils are socialised into.

Our findings show that there is an overweight of closed and reproductive tasks, which may give pupils an understanding of science as a subject with definitive answers and little room for interpretation. There are some differences across topics, where chemistry seems to have more closed tasks and biology seems to have an excess of reproductive tasks. We argue that closed tasks undoubtedly have a place in science, allowing the pupils to practise and display their knowledge of the language of science (Lemke, 1990; Wellington & Osborne, 2001); however, with the current task culture, there is an emphasis on closed tasks, giving little room to address how knowledge is created (Osborne, 2010). The task culture is incompatible with what NOS represents and how science should be understood from the perspective of scientific inquiry. This means that textbook authors need to be more conscientious about ensuring that the tasks in textbooks also reflect the way science should be understood, including the uncertainties and argumentations that 'surround scientific work at the boundaries of our knowledge' (Osborne, 2010, p. 61).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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