Multiple school science literacies

Exploring the role of text during integrated inquiry-based science and literacy instruction

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Thesis abstract

The main aim of this thesis is to explore how literacy is embedded in six primary school science classrooms during integrated inquiry-based science and literacy instruction. This is investigated by analyzing classroom video data from six primary school science classrooms, along with interview data with students (n=33) and textual artifacts from the six classrooms. The classroom video study was conducted through a larger research and development project, *The Budding Science and Literacy* project, in which six primary school science teachers were recruited from an in-service professional development course on inquiry-based science and literacy. The six teachers were then video-recorded, along with their students, as they taught a sequence of lessons, where they were to explicitly integrate disciplinary literacy practices with inquiry-based science, as a part of the professional development course.

The first article included in this thesis (Article I) is an overview video study of the Budding Science and Literacy project, which explores the variation and patterns of integrated inquiry-based science and literacy instruction by mapping the occurrence and co-occurrence multiple learning modalities (reading; writing; talking; doing) and main inquiry phases (preparation; data; discussion; communication) in the six classrooms. The results show that the teachers spent comparably more time on preparation and data than on the consolidating phases of discussion and communication. Reading and writing were also more prominent in these phases of inquiry.

Article II investigates the literacy practices that emerge among primary school students during integrated inquiry-based science and literacy instruction. This is mainly explored through video analysis of *literacy events* that occur in the video material, with student interviews and collected textual artifacts acting as additional data sources. The article reveals how multiple literacies emerged in the context of integrated science-literacy instruction. For example, elements of students' informal literacies became valued resources in the dialogic process of inquiry, but the students also engaged in typically schooled literacy practices that helped structure their learning experiences. The article also indicates that the implemented instruction created new literacy demands that were not always clear to the students.

Article III provides an introduction to what a social view of literacy means for school science. In the first part of the article, we use sociocultural perspectives to argue that literacy in school science is best understood as social practices embedded in cultural and ideological contexts. In the second part, we rely on these perspectives to present a framework for promoting literacy in science classrooms. Finally, the article discusses how a social view of literacy can provide science educators with the theoretical perspectives to consider how literacy is actually used in contexts relevant to a transcending science subject for scientific literacy.

The final article, Article IV, is a methodological contribution that considers the use and re-use of video data from two perspectives: the primary researchers (or archivists) and the secondary analysts. It combines two research projects—The Budding Science and Literacy project (the primary researchers) and the PISA+ video study (the secondary analysts)—to make an argument for establishing more common practices when conducting classroom video studies.

The four articles address the overarching aim of the thesis from different perspectives. While the first article maps the time is spent on different learning modalities in the six classrooms and how these co-occur with science inquiry phases, Article II goes beyond "reading" and "writing" *per se* to investigate what texts students encounter, what they do with these texts, and how they talk about them, from a sociocultural perspective on literacy. These two articles represent the empirical studies that make up this thesis. The third article builds on the first two articles, along with other relevant studies on the role of text in school science, to discuss what a social view of literacy means for science teachers' educational practice. The final article in this thesis, Article IV, considers some of the methodological issues related to using and re-using video data in classroom video studies. In this way, Article IV frames the empirical research reported in articles I and II, in addition to discussing how video can be used to investigate classroom practice in general.

Taken together, this thesis demonstrates how literacy is interwoven in the activities and inquiries of the six participating classrooms. By approaching literacy as a social practice, these findings illustrate how multiple school science literacies, which attend to markedly different purposes in the classroom, can emerge in an inquiry-based context in primary school science. The thesis highlights a need for supporting teachers in the discussion and communication phases of inquiry, as well as providing explicit instruction to the specialized conventions of scientific language that frame reading and writing in school science.

Part I: Extended abstract

Part II: Articles

PART I

EXTENDED ABSTRACT

1 Introduction

1.1 Literacy in the context of school science

The main concern of this thesis is how literacy is embedded in the context of school science. In science, written language has a constitutive and integral role in the social practices that make the construction of scientific knowledge possible (Bazerman, 1988; Knorr Cetina, 1999; Latour & Woolgar, 1986; Norris & Phillips, 2003). Without text, and the socially meaningful ways of dealing with these texts, science would simply not exist in the way we know it today. In school science, however, the ways in which we deal with text have traditionally been of little concern to most science teachers and science educators (Pearson, Moje, & Greenleaf, 2010; Wellington & Osborne, 2001). Thus, investigating how literacy is actually embedded in various school science contexts is crucial to support students in interacting with "reasonable comfort and confidence in a society that is deeply influenced and shaped by the artefacts, ideas, and values of science—rather than feeling excluded from a whole area of discourse, and, as a corollary marginalised" (Osborne, 2007, p. 177).

In this thesis, I explore the role of text in six primary school science classrooms during integrated science-literacy instruction, meaning that the teachers in these classrooms aimed to explicitly integrate disciplinary literacy practices with inquiry-based science education (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Cervetti, Pearson, Bravo, & Barber, 2006; Pearson et al., 2010; Varelas & Pappas, 2006). The work that is reported here is part of and contributes to a larger research and development project, *The Budding Science and Literacy* project (Ødegaard, 2010), which sought to test and refine a teaching model for integrating inquiry-based science and literacy in collaboration with primary school science teachers through a professional development course. Six teachers from the professional development course, and their students, were thereby recruited to participate in a classroom video study. The focus of this thesis, then, concerns the ways in which the students in these classrooms encountered and used text, and how this was relevant to their engagement in school science inquiry.

The thesis builds on a main argument derived from sociocultural studies of literacy, namely that reading and writing can only be understood in the contexts of the particular social practices of which they are a part (Barton, 2007; Barton & Hamilton, 1998; Gee, 2004, 2008; S. B. Heath, 1983; Jewitt, 2008; Lankshear & Knobel, 2006; Lemke, 2004; Scribner & Cole, 1981; Street, 1984, 1995; The New London Group, 1996). In this way, literacy becomes much more than a neutral set of skills that concerns the ability to read or write; rather, it involves engaging and participating in "particular ways of thinking about and doing reading and writing in cultural contexts" (Street, 2003, p. 79). Literacy can thus be described as something people do in their everyday life—a social activity involving text—that necessarily also includes values, talk, social relationships, attitudes and beliefs about these texts (Barton & Hamilton, 1998; Gee, Hull, & Lankshear, 1996). In this thesis, the context for researching literacy is framed within the school science lessons of the six primary school science teachers attending the professional development course on inquiry-based science and literacy.

Already, we are faced with a possible contradiction in the terminology used to describe the empirical setting (integrated science-literacy instruction) and the theoretical framework (sociocultural perspectives on literacy). The term "integrated science-literacy instruction" could imply that there must also be some form of science instruction in which literacy is not integrated. From a sociocultural perspective on literacy, however, literacy will always be integrated into our daily activities, whether in or out of school, although it may be embedded in different ways (Barton, 2007; Barton & Hamilton, 1998). In this thesis, the term *integrated science-literacy instruction* should thus not be taken to represent the integration of something (i.e., "literacy"), which would otherwise not "be there", into science instruction. Rather, the term is used to represent an inquiry-based approach to science education that acknowledges the role of language and literacy in science (Cervetti et al., 2006; Pearson et al., 2010). As Osborne (2002, p. 215) clearly states:

> "[L]iteracy is not an additional element but an essential constitutive practice of science whose study is as vital to science education as sails are to ships, bricks are to houses or engines to cars. Improving the quality of science education, both in terms of the experience it offers to its students and its cognitive and affective outcomes, requires the restoration of language and literacy to the central position it occupies in its practice; nothing less will suffice."

This thesis comprises two main parts. The first part is an extended abstract, which outlines and categorizes the issues and conclusions of the second part: four individual articles that are either published or in the process of being published. The extended abstract thus presents the work of the individual pieces contained within this thesis as a whole. The extended abstract is structured to first provide a contextualization for the thesis through a presentation of the Norwegian educational system and the larger research project of which this thesis is a part. The present work is then situated in the context of relevant research on the role of text in school science classroom, before the theoretical perspectives guiding the research are presented. In chapter 4, methodological approaches and concerns are introduced and addressed. This leads into a summary of the four individual articles that make up this thesis along with the extended abstract. In chapter 6, the findings and implications of these four articles are discussed in light of the preceding chapters.

1.2 Context of the study

1.2.1 The educational system in Norway

The empirical data on which this thesis is based were gathered from six primary school science classrooms in the greater Oslo area of Norway, with teachers attending a professional development course on science inquiry and literacy. To fully grasp the institutional context in which these classroom practices took shape, it is necessary to first consider some of the main characteristics of the Norwegian school system, as well as the governing national science curriculum.

In Norway, all children have a legal right to 13 years of education and usually start school at the age of six. The first ten years—primary school (grades 1-7) and lower secondary school (grades 8-10)—are compulsory and free of cost. While upper secondary school (grades 11-13) is voluntary and free of choice, all young people in Norway are entitled to upper secondary education and there is an explicit priority to increase the attendance and completion rate in upper secondary school (Ministry of Education and Research, 2009). Furthermore, it is largely the municipal authorities that finance Norwegian schools, although 185 private primary and lower secondary schools were approved for the school year 2012/2013 (equivalent to nearly 3 percent of primary and lower secondary school students) (Norwegian Directorate for Education and Training, 2013).

Schools are governed by a centralized national curriculum that is proposed by expert groups of teachers, teacher educators, and various institutions, and approved by parliament. The current national curriculum was implemented in 2006, following the Knowledge Promotion

Reform—a comprehensive national curriculum reform for primary, lower secondary and upper secondary education and training (Ministry of Education and Research, 2006). One of the central changes in the Knowledge Promotion Reform, which is of special importance to this thesis, was an increased focus on five *basic skills* in all subjects: reading, writing, arithmetic, oral skills, and digital skills. These basic skills were based on the OECD framework *Developing Selected Competencies* (DeSeCo) and considered as fundamental across subjects (Knain, 2005a). Hence, teachers are now to integrate and work with these skills in each subject, on the premise of the particular subject they teach. Because the focus on basic skills emphasizes that learning cannot be separated from language and other semiotic resources, Berge (2005, p. 4) has labeled the Knowledge Promotion Reform a "literacy reform".

However, recent evaluations of the Knowledge Promotion Reform indicate that the intention behind basic skills has not been properly communicated to teachers and that the implementation of basic skills has not led to notable changes at the classroom level (Møller, Prøitz, & Aasen, 2009; Ottesen & Møller, 2010). In primary school, it is reading that has received the most attention, but often in relation to language arts lessons (Hertzberg, 2010). Based on these reports, The Ministry of Education and Research decided to revise the subject curricula of five subjects, among them science, to clarify what basic skills implies in each of these five subjects (Ministry of Education and Research, 2010a). The revisions made in the national science curriculum will be explored further in the next section. This section will also give an introduction to science as a school subject in Norway and the national science curriculum as it is stated in the Knowledge Promotion Reform.

1.2.2 Science as a school subject in Norway

Throughout grade 11, school science in Norway appears as an integrated and holistic school subject that comprises areas within the disciplines of biology, physics, chemistry, geosciences, and technology, along with a focus on the process dimension of science. Students are then able to choose specialized science subjects in grades 12 and 13. In primary school—the empirical setting of this thesis—328 teaching hours are allocated to science teaching over the course of these first seven years of compulsory schooling (Ministry of Education and Research, 2006). On average, school science thus constitutes approximately 47 teaching hours per grade level (per year) in primary school. In this regard, it should be noted that the number of teaching hours in science at primary school levels in Norway is markedly lower than the international average, according to TIMSS (Trends in International Mathematics and Science Study) 2007 data (Grønmo & Onstad, 2009).

Following the Knowledge Promotion Reform in 2006, two central changes have been prevalent in the national science curriculum. First, the previously mentioned introduction of basic skills in and across all subjects requires reading, writing, arithmetic, oral and digital competences to be integrated in science teaching and learning at all grade levels. Second, a new main subject area on the processes and nature of science —*The Budding Scientist*—was introduced to the science curriculum (Ministry of Education and Research, 2006). Isnes (2005) states that the decision to implement *The Budding Scientist* as a main subject area of its own was to place further emphasis on the process dimension of science, due to low scores on international comparative studies. For example, PISA (The Programme for International Student Assessment) 2006 data showed that Norwegian students scored below their Nordic counterparts on measures of knowledge *about* science, as opposed to measures on knowledge *of* science (Kjærnsli, Lie, Olsen, & Roe, 2007). Combined, the introduction of basic skills and *The Budding Scientist* as a main subject area to the national science curricula can be said to emphasize both disciplinary literacy and inquiry-based science as prominent foci in Norwegian science classrooms.

Still, there is reason to believe that inquiry-based approaches to science teaching and learning are not prevalent in Norwegian schools (e.g., Kjærnsli et al., 2007; Sikko, Lyngved, & Pepin, 2012; Ødegaard & Arnesen, 2010). In the PISA+ video study, which was conducted the year before the Knowledge Promotion Reform was implemented, "very little inquiry science where students used practical experiments as a basis to actively talk science" was found (Ødegaard & Arnesen, 2010, p. 16). In the PISA 2006 survey, which focused specifically on science, Norwegian students reported that practical work occurred above the international average; science inquiry, on the other hand, was consistently low across the Nordic countries (Kjærnsli et al., 2007). Moreover, in a recent survey among Norwegian science teachers, mainly from lower secondary levels, Sikko and colleagues (2012) reported that the teachers surveyed wanted to implement more inquiry-based approaches than they already did, but that they needed more, and more relevant, professional development courses to do so. Their findings reinforce the impression of the TIMSS 2007 survey, which showed that Norwegian teachers at 4th and 8th grade levels have less formal education and specialization in science than what is common internationally (Grønmo & Onstad, 2009). Accordingly, professional development of science (and mathematics) teachers has become a main priority for the Norwegian Ministry of Education and Research (2010b) over the last few years.

As stated in the previous section, the national science curriculum was one of five subject curricula that was revised and implemented in autumn, 2013. Even though these revisions were implemented after the Budding Science and Literacy data material was collected, they provide important information on the current trends and directions for science education in Norway and helps situate the research presented in a national context.

In the revision process, basic skills and the main subject area The Budding Scientist were given particular attention (Mork, 2013). The science curriculum has, for example, been criticized for not properly emphasizing reading in science or addressing the lack of tradition for reading instruction in school science in Norway (Kolstø, 2009). Thus, in the revised curriculum, each basic skill is now presented with fuller and more detailed descriptions of what they imply for school science, as well as several competence goals having been added or reformulated in the main subject areas—especially within The Budding Scientist. Furthermore, it is now explicitly stated that The Budding Scientist should be integrated into the other main subject areas, which was also the original purpose (Ministry of Education and Research, 2013). Mork (2013) thus argues that the revised curriculum places more emphasis on how scientific knowledge is constructed than the former. Furthermore, the implementation of the Knowledge Promotion Reform and the revision of the national science curriculum illustrate that the Norwegian context is similar to other current international science education efforts and perspectives—many of which centers on scientific literacy, science inquiry and the nature of science (e.g., Abd-El-Khalick et al., 2004; National Research Council, 2012; Rocard et al., 2007).

Clearly, literacy and inquiry science have both become focal points of science teaching and learning in Norway through the Knowledge Promotion Reform, although research following the implementation of the reform has indicated a gap between the curriculum intentions and classroom practice. One of the initiatives to help address the integration of inquiry science and literacy in Norwegian primary school classrooms has been the *Budding Science and Literacy* project, which this thesis is a part of.

1.2.3 The Budding Science and Literacy research project

The *Budding Science and Literacy* project is a research and development project that was established to support teachers in integrating inquiry-based science and literacy in primary school classrooms, as a result of the new demands of the national science curriculum (Ødegaard, 2010). The main aim of the project was to study how an integrated science-literacy approach could help improve science teaching and learning in primary school. Central to the Budding Science and Literacy project was a teaching model for integrating science and literacy through inquiry (see Figure 1). The teaching model builds on an integrated approach to science and literacy that originated with the *Seeds of Science/Roots of Reading*[1] program (Cervetti et al., 2006) at Lawrence Hall of Science, UC Berkeley, and was to be tested and refined in cooperation with teachers' unique competence from the classroom. This was done through an in-service professional development course—generating 10 ECTS-credits—which teachers attended on a monthly basis for two semesters. The course ran twice: in 2009/2010 and in 2010/2011. As a part of the professional development course, the teachers were to teach a sequence of science lessons, in accordance with the Budding Science and Literacy teaching model, with their students. To do so, they were also given access to instructional material, detailed teacher guides, and translated reading materials from the Seeds of Science/Roots of Reading program (Cervetti et al., 2006) that they could use and adapt in their teaching.

Six teachers were then recruited from the second professional development course to participate in the Budding Science and Literacy video study. This involved being videotaped as they taught the science lessons they were supposed to teach towards the end of the professional development course. It also included being interviewed by the research group, as well as having the research group conducting interviews with students. After the final lesson, the research group also collected textual artifacts from the classrooms. In the work presented here, I draw mainly on classroom video recordings, student interviews and textual artifacts from this data material (the empirical setting will be further explored in chapter 4). The Budding Science and Literacy project thus frames the situational context of the data used in this thesis.

[1] http://www.scienceandliteracy.org/

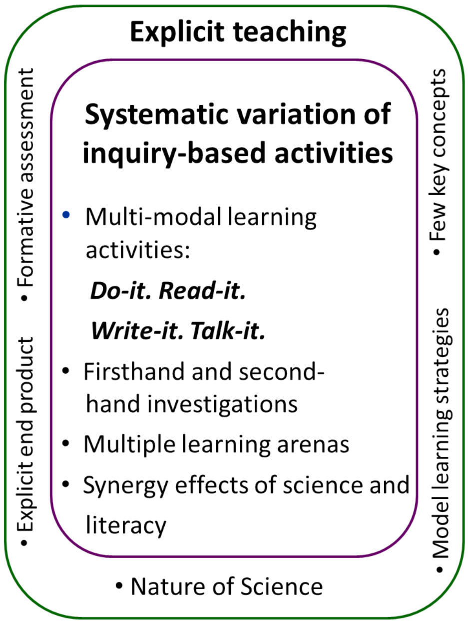

Figure 1. The Budding Science and Literacy teaching model (Ødegaard, Frøyland, & Mork, 2009) focuses on systematic variation of inquiry-based activities. This means that students engage in activities that are multi-modal, involve both first-hand and secondhand investigations, include multiple learning arenas, and rely on synergy effects of literacy and science. Teachers, on the other hand, provide explicit instruction on key concepts, learning strategies, Nature of Science, and the end products of inquiry, and focus on formative assessment.

1.3 Overarching aim of the thesis

The overarching aim of this thesis is *to explore the literacies of school science in the context of integrated science-literacy instruction in primary school*. This topic is mainly addressed through articles I, II, and III of the four that constitute this thesis. The three articles address distinct research questions or aims that, as a whole, inform the overarching aim of the thesis. In addition, I consider central methodological issues when collecting and working with a large body of video recordings and supplementary data sources, like the Budding Science and Literacy data material, which is addressed through article IV in this thesis.

1.4 Presentation of research articles and their contribution to the overarching aim

Article I

Ødegaard, Marianne, Haug, Berit, Mork, Sonja M., & Sørvik, Gard Ove[2] (2014).

Challenges and support when teaching science through an integrated inquiry and literacy approach. *International Journal of Science Education,* 36(18), 2997-3020.

[2] The three co-authors are listed in alphabetical order.

Article I is a video study of the variation and patterns of integrated inquiry-based science and literacy instruction at the classroom level. The article is written by the entire Budding Science and Literacy research group and presents an overview of the video data from the six participating classrooms. Video recordings were coded for multiple learning modalities (reading, writing, doing, talking) and phases of science inquiry (preparation, data, discussion, communication), and analyzed for occurrence and co-occurrence. The analysis suggests that the participating teachers spent much time in the preparation and data phases of inquiry, and comparably less time in the discussion and communication phases of inquiry. The learning modalities were also more evenly distributed in the preparation and data phases than in the discussion and communication phases. Thus, we discuss the importance of supporting teachers in these two consolidating phases of inquiry.

Article II

Sørvik, Gard Ove, Blikstad-Balas, Marte & Ødegaard, Marianne (2015). ”Do books like these have authors?” New roles for text and new demands on students in integrated science-literacy instruction. *Science Education*, 99(1), 39-69.

Article II investigates the literacy practices that emerge among primary school students during integrated science-literacy instruction. This is mainly explored through video analysis of literacy events that occur in the video material, with student interviews and collected textual artifacts acting as additional data sources. The article reveals how multiple literacies emerged in the context of integrated science-literacy instruction, where elements of students' informal literacies became valued resources in the dialogic process of inquiry. Accordingly, we discuss the formal and informal elements of students' literacy practices and identify some of the challenges that these students faced in their encounters with science text in this setting.

Article III

Sørvik, Gard Ove & Mork, Sonja M. (submitted, 07.12.2014). A social view of literacy for school science. Revisions required by *Nordic Studies in Science Education*, 02.02.2015. Original Manuscript.

Article III provides an introduction to what a social view of literacy means for school science. From this view, we outline a framework to promote disciplinary literacy practices in science classrooms. In the framework, four main themes from research on the role of text in school science and science are elaborated on to consider the ways in which text can be used as an integrated part of science teaching and learning: 1) science texts are written for particular purposes and audiences, 2) school science literacy builds on students' informal literacy practices, 3) science reading and writing activities differ in their "authenticity", and 4) school science literacy is embedded in explicit instruction. Finally, we claim that this view of literacy provides science educators with the theoretical perspectives to consider how literacy is actually used in contexts relevant to a transcending science subject.

Article IV

Andersson, Emilia & Sørvik, Gard Ove[3] (2013). Reality Lost? Re-Use of Qualitative Data in Classroom Video Studies. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, 14(3), Art. 1, 1-25. Available from http://www.qualitative-research.net/index.php/fqs/article/view/1941

Article IV is a methodological contribution that considers the use and re-use of video data from two perspectives: the primary researchers (or archivists) and the secondary analysts. It combines two research projects—The Budding Science and Literacy project (the primary researchers) and the PISA+ video study (the secondary analysts)—to make an argument for establishing more common practices when conducting classroom video studies. A main characteristic of video data is that they have the potential to capture complex social phenomena that are open to a number of analytical and theoretical perspectives. Yet, video data have rarely been discussed in the debate on re-using qualitative data, where key challenges concern the methodological issue of context and ethical issues related to anonymity and confidentiality. As classroom video studies often amass large amounts of data material, it is of interest to the educational sciences in general to explore how these data can best be utilized to provide insights into classroom practices.

The four articles that constitute this thesis address the overarching aim from different perspectives, with their own distinct aims or research questions. Articles I and II are empirical studies of the six participating classrooms in the Budding Science and Literacy video study. Article I investigates the patterns and variation of activities in the data material by

[3] The two authors are co-authors and are listed in alphabetical order.

categorizing the interaction in the classroom according to multiple learning modalities and phases of science inquiry. In the wider scope of this thesis, Article I provides an overview of the entire video data corpus and reveals quantified patterns of classroom activity therein. While Article I gives information on how much time is spent on different modalities in the six classrooms and how these co-occur with science inquiry phases, Article II goes beyond "reading" and "writing" *per se* to investigate what texts students encounter, what they do with these texts, and how they talk about these texts, and what they do with them, from a sociocultural perspective on literacy. The article focuses on students' literacy practices as they are manifested in observable literacy events in the six classrooms and from interview data. This way, the article provides an empirical grounding for discussing how multiple literacies can be embedded in the context of primary school science. The findings and theoretical background from Article II are then expanded and elaborated on in Article III to present a framework for teachers to promote literacy in school science. The final article in this thesis, Article IV, considers some of the methodological issues related to using and re-using video data in classroom video studies. In this way, Article IV frames the empirical research reported in articles I and II, in addition to discussing how video can be used to investigate classroom practice in general.

2 Review of relevant research

As this thesis explores how literacy is embedded in the specific context of integrated science-literacy instruction at primary school levels, I will in this chapter review key studies that inform the present study with regards to I) the role of text in school science, and II) integrated science-literacy instruction. The research literature in the extended abstract is grouped under these two themes to first provide a background of how text is traditionally embedded in a school science context, with an emphasis on studies from primary school levels, and second, to review and situate the present study in the context of integrated science and literacy instruction.

2.1 The role of text in school science

In most science classrooms, the science textbook is, and has long been, the dominant text; it is often the only textual source of information available to students and it dictates how teachers plan and conduct instruction (Driscoll, Moallem, Dick, & Kirby, 1994; Goldman & Bisanz, 2002; Hodgson, Rønning, & Tomlinson, 2012; Nelson, 2006; Yore, 1991; Yore, Bisanz, & Hand, 2003). Recent numbers from the TIMSS 2011 survey, for example, showed that 83% of Norwegian fourth-grade science teachers and 92% of Norwegian eight-grade science teachers reported to use the textbook as the basis for their instruction (international averages were respectively 70% and 74%) (Martin, Mullis, Foy, & Stanco, 2012, pp. 402-405). Science textbooks, however, have been heavily criticized for focusing too much on consensual and well-established science, lacking argumentation, and presenting an individualistic image of science where individual scientists discover "truth" through experiment (Bauer, 1994; Knain, 2001; Penney, Norris, Phillips, & Clark, 2003). In addition, science texts also present students with specialized linguistic and multimodal demands that are difficult for those who are not familiar with scientific language and representation (Fang, 2006; Kress, Jewitt, Ogborn, & Tsatsarelis, 2001). While these demands indicate that science reading and writing requires specific attention, they are often left unattended in the classroom (Wellington & Osborne, 2001). Despite the dominant role of the textbook in science classrooms—and the obvious challenges associated with their structure and content—what matters most to the present study is rather *how* the textbook and other available texts are actually used by science teachers and students at the classroom level.

Driscoll and colleagues (1994), for example, investigated the natural use of the textbook in a middle school science classroom over the course of three weeks. In their study, the participating teacher used the textbook as the foundation for her instruction, and primarily to facilitate scientific vocabulary learning and study skills. Moreover, the teacher viewed the textbook as a resource for herself, as well as for her students. The students, on the other hand, largely used the textbook when prompted by the teacher. For the most part, the students' use of the textbook was directed towards answering specific questions in the text or questions raised by the teacher, or for looking up vocabulary words. In problem-solving activities and during experiments, however, the textbook was neither referred to by the teacher nor used by the students. Thus, the textbook was mainly used in this classroom to support factual learning, which, according to Driscoll et al. (1994, p. 96), "was also assessed by the accompanying unit test".

In a similar study of literacy events in an eight-grade Finnish-Swedish chemistry classroom (Danielsson, 2010), the textbook was clearly a prominent text, but only in the sense that it was kept on the desk in front of the students throughout the observed lessons. Most of the time, it was simply kept open to show the periodic table. Instead, the students were given homework assignments in the textbook, and the final test built solely on information from the textbook. Because of this, Danielsson (2010) argues that the textbook was not a very important text in the classroom situation. There was, however, a wide range of texts present in the lessons (e.g., teacher notes on the blackboard, labels on chemical containers, texts on the classroom walls), but longer running text was neither read nor written in class. The students took notes during the lessons, but these were rarely other notes than mere copies of the teacher's notes on the blackboard. Danielsson (2010, p. 22) concluded that there was "an unutilized potential for working with the enculturation of the students into the written discourse of natural (school) science" in this particular classroom.

Another common text in science classroom is the experimental lab report based on practical work. For example, af Geijerstam (2006) found that lab report writing was a dominant practice in her study of school science writing in grades 5 and 8 in Swedish schools. However, there were few opportunities for the students to discuss the content, purpose and receiver of these texts in class. The students rarely sought a receiver for their texts, and the teacher was normally the only one reading the students' reports. Similarly, Knain (2005b) compared two Norwegian secondary school students' writing of lab reports in science. He found that even though specific purposes for writing lab reports in science were presented as important to the students (e.g., replication of a study), they were not operationalized in practice.

Furthermore, the ways in which text is used in school science appear to be far removed from many students' everyday use of language and literacy. For example, in a seminal ethnographic study, Shirley Brice Heath (1983) explored how people in three rural communities in North Carolina used language in their daily lives, particularly in home and school contexts. In her study, the first two communities—a pre-dominantly white working class community (Roadville) and a pre-dominantly black working class community (Trackton)—were contrasted with the town's mainstream population (Maintown) in relation to the language practices valued in institutions like school or the workplace. Heath (1983) found that only the middle class residents of Maintown used language in ways that were congruent with school, while students from Roadville and Trackton—whose language use were distinctly different from those promoted in the science classroom and the school setting in general—became unsuccessful at school.

The work of Moje and colleagues (2004; 2001) has focused specifically on how different "funds of knowledge" frame students' disciplinary literacy learning in seventh- and eight-grade public school science classrooms. In an ethnographic study of the various funds that shape the texts of 30 young people in the community they studied, Moje et al. (2004) found that the students relied on popular cultural texts (e.g., movies, news media, talk shows) at least as much as they used their own experiences with the natural phenomena to frame their understandings of the related science concepts. For example, when reading a school text about a scientific experiment (growing square watermelons), one of the students reported that this was also the topic of an episode of *The Simpsons*. The authors argued that these popular culture texts were important funds of knowledge for learning because they enabled the students to engage with each other and with the science in the school text. However, the students did not generally volunteer their home experiences in the classroom, as they appeared to not consider these sources as valid types of knowledge in the classroom.

The above studies fit well with an increasing body of research indicating that school science is frequently experienced as the transmission of decontextualized scientific knowledge from expert sources, like the teacher or the textbook (Lyons, 2006; Osborne & Dillon, 2008). In this mode of science teaching, students' reading and writing activities are often reduced to copying information from the blackboard or the textbook, and answering textbook questions (Lindahl, 2003; Osborne & Collins, 2001). This is worrying because it contributes to students regarding science as a body of knowledge to be transmitted and memorized, thereby neglecting central aspects of what it means to become scientifically literate. A possible explanation is offered by Knain (2001, p. 322), whose study of Norwegian 8th grade science textbooks found that "textbooks create (and are part of) a discourse which focus on the end products of science". Unfortunately, as indicated by Lyons' (2006) review, these are patterns that appear to be consistent across national boundaries.

It appears, then, that the transmissive mode of science teaching and learning is particularly relevant for understanding how reading and writing is traditionally embedded in the context of school science. Goldman and Bisanz (2002, p. 40) similarly argue that the role (and nature) of science textbooks in school science leaves students with "few processing options other than trying to memorize 'important information', often defined by what will be tested". Along the same lines, Yore, Bisanz and Hand (2003, p. 713) summarize how writing has traditionally been conceived of in science classrooms in their comprehensive review of research on literacy in science education:

> Traditional writing tasks in science have centered on such activities as keeping accurate records, completing laboratory reports, and demonstrating an understanding of concepts for assessment purposes. These writing tasks do not explicitly place strong emphasis on students moving beyond the duplication of knowledge.

2.2 Integrated science-literacy instruction

Over the last couple of decades, science and literacy educators interested in the authentic ways in which scientists read and write have sought to develop pedagogical approaches that explicitly integrate science and literacy through inquiry (Cervetti et al., 2006; Gaskins et al., 1994; Glynn & Muth, 1994; Hand et al., 2003; Moje, 2008; Palincsar & Magnusson, 2001; Pearson et al., 2010; Yore et al., 2004). This initiative acknowledges that "science is a process of inquiry conducted through the use of language" (Yore et al., 2004, p. 348) by embedding disciplinary literacy practices in school science inquiry. As Cervetti and Pearson (2012, p. 582) claim, the common thread in studies of integrated science-literacy instruction has been to engage students in "reading meaningful texts for meaningful purposes in knowledge-building contexts".

Several empirical studies now suggest that integrated approaches can improve student outcomes on science and literacy measures (e.g., Cervetti et al., 2012; Fang & Wei, 2010; Greenleaf et al., 2011; Guthrie et al., 2004; Purcell-Gates, Duke, & Martineau, 2007; Vitale & Romance, 2012). In a systematic review on quasi-experimental studies of integrated science-literacy instruction, Bradbury (2014, p. 483) noted that the reviewed studies "indicated positive outcomes for student achievement in both science and reading, as well as for affective factors". For example, in Romance and Vitale's (Romance & Vitale, 1992; Vitale & Romance, 2012) *In-Depth Expanded Applications of Science* (IDEAS) model of integration, traditional language arts instruction was replaced with joint science-reading instruction in grades 1 to 5. Central to the IDEAS model was a focus on core science concept instruction that involved firsthand experiences, reading comprehension, use of science process skills, and journal writing. In a recent summary of their multi-year research, Vitale and Romance (2012) documented increased effects on both science and reading measures. IDEAS students have also been shown to display more positive attitudes towards and self-confidence in science and reading (Romance & Vitale, 2001).

Some of the quasi-experimental studies on science-literacy integration are particularly interesting because they compare integrated inquiry science and literacy instruction with inquiry-based approaches that did not focus specifically on reading and writing. Fang and Wei (2010), for example, assigned ten 6th grade science classes into two groups: inquiry-based science plus reading and inquiry-based only. Their results showed that students in the first group outperformed students in the second group on measures of both science text reading and scientific knowledge. More specifically, Fang and Wei (2010, p. 270) argued that "discussion helped consolidate the students' understanding of text and enhanced their learning of text information […] [while] the teaching of reading strategies also enabled students to better comprehend and learn from science texts, therefore effectively increasing their content knowledge about science". Similarly, Girod and Twyman (2009) compared two inquiry-based curricula: one integrated and one inquiry-based only. In this study, the integrated approach showed favourable effects over the inquiry-based only approach on students' identity as science learners, knowledge about nature of science, and conceptual understanding. Both curricula, however, showed positive effects on interest and attitudes towards science.

While quasi-experimental studies provide valuable evidence that integrated science-literacy instruction supports student learning in science, it is mostly qualitative, classroom-based studies that frame the present study. A key study in this sense is Magnusson and Palincsar's (2001) *GiSML* project (Guided Inquiry supporting Multiple Literacies*)*, where a group of elementary school teachers collaborate with the researchers through a professional development course. In GIsML, two forms of investigations were combined to support teachers' and students' participation in science inquiry: firsthand investigations (hands-on) and secondhand investigation (consulting text to learn from others' interpretations). Classroom observations and focus group interviews with the teachers regarding secondhand investigations revealed that the teachers' main concern was that students would submit to the authority of the text, and not rely on their own firsthand experiences (Palincsar & Magnusson, 1997). This led the researchers to design "the scientist's notebook" genre, which models how a scientist interprets data with a critical stance. When the participating students were subsequently compared with a test group that was taught with a considerate, non-refutational, expository text, results showed that the group with the notebook text was favored (Palincsar & Magnusson, 2001). Relying on their classroom observations, the authors claimed that the use of the notebook text provided opportunities for the students to actively engage in their own interpretations along with the scientist's, while the traditional text did not afford the same constructive process.

Varelas, Pappas and colleagues (Pappas, Varelas, Barry, & Rife, 2003; Varelas & Pappas, 2006; Varelas, Pappas, & Rife, 2004) studied urban classrooms where teachers enacted integrated science-literacy instruction. In these classrooms, students engaged in hands-on activities, dialogically oriented read-alouds, the making of class artifacts and individual texts, drama experiences, and home projects that were later shared in class to inform their inquiries. The range of classroom activities was designed to provide the students with multimodal opportunities to theorize about the natural world and construct empirical evidence through collecting, analyzing, and interpreting data. In one study, Varelas and Pappas (2006) investigated the intertextual links that students in two classrooms made during read-alouds of seven related science texts. Their analysis showed that the number of connections the students made between personal experiences, written texts, discussions, and hands-on experiences increased over this sequence of read-alouds. In these read-alouds, the students were able to use and build on their own language and experiences, in a manner that resembled scientific reasoning, to theorize about their firsthand experiences.

In the Norwegian *ElevForsk* project (Students as Researchers in Science Education), Knain and Kolstø (2011) aimed to develop new practices to support the integration of inquiry-based science and literacy—in line with the newly implemented competence objectives of the Norwegian curriculum (see Section 1.2.2). In this action research project, researchers and teachers at lower and upper secondary school levels collaborated over several years in different inquiry-based projects. A central finding in the project was the importance of creating different support structures to advance and focus students' inquiries, which teachers had to adapt to the different aims and phases of students' investigations (Knain, Bjønness, & Kolstø, 2010). For example, they identify learning goals, time limits, visible end products, research meetings, templates, and available information sources as possible support structures. In one particular study, Mestad and Kolstø (2014) worked with five teachers to enhance student learning from practical activities. Their analyses showed that the teachers emphasized theoretical knowledge and language to enable the students to make the correct interpretations, but, in fact, hindered the students in articulating their developing understanding. In line with Varelas and Pappas (2006), Mestad and Kolstø (2014) highlight the importance of creating *third spaces*, where students work with their own authentic language during practical activities on their way towards more scientific language.

The work of Howes, Lim and Campos (2009) on three elementary school teachers' efforts to integrate literacy and science sheds light on how different models of integration occur. In their study, they described the ways in which these teachers linked science and literacy; even though the teachers in the study held similar views about the nature of inquiry, comparative analysis showed that the role of literacy in their teaching differed. In some cases, integrating science and literacy resulted in privileging literacy learning over science learning, which were not equally supportive of students' engagement in science inquiry. Based on these findings, the researchers indicated that there was a need for further research "to understand more clearly what challenges teachers' encounter in employing science–literacy integration and how we can support teachers to practice such integration successfully in their inquiry science teaching" (Howes et al., 2009, p. 214).

In sum, the evidence base for integrated science-literacy instruction is indeed promising, with an increasing number of studies documenting positive effects of explicit integration of disciplinary literacy practices into school science inquiry. Seeing that this particular line of research is still young, it is necessary to gain a better understanding of what works—and how—when literacy is positioned "to support rather than supplant the acquisition of knowledge and inquiry in science" (Pearson et al., 2010, p. 461).

2.3 Summary

From this review chapter, it becomes clear that the role of text in school science is often characterized by a dominant (but unutilized) use of the science textbook, coupled with reading/writing activities that appear to be embedded in a transmissive mode of science teaching. Typical practices include copying information and answering textbook questions. In contrast, integrated science-literacy instruction uses inquiry as its guiding principle in an attempt to provide meaningful contexts for reading, writing and engaging with science. While the evidence base in-favor of integrated approaches is growing, there are comparably few in-depth studies of science-literacy instruction at the classroom level. Hence, the present study aims to provide an image of how literacy is actually used in this context and mainly from the students' perspectives. Hopefully, this might provide information to science educators on how to promote literacy practices in school science that are meaningful to students and the long-term goal of scientific literacy.

3 Theoretical framework

In this chapter, I present the theoretical perspectives that inform this thesis. First, I will discuss what a sociocultural perspective means for researching literacy in a school science context. Second, the notion of scientific literacy is explained, which is instrumental to understand the general aims of formal education in science. Third, I will elaborate on the idea of inquiry-based science education; a central term in the empirical context of this thesis that often takes on a wide variety of meanings.

3.1 Sociocultural perspectives for researching literacy in a school science context

In order to explore the overarching aim of this thesis, this study relies on a main argument derived from sociocultural studies of literacy. Namely, that literacy is best understood as a situated social practice involving text (Barton, 2007). Because this study aims to investigate literacy in a science education setting, it is also necessary to consider how a sociocultural perspective informs our understanding of science education. A sociocultural perspective of science education, where language is regarded as the main mediational means on both the social and the individual plane (Leach & Scott, 2003), is thus central to all of the articles that this thesis comprises.

First of all, taking a sociocultural approach builds on the assumption that all human action is situated in social, cultural, historical and institutional settings (Wertsch, 1991). Hence, science education can be seen as the enculturation of students into the particular ways of knowing and doing that has been developed within the culture of science (Gee, 2005; Leach & Scott, 2003; Lemke, 2001; Mortimer & Scott, 2003; Wertsch, 1991). This includes the distinctive ways of talking and thinking about the world, but also the ways in which reading, writing, acting, and interacting occur within the scientific community. Similarly, other social groups have their own specific practices in which oral and written language, activities, values, and beliefs are tightly interwoven (Gee, 2004). Bakhtin (1981) considers how these specialized ways with language are used for specific purposes in different parts of society in terms of *social languages*. Gee (2004) builds on Bakhtin's notion when he refers to the social language of science (and the social language of school science) as an academic variety of specialist language, which can be distinguished from vernacular language; the language we normally use in everyday situations. This latter variety of language is also referred to as "spontaneous" (Vygotsky, 1987) or "everyday" language (Leach & Scott, 2003). Science learning can thus be said to "occur against a backdrop of everyday/spontaneous ways of talking and thinking about phenomena" (Scott, Mortimer, & Ametller, 2011, p. 6), where several discourses and social languages (both oral and written) are present. However, the language of science differs from our everyday ways with language in both its linguistic demands and its cultural conventions of use, which, for many students, makes learning the language of science the greatest obstacle in science learning (Wellington & Osborne, 2001).

When researching literacy from a sociocultural perspective, the idea of social languages is particularly helpful, because it frames our ways with *written language* in the social practices of specific social groups or communities—such as school science. Thus, from a sociocultural perspective, learning to read a certain text in a certain way (in this case, texts with scientific information) requires "having access to, and ample experience in, social settings where texts of that type are read in those ways" (Gee, 2008, p. 48). It is exactly these kinds of experiences with literacy and the social settings in which literacy is embedded that are explored in this thesis.

Taking a sociocultural approach to literacy, however, is by no means restricted to the context formal schooling. In fact, sociocultural studies of literacy, often referred to as the "New Literacy Studies" (NLS), signalled an attempt to understand literacy as a social practice across local contexts by documenting how people use literacy in their everyday lives (e.g., Barton & Hamilton, 1998). According to Jewitt (2008), NLS has in this way been central in the theorization of literacy as historically, socially, and culturally situated.

In contrast to the sociocultural view, literacy has traditionally been regarded as a universal skill or skill-set situated in the individual: i.e., "the ability to read" and "the ability to write" (Barton, 2007). In science education, Norris and Phillips (2003) claim that "a simple view of reading" has been prevalent in much of the literature and reform efforts focused on scientific literacy[4]. In this view, being able to read simply involves the combination of decoding and comprehension (Gough & Tunmer, 1986). When it comes to science education, then, reading and writing is positioned only in a functional relationship to science. They become little more than tools to "get to" the actual science, instead of a constitutive practice of the scientific enterprise. One of the prominent NLS scholars, Brian Street (1984), refers to the simple view of reading as an "autonomous model" of literacy, because it relies on the idea that literacy in itself—autonomously—will have specific cognitive effects regardless of the context in which these "skills" are applied. Autonomous models of literacy thus ignore how factors such as prior knowledge and cultural conventions greatly influence our understanding of a text (Norris & Phillips, 1994; Samuelstuen & Bråten, 2005)

A social view of literacy, on the other hand, shifts the focus from a set of individual skills or competences to a view of literacy as something you *do*—a social practice involving text (Barton, 2007). Street (1984) refers to this as an "ideological model" of literacy, because it acknowledges that literacy is always embedded in different cultural and ideological contexts. In this view, literacy involves engaging and participating in "particular ways of thinking about and doing reading and writing in cultural contexts" (Street, 2003, p. 79), which must necessarily also involve our values, power relations, talk, social relationships, attitudes, and beliefs regarding text (Gee et al., 1996). It follows that literacy is not just one thing; rather, there are multiple literacies just as there are social languages and social contexts of which literacy is a part. Take, for example, a group of local fishermen debating the latest news briefs about potential oil drilling in Lofoten, or teenagers playing a video game on their iPhones during recess. Both the fishermen and the teenagers take part in local and situated literacies, adhering to the specific conventions and ways with written language that are socially and culturally valued within those particular social groups and contexts (Barton & Hamilton, 1998).

However, as Street (2003, p. 78) points out, researchers "would find it problematic to simply use the term 'literacy' as their unit or object of study", because it is hard to separate literacies from their ideological roots. NLS scholars have therefore developed two instrumental terms for researching literacy from a sociocultural perspective: *literacy event* and *literacy practice* (Barton & Hamilton, 1998; S. B. Heath, 1983; Street, 1984). These two concepts constitute

[4] Scientific literacy is often referred to as what the general public ought to know about science, and will be further discussed in the next section.

the two basic units of analysis within NLS, because literacy practices are "observable in events which are mediated by written text" (Barton & Hamilton, 2000, p. 9). According to Barton (2007, p. 35), literacy events comprise "all sorts of occasions in everyday life where the written word has a role"—in other words, they are empirically observable events in which text is used, read, written or talked about in some way or another. Literacy practices, on the other hand, are regarded as the general cultural ways of utilizing literacy, which people draw on in a literacy event. Thus, literacy practices can only be inferred from literacy events, because they also include unobservable factors, like values, power relationships, and attitudes. In Article II, literacy events in the classrooms are identified from video data and used to discuss the emerging literacy practices of the six primary school classrooms in the study.

Another central aspect of literacy, in this view, is the influence that certain socially powerful institutions have on how literacy is perceived by the general public (Barton, 2007). School, in particular, construct and shape literacies that are often more influential and valued than literacies related to out-of-school contexts. This creates a distinction between literacies that are dominant, formal or sponsored and literacies that are vernacular, informal or of personal choice (Barton & Hamilton, 1998; Gee, 2004; Street, 1993). In a school setting, this distinction can help us consider how certain literacies are regulated by others (mostly the teacher), and which literacies are student-initiated. However, when researching literacy in a school context, Maybin (2007) cautions against a strict dichotomy, because it easily conflates home literacy with vernacular literacy when this is not always the case. Maybin (2007) demonstrates that the school domain is actually far more heterogeneous than those who equate home and vernacular literacy often suggest. In turn, this might develop an unfortunate opposition between school and home. In Article II, we distinguish between formal and informal elements of school science literacy to highlight how students draw on vernacular or informal literacy practices in a formal school science setting. These aspects of literacy as social practice are then further employed in Article III to articulate what a social view of literacy means for educational practice in school science.

3.2 Scientific literacy—the aim of science education

Not to be confused with the literacies of school science, *scientific literacy* is a central term in this thesis and for science education in general. The term is often used to refer to what "the general public ought to know about science" (Durant, 1993, p. 129), and by many considered as the desired outcome of science education (DeBoer, 2000; Sjøberg, 2009). According to

Roberts (1983, 2007a, 2007b), scientific literacy was first introduced as an educational slogan by US science educators (e.g., Fitzpatrick, 1960; Hurd, 1958) around the time of the Soviet Sputnik launch[5]. This had mainly to do with concerns about recruitment into science and the public's understanding about science in the era of the Space Race[6]. At the time, scientific literacy was primarily used to refer to a science education for the general public, and not students who were "potential scientists" (Klopfer, 1969). Following this first period of use, however, the term itself became subject to a "deluge of definitions" (Roberts, 2007a, p. 11) regarding what it means to be scientifically literate, which has also rendered the concept to be regarded as "diffuse, ill-defined, and difficult to measure" (Laugksch, 2000, p. 90). Here, I will rely on two main distinctions regarding scientific literacy. The first distinguishes between Vision I and Vision II, the second between the fundamental and the derived sense of scientific literacy.

In his comprehensive review of the literature on scientific literacy, Roberts (2007b) proposes that scientific literacy is best conceptualized as two overarching visions, rather than chasing consensus about one specific definition. These two visions are then taken to represent two extremes on a continuum. Whereas Vision I looks inward at science, concentrating on the promotion of scientific concepts and processes from the perspective of a professional scientist, Vision II focuses on a citizen's understanding and use of science outside the traditional boundaries of science. In Vision I, it is thus presumed that scientific knowledge can be automatically applied and transferred to other settings in which that knowledge is needed. The presumption that science, in itself, has direct applicability to everyday life has however been shown to find little empirical support (Layton, Jenkins, Macgill, & Davey, 1993). This leads us to Vision II, which takes a more context-sensitive approach to scientific literacy, paying attention to the different situations and social contexts in which science plays a part. In these situations, personal decision-making is necessarily also influenced by factors outside of science, such as social, political, ethical and aesthetic ones. Wickman, Liberg and Östmann (2012) note that the inclusion of this normative dimension of human lives is a central difference between Vision I and Vision II. In Vision I, they argue, the normative is

[5] Sputnik 1 was launched by the Soviet Union on October 4, 1957, and became the first artificial Earth satellite.
[6] The Space Race denotes the period from 1955 to 1970, which marked the Cold War rivalry of the US and the Soviet Union (USSR) for spaceflight capability. This period also gave way to an increased interest in science education, in order to increase the scientific literacy of the general public (Roberts, 1983). As Paul Hurd (1958, p. 52) wrote: "What have satellites, rockets and missiles contributed to American education? They have created an awareness of the importance of science and technology to social progress and economic security. The public realizes more clearly than heretofore that it is through the program of schools that science will be advanced and the ideals of the free world perpetuated".

seen as irrational or possible to rationalize through science. The inclusion of values in the science curriculum is one example of the inherent tension between the two visions, which is also described by Roberts (2007a, p. 11):

> Everyone agrees that students can't become scientifically literate without knowing some science, and everyone agrees that the concept needs to include some other types of understanding about science. The differences in definition have to do with just what, how much, for whom, and in what sort of conceptual balance.

From a Vision II perspective, Wickman and colleagues (2012) further claim that science education needs to transcend not only the academic subject it aims to teach, but also the idiosyncratic backgrounds and experiences of students as citizens in a democratic society if science education is to prepare them for making informed decisions in their daily lives. Because of this study's focus on literacy as a situated social practice, the context-sensitive approach to scientific literacy of Vision II is drawn upon to discuss how literacy in school science aligns with other contexts where scientific information is used and produced for various purposes (e.g., professional science or daily life).

Another perspective on scientific literacy that is central to this thesis, considers the role of literacy in scientific literacy. Although scientific literacy has become a heavily discussed term, the role of literacy, in its literal meaning, has traditionally not been the subject of these discussions. Rather, scientific literacy has usually been described in the tradition of *cultural literacy* (Trefil, 1995)—literacy in the form of *thorough knowledgeability* in and about science (2007b). In a much-cited article, however, Norris and Phillips (2003) theoretically positions literacy, in its literal meaning, as the fundamental sense of scientific literacy, while being knowledgeable, learned and educated in science refers to the derived sense of scientific literacy. The authors make an important clarification when they state that the two senses "can be separated in thought, but even here the separation quickly becomes strained with anomalies that urge us to merge the two senses into a complete whole" (p. 236). The central idea in this perspective is that because science is in part constituted by texts and our social ways of dealing with these texts, having access to and becoming critical consumers of scientific information is fundamental to scientific literacy. Indeed, when confronted with controversial socio-scientific issues in our daily lives, it is necessary to focus on the relevance of different sources (e.g., news media, scientific reports, personal accounts) and the trustworthiness of the knowledge claims therein (Kolstø, 2001). Accordingly, taking the fundamental sense of scientific literacy seriously means that science education should enable students to "live and act with reasonable comfort and confidence in a society that is deeply influenced and shaped by the artefacts, ideas, and values of science—rather than feeling excluded from a whole area of discourse, and, as a corollary marginalised" (Osborne, 2007, p. 177). The articulation of a "fundamental sense" of scientific literacy has also influenced to a promising line of work on how literacy, in its literal meaning, contributes to our understanding of what a science education for scientific literacy might look like (e.g., Hand et al., 2003; Pearson et al., 2010), which also includes the present thesis.

3.3 Inquiry-based science and scientific practices

Inquiry-based science education is used as a guiding principle for science education worldwide (Abd‐El‐Khalick et al., 2004; Ministry of Education and Research, 2006; National Research Council, 1996, 2012; Rocard et al., 2007). It is also at the heart of the science-literacy integration model applied in the Budding Science and Literacy project (see Figure 1, p. 11), which makes it instrumental to clarify how the term is used in this thesis. First, it should be mentioned that the idea that science education should, to some degree, reflect the practices of professional scientists is not new. Rather, inquiry has a "decades-long and persistent history as the central word used to characterize good science teaching and learning" (R. D. Anderson, 2002, p. 1). It can be traced back to John Dewey (1910), who, in his address to the American Association for the Advancement of Science (AAAS) in 1909, argued that school science had too long concerned itself with science as a fixed body of knowledge, when the power of science lay in its processes and methods of thinking.

Despite its long history, and the prevalence of inquiry-based approaches to science education in reform efforts and policy documents, it is difficult to find an agreed-upon definition of what it means to "do" inquiry-based science in the classroom (Crawford, 2014). Thus, inquiry is often confused with hands-on activities, discovery learning, and problem-based learning (Hmelo-Silver, Duncan, & Chinn, 2007). Other times, inquiry-based science is associated with the use of "The Scientific Method" in the classroom, which distorts the complexity of scientific practice (Windschitl, 2004). Sociological studies of scientific practice have clearly shown that there is no one scientific method, and that the sciences have distinctly different “machineries” for constructing and validating knowledge (e.g., Knorr Cetina, 1999). Bell and colleagues (2010) provide some insights into what inquiry-based science entails in their comparison of main inquiry processes in different inquiry models: Orienting and asking questions; hypothesis generation; planning; investigation; analysis and interpretation; model (exploration and creation); conclusion and evaluation; communication, and prediction. However, the authors emphasize that these categories do not represent a fixed order, but should be considered as processes students may go through in the order needed and returned to if necessary. The framework for the latest American science education standards (National Research Council, 2012), however, chose to emphasize *scientific practices*—instead of the term inquiry-based science—because of the many different interpretations associated with the term. This was done to minimize the tendency within inquiry-based approaches to reduce scientific inquiry to a single set of procedures, which often “overemphasizes experimental investigation at the expense of other practices, such as modeling, critique, and communication” (National Research Council, 2012, p. 43).

What is particularly interesting to this thesis is the lack of attention traditionally given to literacy in various conceptualizations of inquiry-based science. Whereas written language and inscriptions are embedded in the social practices and culture of science (Bazerman, 1988; Latour & Woolgar, 1986), texts have often been deemphasized in many inquiry-based science classrooms to avoid reading about science instead of “doing” science (Pearson et al., 2010). Andersson (1999, p. 973) describes the lack of attention to literacy in many inquiry-based approaches:

> We have rightly been critical of science classes where students learn facts from textbooks and worksheets. These classroom practices bear little relationship to the activities of scientists. In response, though, science educators have sometimes treated reading and writing as, at best, necessary evils, concentrating on hands-on experience as the essential core of scientific practice.

However, because science is constituted by both material and literate practices (Hacking, 1983; Halliday, 1998), there is a need to emphasize the role of literacy in inquiry-based science as well. As Pearson et al. (2010, p. 460) argue, “[s]cience literacy instruction should engage children and youth in making sense of scientific texts as one form of scientific inquiry”. This idea is at the core of the initiative to explicitly integrate science and literacy through inquiry that is described in section 2.3, and in the Budding Science and Literacy teaching model (Figure 1). In this thesis, the perspectives on inquiry-based science that are outlined here have also contributed to the development of the coding scheme applied in Article I (see also Appendix III).

3.4 Operational definitions

I will in this section summarize and provide operational definitions of some of the key terms employed in this thesis: inquiry, literacy event, literacy practice, and, text.

3.4.1 Inquiry-based science education

In this thesis, the term inquiry is used to refer to a set of interrelated practices by which scientists and students pose questions about the natural world and investigate phenomena (Crawford, 2007), many of which are mediated through written text (Goldman & Bisanz, 2002). In the classroom, this involves supporting students in "using critical thinking skills, that includes asking questions, designing and carrying out investigations, interpreting data as evidence, creating arguments, building models, and communicating findings, in the pursuit of deepening their understanding by using logic and evidence about the natural world" (Crawford, 2014, p. 514). Inquiry is central to describe the empirical context (integrated science-literacy instruction), but also to the development of the coding scheme developed in Article I on different inquiry phases (preparation, data, discussion, and communication). In this regard, it is important to emphasize that these phases do not represent a fixed order through which inquiry is "accomplished". Rather, they represent four overarching phases of inquiry that comprise observable practices that students in the participating classrooms rely on in their school science inquiries.

3.4.2 Literacy event

Literacy events are the main unit of analysis in Article II, in which literacy events in the participating classrooms were identified, coded, and inductively analyzed. In Article II, we chose to operationalize literacy events as the observable episodes in which the social interaction revolved around written text (Barton & Hamilton, 1998). By emphasizing that the social interaction should revolve around text, we were able to include when the teachers and students talked about text or used other means of communication to include text in their interaction (e.g., a teacher pointing to a note on a concept wall). In our data material, this was possible to identify because we relied on video and audio data from multiple cameras in the six classrooms in the study. More specifically, we defined the start of a coded literacy event as the occasion when a text was first referenced, verbally or non-verbally, and the end-time as the end of the last connected utterance that made reference to the same text.

3.4.3 Literacy practice

A sociocultural perspective on literacy implies that literacy is best understood as a social practice situated in specific cultural and ideological contexts (e.g., Barton, 2007; Gee, 2008). Literacy practice is here used to refer to the general cultural ways of utilizing literacy; it is what we *do* with text in everyday situations (Barton & Hamilton, 2000). Hence, literacy practices can only be inferred from patterned literacy events, because they also include unobservable factors like social relationships, values, attitudes, and beliefs regarding text in those situations.

3.4.5 Text

Texts serve as an entry point for identifying literacy events and conceptualizing literacy in this thesis. However, in today's digital media age, the notion of "text" is becoming more fluid, and it is harder to distinguish between texts (Barton & Lee, 2013). In addition, science is not communicated or represented through language alone, but in a combination of semiotic modes (including figures, images, video, mathematical formulae, inscriptions from various devices, and gestures) (Lemke, 1998). A helpful definition of text is in this regard is "any instance of communication in any mode in any combination of modes" (Kress, 2003, p. 48).
However, in order to empirically categorize literacy events, I have—in line with many NLS researchers—found it necessary to limit literacy events to observable occasions where written text has a role, whether that text is read, written, talked about, or used any other way in the classroom. This implies that I have not focused on oral texts (e.g., oral recounts of a lived experience, Varelas & Pappas, 2006), but included a wide range of texts, digital and in print, where the written word is used in combination with other modes (e.g., figures, mathematical formulae, diagrams, digital quizzes, or television).

4 Methods

In this chapter, I provide an overview of the research design and discuss methodological issues related to the data material and analyses. The chapter serves as a supplement to the methodological sections provided in Article I and II, and builds on some of the arguments presented in article IV. As this thesis is a part of a larger research project, which creates both opportunities and challenges for a PhD project, I will also address my role as a researcher in a larger research project throughout this chapter.

4.1 Using video to research classroom practices

Video recordings stand at the centre of the data sources drawn upon in this thesis and in the Budding Science and Literacy research project at large. Additionally, when exploring literacy from a sociocultural perspective, the contexts in which literacy is embedded cannot be separated from the reading and writing that goes on (Barton, 2007). This implies that literacy needs to be studied *in context*, where actual practices are occurring. While literacy studies often rely on traditional ethnographic approaches, video observations have become an increasingly rewarding and adaptive strategy for gathering data in complex learning environments, including school literacies (Blikstad-Balas & Sørvik, 2014; Derry et al., 2010; Erickson, 2006; Klette, 2009). As Heath, Hindmarsh, and Luff (2010, p. 5) state, it is now common within studies of situated action and interaction to see video as an analytic resource "to explore, discover and explicate the practices and reasoning, the cultures and competencies, the social organisation on which people rely to accomplish their ordinary, daily activities".

The main advantage with video is that it can provide a continuous record of the social interaction that arises in a natural habitat (Erickson, 2006)—in our case, the science classroom—which can then be subjected to a number of analytical approaches and perspectives after having been recorded *in situ* (Derry et al., 2010). The rapid advances in recording technology have also contributed to making video recordings a more flexible methodological design in educational research, as well as a less intrusive mediator between researchers and research participants (Klette, 2009). For example, whereas a common debate in the field of video research has long centered on the differences between using a fixed camera or a moving, handheld camera (cf., Bateson & Mead, 1976), classroom studies such as the present one now employ multiple cameras from multiple angles. This way, one camera can be devoted to filming the whole classroom, while other cameras (and their fields of vision) are more dependent on the theoretical perspectives and aims of the study (Tiberghien & Sensevy, 2012). Nevertheless, it is important to mention that videos, by themselves, are artifacts or documents of a certain situation or event (Erickson, 2006; Schnettler & Raab, 2008). They have been recorded for particular purposes and in particular contexts, in addition to being a product of the recording activity itself, thereby representing chosen aspects such as camera angle or focus (Knoblauch, Schnettler, & Raab, 2006). According to Erickson (2006), it is important to keep this in mind when analyzing video data, as they in no way give unmediated access to "reality", and should be treated accordingly.

In the present study, video was used to "capture" the interactional context of six primary school science classes where the teachers relied on a teaching model for integrating inquiry-based science and literacy. This particular PhD-project was a part of the larger research and development project Budding Science and Literacy, which has guided the research design by having to conform to the overall aim of the Budding Science and Literacy project, but also the aims of the individual researchers involved. However, as argued in Article IV, the Budding Science and literacy research project has from the start attempted to facilitate for future re-use of the data by colleting videos with different fields of visions (i.e., to capture the "whole" of the classrooms), as well as artifacts, interview data, and contextual data from the classrooms and participants. This has also benefitted the individual researchers in the research group, like myself, by providing a larger set of varied data to draw upon than what would be possible otherwise.

4.2 Participants and professional development course

In the Budding Science and Literacy project, primary school teachers were invited to take part in an in-service professional development course (equivalent to 10 ECTS credit points) that took an integrated approach to inquiry-based science and literacy. The course ran in two cohorts: the first in 2009/2010 and the second in 2010/2011. For the video study, six teachers from the latter course were asked to participate in a video study halfway through the professional development course. Thus, when referring to the professional development course from this point, it will concern the second cohort, from which the participating teachers were recruited. The premise of their participation in the study was that they would be video recorded when they—as part of the professional development course—taught a sequence of science lessons in accordance with the Budding Science and Literacy teaching model (Figure 1, section 1.2.3). In the following, in-depth information about the situational context that informs the data corpus is provided, particularly regarding the professional development course and its participants.

The in-service professional development course was spread out over two semesters, with three-hour sessions on a monthly basis. I attended all of the monthly sessions for the professional development course, but did not have any formal obligations related to the course. For the most part, attending teachers had signed up for the course along with a colleague from their school. This had been recommended in order to have teachers cooperate locally at their own schools. The monthly sessions were normally divided in two parts: first, a talk on a given subject related to inquiry or literacy was given by academics within the field, and second, a practical investigation guided by the researchers and followed by a discussion. In the practical activities, attending teachers took on the role of students, while researchers modeled teachers. These activities were often, but not exclusively, derived from teaching materials from the Seeds of Science/Roots of Reading program (Cervetti et al., 2006). In the first semester of the professional development course, the teachers tried out a single lesson from the Seeds/Roots material with their students. In the second semester, they implemented a sequence of science lessons, in accordance with the Budding Science and Literacy teaching model, with their students. In this phase, the teachers could draw on or adapt teaching material from Seeds/Roots if they wished to do so. Their experiences with taking an integrated science-literacy approach to their science teaching were then the subject of their exam papers, which they could write collaboratively. They also documented and presented their experiences to the other attending teachers on the final course session.

The six teachers that were asked to participate were selected on the basis of their educational background, school locations, the grade levels they taught, and their years of teaching experience. This was done to provide a varied sample of teachers and students. The six teachers, along with most of the attending teachers in the professional development course, were generalist teachers with little formal science education. This means that they did not have specialization in science, but that their science background mainly consisted of science courses from their teacher education programs. After the six teachers were approached to participate in the video study, the principals from each school were approached, before students at the school were asked to participate on the basis of parental consent. The students ranged from grade 1 (6 year-olds) to grade 5 (10 year-olds). The participating schools were located in both rural and suburban areas of the greater Oslo area, but, in an international perspective, the students still come across as a relatively homogeneous group (cf. Kjærnsli & Lie, 2002). Table 1 summarizes information on the six participating teachers.

Table 1. Information about the participating teachers in the Budding Science and Literacy video study.

Teacher	Grade	Years of teaching experience	ECTS credits in Science	Number of students in class	School location*
Anna	5	0-5	16-30	14	S
Betsy	1	11-15	16-30	18	R
Birgit	4	11-15	16-30	24	R
Cecilia	3	20+	16-30	19	S
Ellinor	3	11-15	31-60	16	R
Emma	3	20+	16-30	21	R

*S=Suburban, R=Rural

Both the professional development course and the six participating teachers relied in some ways on ideas and teaching materials from the Seeds of Science/Roots of Reading program developed at Lawrence Hall of Science, UC Berkeley (Cervetti et al., 2006). Thus, the main ideas behind Seeds/Roots require some clarification. According to Gina Cervetti and P. David Pearson (2012, p. 580), founding developer and co-director of the Seeds of Science/Roots of Reading program, the Seeds/Roots model of science-literacy integration pertain to two central questions: "How can reading, writing, and language be used as tools to enhance the acquisition of science knowledge and inquiry processes?" and "How do reading, writing, and language benefit from being put to service in pursuit of the goals of inquiry based science?" From these two questions, then, Seeds/Roots evolved into an integrated curriculum program for primary school, consisting of curricular units of 20 to 40 sessions developed in accordance with national and state science and literacy standards in the US, and subsequently field-tested in classrooms. Each unit is specially designed to address specific topics and key science concepts, and includes detailed teacher guides, student books, investigation notebooks, equipment kits, and a summative assessment booklet[7].

Furthermore, Cervetti and colleagues (2006) refer to five main principles that have guided the integrated model on which these units are based. First, *texts can support scientific inquiry*, which acknowledges that scientists "learn about and come to understand the natural world through text as well as firsthand experience" (p. 227). Second, *comprehension strategies are inquiry strategies*. This principle relies on the recognition that science and literacy share many of the same meaning making strategies—for investigating natural phenomena and understanding a text, respectively. Third, *words are concepts*. The third principle focuses on conceptual learning; in the form that learning science involves developing rich conceptual networks of words and ideas (over mere word learning)[8]. Fourth, *science is discourse*. This principle relies on an understanding of science as a social context in which a specialized language is used to communicate: the social language of science (Gee, 2005). And fifth, *literacy is visual literacy*. The final principle relates to how scientific ideas are represented though a wide range of visual elements that goes beyond words on the printed page. For example, science texts employ pictures, videos, animations, figures, graphs, and equations to present and provide multiple representations of scientific information (Kress et al., 2001; Lemke, 1998).

For the present study, the Budding Science and Literacy teaching model (Figure 1) and the Seeds/Roots teaching material serves as the two central points of reference for framing the interventions in the six classrooms. All of the six participating teachers chose to use material from the Seeds/Roots units, but there were individual variations in how closely they followed the teacher guides. This is evident in Article I, where a supplementary analysis comparing the teacher guides to the observed teaching was performed. This analysis indicated that the teachers followed the main activities from the teacher guides, but different teacher emphasized different aspects. Some of the teachers also added their own activities.

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[7] http://www.scienceandliteracy.org/about/whatisit/components

[8] The work of fellow Budding Science and Literacy PhD student, Berit Haug, has focused specifically on how teaching for conceptual understanding occurs in an integrated inquiry-based science and literacy setting (Haug, 2014).

4.3 Data sources

4.3.1 Acquisition of data material

The data material for the Budding Science and Literacy video study was acquired in autumn, 2010, and spring, 2011. Prior to main data collection period, the Budding Science and Literacy video study design was piloted in a similar setting, at a near-by school in Oslo. In this section, I will mainly focus on how video and audio data, semi-structured group interview data with students, and textual artifacts were generated in the Budding Science and Literacy project, since these are the data sources that are drawn upon in the work presented here. In the larger research project, however, we also collected survey data on the teachers that attended the professional development course; pre- and post-interview data with the six participating teachers; video and audio recordings of teacher presentations at the professional development course; written exam papers from the professional development course; and, reflection notes from the professional development course. However, classroom studies, like the Budding Science and Literacy project, often generate large corpora of data material and a central step in the analytical process is therefore to restrict and select data sources fitting to the particular research questions (Derry et al., 2010). In the Budding Science and Literacy project, we engaged in a comprehensive data collection to fit the overarching goals of the project, as well as those of the individual researchers. Wanting to focus on students' interactions with text as teachers implemented integrated science-literacy instruction, it was the classroom-based data sources that has been the main interest in this PhD project; namely, video and audio from the classrooms, the textual artifacts that were present or produced in the classrooms, and getting the students' own perspectives on the observed lessons.

4.3.2 Video and audio observations

The six classrooms in the study were video-recorded with a four-camera set-up, as the teachers implemented an integrated science and literacy lesson sequence, to capture the interactional context of the classroom by relying on cameras from multiple perspectives. The camera set-up included a fixed whole-class camera to capture the events of the entire classroom, located in the front of the classroom and focusing on the students; a teacher camera located in the back of the classroom, operated by a research assistant, which followed the teacher's movements; and, two head-mounted cameras on a student in each of two focus groups in the classroom. In Figure 2, it is possible to see how the four cameras capture the four perspectives at a given moment in one of the classrooms. Additional sound recorders were also used in each classroom to record focus group discussions in case of camera malfunction. In this way, the particular video design and positioning of cameras employed in The Budding Science and Literacy study builds on prior classroom video studies, such as the PISA+ video study (Klette, 2009; Klette et al., 2008; Ødegaard & Arnesen, 2010). The connection between these two classroom video studies is further explored in Article IV.

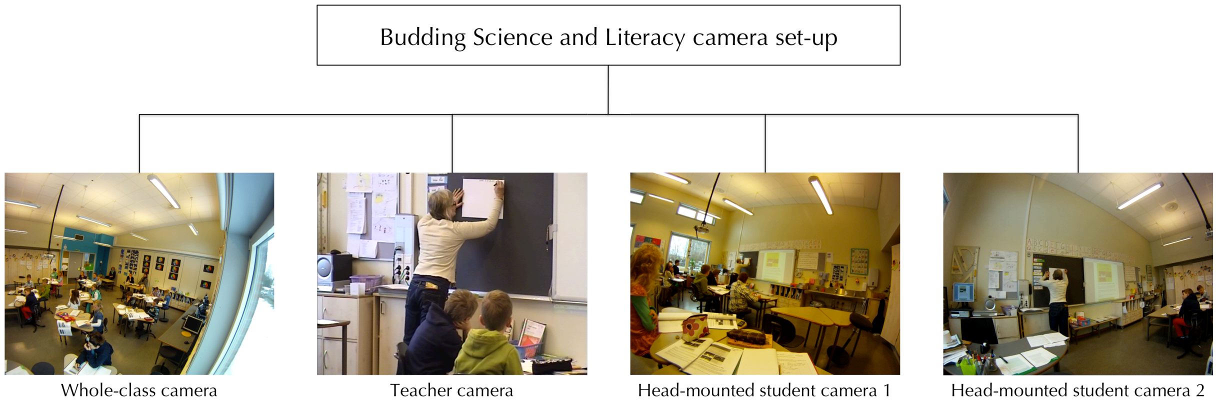

Figure 2. Snapshots from the four cameras illustrate how the Budding Science and Literacy camera set-up captures multiple perspectives at a given moment in one of the classrooms in the study.

The inclusion of head-mounted cameras distinguishes the Budding Science and Literacy design from the PISA+ study, but similar cameras have been used in recent studies to explore geoscience fieldwork and outdoor learning (Remmen & Frøyland, 2013; Stolpe & Björklund, 2012) and students' use of laptops during teacher instruction (Blikstad-Balas, 2012). We used high-definition cameras from GoPro[9], which were mounted on the students' heads with a headband during the observed lesson. By using these head-mounted cameras, we were able to obtain a record of that student's perspective in the classroom (see Figures 2 and 3 for screenshot examples from these cameras), along with the interaction that student had with the other students in her/his sitting group and with the class in general. This means that it is possible to observe how two students in each class actually read and wrote, but also how they talked about texts with the other students in the focus groups. For example, in Figure 3, we see how one student produces a figure of a small ball-sorting system that he and the other students in his sitting group had made in the previous lesson. He starts out by drawing the system, before he makes labels with the form and function of the different parts in the system. From these snapshots, it is possible to see that the head-mounted cameras enables us to

[9] http://www.gopro.com

consider what kind of writing the students is actually doing, not only what they are told by their teacher to do.

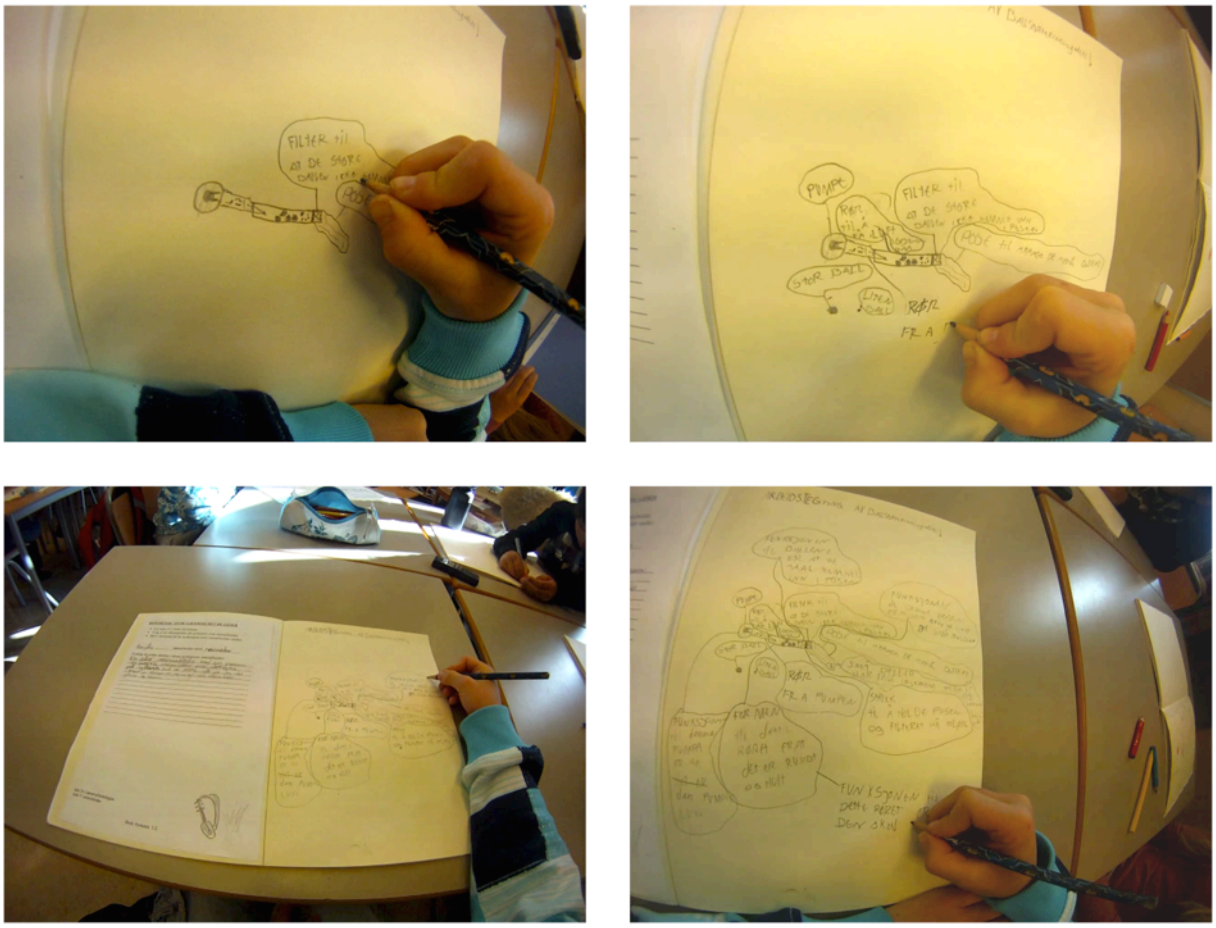

Figure 3. Snapshots from a head-mounted camera. The student wearing the head-mounted camera is in the process of making a figure of a physical model from the previous lesson.

The selection of student focus groups was made in cooperation with the teachers to procure focus groups that were representative of the class. One student in each group was then asked to wear a head-mounted camera, which was also decided on with the assistance of the teacher to make sure that the student wearing the head-mounted camera was comfortable doing so. The seating arrangements in each classroom varied somewhat, from students sitting in pairs facing the blackboard (e.g., Betsy's and Anna's classrooms) to groups facing each other (e.g., Birgit's and Ellinor's classroom), which influenced the number of students in the focus group. In most of the classrooms, students were eager to wear the head-mounted cameras, which resulted in a decision to allow the students within the focus group to take turns wearing the head-mounted camera from lesson to lesson if needed. Most importantly, the interaction within the group would be recorded regardless.

The Budding Science and Literacy research group, along with two research assistants, recorded all of the video observations. I was present for almost all of the lessons being recorded, taking time-indexed field notes during the observations. By time-logging our field notes, we could easily correlate our initial observations in the field with the time codes of the video recordings in the beginning stages of analysis or mark particularly interesting events. Being present in the field and taking field notes were also important structures before interviewing the focus group students after their final lesson. We recorded for the duration the lesson sequence that the teachers implemented with their students in each classroom, but the teachers were not given any instructions on the length of these sequences (rather, they were told to include reading, writing, doing and talking activities in the lessons). The amount of recorded material thus differs between the classrooms. In total, approximately 33 hours (per camera) were recorded of the six teachers and their students. After each observed lesson, the research group archived the video recordings on a secure server, along with essential metadata, such as school code, date, time, and camera source. In Article I, the video data corpus is used to answer the research question, whereas 30 hours of video data are analyzed in Article II. In that study, two lessons of 83 and 85 minutes were removed from the total number of video recordings to provide a more homogeneous sample, because they differed in science topic from the rest of the video-recorded lessons in two of the classrooms.

Table 2. Distribution of interviewed students and time of video recordings for each classroom in the Budding Science and Literacy study. The distribution of video recordings analyzed in Article II is also listed.

Teacher	Grade	Interviewed students from group	Total time of video recordings (in minutes)	Time of video recordings analyzed in article II
Anna	5	5	343	260
Betsy	1	4	165	165
Birgit	4	8	426	426
Cecilia	3	4	540	455
Ellinor	3	8	224	224
Emma	3	4	269	269
Total		33	1967	1799

4.3.3 Semi-structured focus group interviews

Following the observed lesson sequences, 33 of the students in the participating classrooms were interviewed on the basis of being included in the classroom focus group (i.e., students wearing the head-mounted cameras or being in the same sitting group as the students wearing the head-mounted camera). The interviews were conducted as semi-structured focus group interviews, which combines a predetermined set of questions with the flexibility to explore themes that the interviewees bring up (Kvale & Brinkmann, 2009). The overall distribution of interviewed students across the six classrooms is presented in Table 2. In this thesis, the interview data are drawn on in Article II, where the main purpose was to gain access to the students' own thoughts and ideas about their experiences with literacy and science in the context of integrated science-literacy instruction. Due to the young age of the participating students—from six year-olds to eleven year-olds—particular attention was given to creating a safe and informal environment for the students. For example, the students were interviewed in groups, they were asked age-appropriate questions, the interviews took place in the classroom or adjoining rooms after the lesson, and the students were encouraged to bring their lunch boxes if it was close to lunch time. However, focus groups interviews are also suitable for exploratory studies, like this one, because the collective interaction may elicit more spontaneous and expressive views than in individual interviews (Kvale & Brinkmann, 2009).

Interview guides for the semi-structured focus group interviews (Appendix II) were developed and designed to reflect the broad objectives of the Budding Science and Literacy project as a whole, as well as the individual foci of the researchers. Being particularly interested in the students' perspectives, I had a central role in designing the interview guides. I also acted as interviewer in most of the student interviews. The main priority in the interviews was to allow the students to speak freely about their experiences in the observed lessons. Hence, we structured the interviews around certain artifacts (i.e., texts and practical equipment) from the observed lessons and initiated the interview with introductory questions around these artifacts. According to Kvale and Brinkmann (2009), introductory questions (e.g., "Can you tell us about what you did in class today?") may yield rich descriptions of what the subjects themselves experienced and in their own words. The interview guides then provided additional probing questions to further pursue specific themes or direct questions to introduce new topics later in the interviews if required. The interviews were video and audio recorded, and subsequently transcribed.

4.3.4 Textual artifacts

Students and teachers in any classroom use and produce a number of texts during a regular school lesson that are central to understand how literacy is embedded in the teaching and learning of science in that classroom. For the researcher, these physical objects (e.g., a drawing in a student's notebook, a textbook, a concept map on the blackboard, or a poster on the classroom wall) can become textual artifacts from a certain situation or context (Borko, Stecher, Alonzo, Moncure, & McClam, 2005). With help from the teachers, the research group collected these textual artifacts after the observed lessons. In some cases, however, textual artifacts were not easy to collect. For example, Anna used a digital quiz on the interactive whiteboard in her classroom, and students in Ellinor's classroom tested different types of glue on inscribed paper sheets. In these situations, the multiple camera set-ups provided us with video recordings that documented these and similar texts. The textual artifacts were only drawn upon in Article II, but mainly as a supplement to the video data or as a stimulant in the semi-structured interviews. While a textual artefact, on it's own, give little information about how that text was actually used, it provided us with the opportunity for closer inspection of the texts that were present and used in the video recordings. Some examples of textual artifacts are presented below (Figure 4).

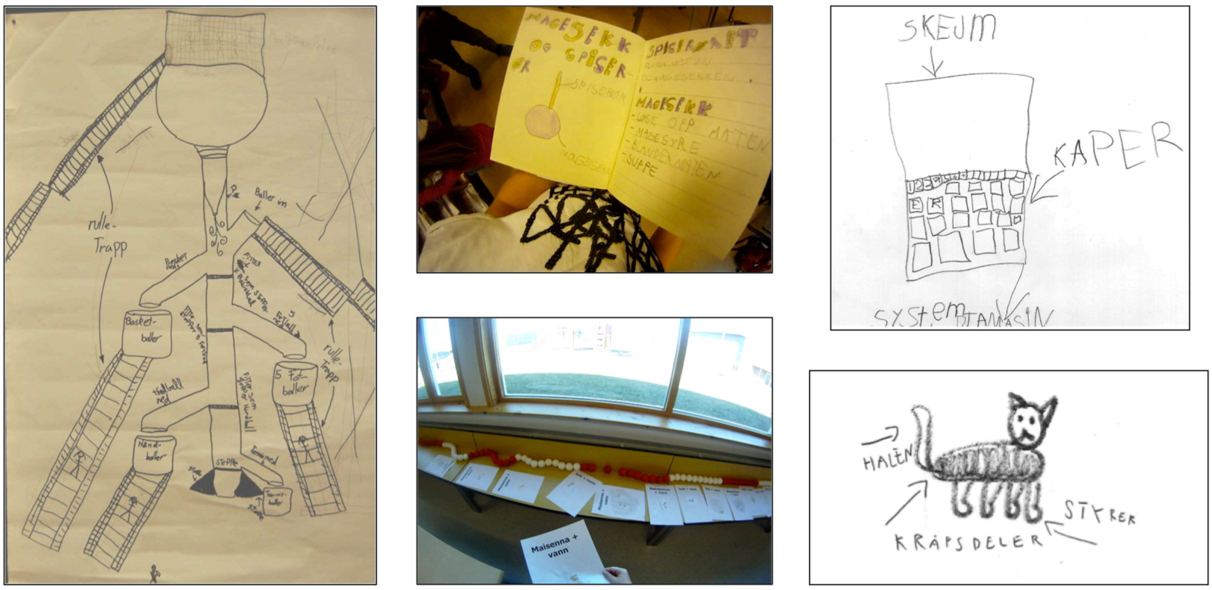

Figure 4. Examples of student texts either collected or captured by video.

4.4 Data analysis

The empirical work presented in this thesis draws primarily on video data, which are central to Article I and Article II, in addition to interview data and textual artifacts, which are drawn upon in Article II. In what follows, I describe the analytic process that was applied to the data sources in the two articles. The textual artifacts were mainly used to provide additional information on particular literacy events in Article II and will not be further discussed in isolation from the particular literacy events in which they were used.

The analytic approach of video coding was central to both of the empirical articles. According to Derry et al. (2010), analyzing video by coding is rooted in disciplined observation, a core feature of scientific methodology, and developed and used by social scientists to "document, analyze and report human behavior observed in natural contexts" (p. 20). More specifically, coding involves a transformation of people's actions, utterances and gestures into a formal code, which corresponds to a specific reference (Tiberghien & Sensevy, 2012). Thus, coding schemes were developed to answer the particular research questions of the two articles. These are briefly described below. For the actual coding, InterAct[10] coding software was used to code the videos directly, without having to transcribe speech into written form. This process is illustrated in Figure 5, where a segment from one of the classrooms in the study has been coded with the coding scheme from Article II (Table 4). InterAct also allowed for multiple videos to be juxtaposed (e.g., video from a head-mounted student camera and from the teacher camera), which was helpful for in-depth analysis of particular events. I will first go more into detail about the video analyses of Article I and Article II, before ending this section with a description of the analysis applied to the interview data in Article II.

[10] http://www.mangold-international.com/software/interact/what-is-interact.html

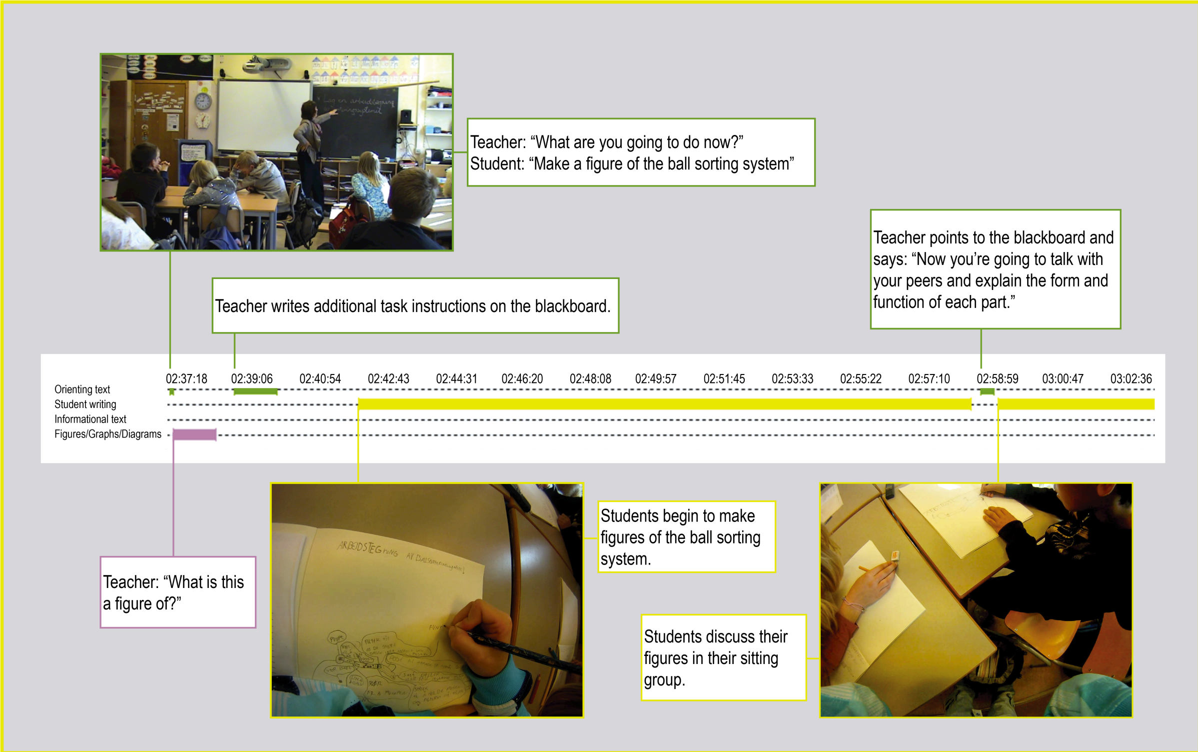

Figure 5. Example of coded segment of classroom video recording with InterAct coding software. The figure shows six coded literacy events from one of the classrooms after being coded with the coding scheme applied in Article II. The coding categories are summarized in Table 4.

In Article I, the entire Budding Science and Literacy research group aimed to investigate the challenges encountered and the support needed when teachers implement integrated science-literacy instruction. This was addressed through mapping time spent on different learning modalities (reading; writing; talking; doing) throughout four different phases of inquiry (preparation; data; discussion; communication) with systematic video coding. All of the four researchers in the Budding Science and Literacy project took part in the development of the coding schemes and in the data analysis. First, a coding scheme for inquiry was developed based on extensive review of the literature on inquiry-based science (e.g., Barber, 2009; Bell et al., 2010; Bybee et al., 2006; Knain & Kolstø, 2011), and from iteratively reviewing and operationalizing these codes in conjunction with the video material. We distinguished between two levels of analysis by having specific codes for central inquiry processes constituting the four overarching inquiry phases. Table 3 gives provides an introduction to these codes (see also Appendix III). Second, codes for different learning modalities were developed to correspond with the multimodal activities that are emphasized in the Seeds/Roots materials (reading, writing, talking, doing), and included codes for instructional organization (whole-class, group, pair, individual). The latter codes were inspired by the

PISA+ video study (Klette, 2009; Ødegaard & Klette, 2012). Finally, we also included a code to indicate when the teaching explicitly focused on concepts that were accentuated in the Seeds/Roots teaching material.

Table 3. ***Coding scheme for video analysis in Article I based on Ødegaard, Mork, Haug, & Sørvik (2012). See also Appendix III for the entire coding manual developed by Ødegaard et al. (2012).***

	Category	Subcategories
Inquiry	Preparation	Background knowledge/ wondering/ researchable questions/ prediction/ hypothesis/ planning
	Data	Collection/ registration/ analysis
	Discussion	Discussing interpretations/ inferences/ implications/ connecting theory and practice
	Communication	Orally/ in writing/ assessing their work
Multiple learning modalities	Oral activities	Whole-class/group/pair/individual
	Writing activities	Whole-class/group/pair/individual
	Reading activities	Whole-class/group/pair/individual
	Practical activities	Whole-class/group/pair/individual
Key concepts	Focus on key concepts	

These codes were then applied to the video material to investigate the occurrence and co-occurrence of inquiry and learning modalities in the six classrooms in the study. To begin with, the four researchers worked in pairs to code two randomly assigned lessons and agree upon when the codes should be applied. The researchers then coded the rest of the material individually. However, to determine inter-rater reliability, about 20 % of the material was double-coded by two individual researchers. The topic of inter-rater reliability will be addressed more closely in Section 4.5.2.

In Article II, the aim was to identify literacy events in the material and explore the emerging literacy practices that students engage in during integrated science-literacy instruction. Thus, literacy events acted as the main unit of analysis in this study. Here, the data analysis was performed by myself and in three main steps. First, a coding scheme was inductively developed from the video material (Table 4) and used to identify literacy events by logging the onset and offset times of each event in which the social interaction revolved around a particular text. This way, it was the text that the participants made reference to that characterized the categories for coded literacy events. Another possibility could have been to categorize literacy events according to the nature of the interaction around the text, instead of the type of text that was the object of interaction. In this data material, however, it worked well to categorize the coded literacy events in this way because the teachers and students often focused on a particular text at a particular time. In other school situations where students often interact with multiple texts at the same time (e.g., in upper secondary schools where students have access to computers during whole-class instruction (Blikstad-Balas, 2012), a strict *analytical* demarcation between literacy events like the one applied here might become more problematic. In this case, the coding approach served to provide detailed information on how different types of texts were used in the six classrooms, as well as important information on the typicality and atypicality of certain literacy events in the participating classrooms.

Table 4. ***Coding scheme for the main coding category Text. These codes were applied to the video material to identify literacy events in Article II.***

Subcategory	Description of subcategory
Fictional narratives	Narrative text that does not aim to communicate scientific information (e.g., story books or fictional films)
Hybrid informational text	Atypical informational text that incorporates elements from different genres (e.g., narrative, poetry etc.) to communicate scientific information
Informational text	Typical informational text, such as traditional science textbook texts and authentic science texts
Internet	Text that is accessed online in the classroom
Orienting text	Concept walls, learning goals on blackboard, work plans, written instructions etc.
Graphs, figures and models	Explicit focus on visual representations of scientific information
Student writing	Texts produced by the students. This subcategory also includes texts co-produced by teacher and students (e.g., if the teacher constructs a text on the blackboard in co-operation with the students)
Other	Texts not included in the previous subcategories (e.g., digital quizzes)

Second, the coded literacy events were analyzed through *analytic induction*, which involves the iterative process of "reviewing evidence with an assertion in mind, revising the assertion in light of the evidence, and then reviewing the evidence again" in search of emerging patterns and themes across the data material (Erickson, 2012, p. 1460). We began by drawing on sociocultural perspectives on literacy to consider the contexts that were relevant to the students' interaction with text. This led us to differentiate between literacy events that were typically "schooled" and literacy events that relied on both formal and informal elements in the students' inquiry engagement, which were categorized into tentative categories for emerging literacy practices. In the third step of the analysis, we analyzed interview data to uncover some of the feelings, attitudes, values, and social relationships from the students' own experiences in the observed lessons. This analysis is accounted for in more detail at the end of this section to discuss the video analyses in the two empirical studies.

In both of the empirical studies, systematic video coding allowed for quantification to be employed in qualitative research. According to Erickson (2012, p. 1462), it is apparent that:

> […] the [qualitative] researcher must pay careful attention to frequency of occurrence, especially to relative frequency, in comparing different kinds of phenomena across different comparison groups. It is necessary to count things and to make decisions carefully about what things to count and in which sets.

The coding approaches applied in the two articles rely on systematic results for two particular purposes. In Article I, systematic coding and quantification were used to illuminate the occurrence and co-occurrence of multiple learning modalities and inquiry phases. This was not done to generalize from the findings, but to reveal patterns of classroom activity in the data that are not easily observed (Ødegaard & Arnesen, 2010). In Article II, systematic coding allowed for close attention to be paid to specific literacy events as part of larger patterns in the classrooms. In turn, this enabled us to distinguish between the typical and the atypical (Erickson, 2012) when analyzing and describing those events. While systematic video coding inevitably reduces complex social situations into seemingly clear-cut categories, in-depth analysis helps add nuance to the results (Snell, 2011). This is achieved with an illustrative example of the video analysis in Article I (from Birgit's classroom), and with the combination of systematic coding of events and analytic induction of those events in Article II. Snell (2011, p. 257) argues that the two methods of analysis are, in fact, complementary: "micro-ethnographic analysis adds nuanced interpretation and prevents systematic results from being used in a reductionist manner; and systematic quantitative analysis build rigour into the selection process, warding off claims of researcher basis in 'cherry-picking' video clips".

Lastly, in article II, interview data were analyzed to get the students' own perspectives on the observed science lessons and science in general. Thus, the transcribed student group interviews were subjected to meaning condensation, which, according to Kvale and Brinkmann (2009), entails compressing the interviewees' statements into briefer statements that retain the main sense of what is said. Following Kvale and Brinkmann's approach, I started out by reviewing the video recorded interviews and reading through the entire transcripts to get a sense of the whole. I then determined natural "meaning units" as expressed by the students and restated these units into simpler themes, such as *Working like a scientist involves doing experiments* or *I used my imagination when I wrote the text*. These themes were subsequently aligned with the study's focus on how the students' viewed and used literacy in school science, and tied together into descriptive statements. In article II, the interviews served to provide insights into the students' experiences regarding text and social practices in the observed lessons. In this regard, it was central to explore what the students themselves thought about what they did in the observed lessons. Meaning condensation was in this way a valuable analytical tool to maintain the students' everyday use of language and ways of talking about their experiences in the classroom (Kvale & Brinkmann, 2009).

4.5 On the quality and credibility of the research

In all research, it is necessary to discuss the quality and credibility of the work. Here, I discuss the present study's validity, reliability, and generalizability.

4.5.1 Validity

The concept of validity in qualitative research has been treated to a vast array of related terms (e.g., credibility, authenticity, trustworthiness etc.), but there is little doubt that qualitative researchers need to demonstrate that their study is credible (Creswell & Miller, 2000). More specifically, the validity of a qualitative study concerns "whether or not the inferences that the researcher makes are supported by the data, and sensible in relation to earlier research" (Peräkylä, 2011, p. 365). Creswell (2007) uses the term to emphasize a process, rather than a strict verification, where different strategies are chosen and applied to add to the accuracy of a study's findings. This includes scrutiny and presentation of the choices made regarding collecting, processing, and analyzing the data. In turn, these validation strategies should be made clear to the reader.

In this thesis, *prolonged engagement* in the field has been a central strategy to form an accurate impression of the social action in the six participating classrooms. In addition to the hours of actual video recording in the classrooms, I and other researchers in the project group visited participating teachers and students prior to the video observation to observe and build trust in the classrooms. I was also present at the professional development course meetings as an observer. In Article IV, it is further explored how the Budding Science and Literacy project has aimed to facilitate for future re-use of the data corpus from the start. This means that we have attempted to generate a rich data corpus, which goes beyond the individual researchers' research interests or need, paying specific attention to document contextual information and other relevant data from the field.

Triangulation has been another central strategy to improve the validity of the study. The process of triangulation involves using multiple data sources, theories, and methods while searching for convergence in a study (Creswell & Miller, 2000). As described in the previous sections, observational data, interview data, and textual artifacts have been combined in this thesis to explore literacy in the six classrooms. However, the reason for using data collected through multiple methods is not for validity concerns alone; they are also closely intertwined with the object of study (i.e., school science literacies) and the theoretical perspectives (i.e., literacy as social practice). In a social view of literacy, feelings, attitudes, values, and social relationships are central to people's literacy practices, but not necessarily readily observable in a literacy event. This implies that it is important to gain insights into the participants' experiences of the classroom activities, in addition to the video-recorded events.

Peer debriefing has also been used continually in the research process to challenge and check methods and interpretations (Creswell & Miller, 2000). Video recordings have been central in this regard, because they can be viewed multiple times by multiple researchers and allows for inferences to be debated among several researchers or for a researcher's interpretations to be checked against the specific events (Derry et al., 2010).

When researching sites chosen on an *a priori* theoretical basis—in this case, an integrated science-literacy intervention—a possible threat to validity is that the researcher is overly committed and influenced by that perspective (Schofield, 2002). In the two empirical studies included in this thesis, however, the aim was not to prove or falsify such an approach, but to investigate what was actually happening in the six classrooms when the participating teachers implemented integrated science-literacy instruction. Validity problems of this sort can then be somewhat mitigated by approaching the data as openly as possible (Schofield, 2002). In the work presented here, it has been important to explore both the opportunities and the challenges that arose in the participating classrooms to best support teachers and students in reading and writing science texts in meaningful contexts. Accordingly, openness towards the data has been a premise for the project from the start.

Another threat to validity in a classroom video study concerns how the participants react to the presence of video cameras in the classroom—an issue often referred to as *reactivity* (C. Heath et al., 2010; Knoblauch et al., 2006; Lomax & Casey, 1998). It is a serious methodological issue to consider for researchers exploring social action in the context in which that action occurs, because the situations to be studied can be modified by the camera to greater or lesser extent (Knoblauch, Tuma, & Schnettler, 2014). However, Heath, Hindmarsh and Luff (2010, p. 49) argue that reactivity is often minimized as the research participants get used to the camera with time:

> Throughout our studies of a diverse range of settings and activities we found that within a short time, the camera is 'made at home'. It rarely receives notice or attention and there is little empirical evidence that it has transformed the ways in which participants accomplish actions.

While we initially were anxious to see how such young children adjusted to wearing head-mounted cameras, when asked informally after class or in the interviews, most replied that they had forgotten they were wearing the camera in class. This was particularly evident in one of the third-grade classrooms, where a student with a head-mounted camera simply got up, asked her teacher to go to the bathroom, and walked out of the classroom with the camera still on her head—leaving the researcher closest to the door in a sudden rush to catch up with the student and turn the camera off (which was accomplished). It was also the case in the other classrooms that the cameras soon became a regular aspect of the school science lessons we observed. In line with Heath et al. (2010), reactivity is accordingly not regarded as a major threat to the validity of the present study.

4.5.2 Reliability

Reliability is used here to refer to ”the degree of consistency with which instances are assigned to the same category by different observers or by the same observer on different occasions (Hammersley, 1992, p. 67). In other words, the reliability of a study concerns whether or not a study is replicable—if other researchers could perform the same study with the same results (Silverman, 2011). However, actual replications of qualitative studies are often hard to achieve in practice, because they involve unique settings that change over time

(Seale, 1999). Rather, to satisfy reliability criteria in qualitative research, Moisander and Valtonen (2006) propose that the research and analytic process must be made transparent, as well as the researcher being theoretically transparent (being explicit about the theoretical stance that influences your interpretation of data). Here, theoretical transparency is addressed through the theoretical perspectives presented in chapter 3.

The reliability of a qualitative study can however be enhanced when working with video recordings, because they make it possible to "capture" social interaction in the context in which it occurs. Peräkylä (2004) thus claims that video recordings have an "intrinsic strength" when it comes to reliability. In contrast to traditional ethnographic approaches, which are often based on the accuracy of a researcher's field notes, video has the opportunity to provide highly detailed representations of the social interaction it is intended to document. Being part of a larger research project also enabled the researchers in the Budding Science and Literacy group to take part in joint viewings, coding workshops, and debates concerning code descriptions and particular events in our data material, thereby enhancing the reliability of our analyses. Moreover, in Article I, the members of the research group jointly developed the coding schemes and all four researchers took part in coding the video data corpus. Determining inter-rater reliability is then a common procedure to assess reliability, which was used to evaluate the coding procedures in Article I. In Article II, the first author carried out the entire video analysis, but the second author coded a sub-set of the video material to test the reliability of the coding scheme that was applied. In both cases, inter-rater reliability was deemed satisfactory with Kappa values of respectively 075-0.80 for the coding procedures used in Article I (among the four authors) and 0,81 for the coding procedures in Article II (cf. Banerjee, Capozzoli, McSweeney, & Sinha, 1999). In instances where there were discrepancies, these were subsequently solved collaboratively.

Despite the intrinsic strength of video recordings in reliability matters, there are certain challenges to transparency that are not trivial when *reporting* on video-based research (Erickson, 2006). The complexities caught on tape will in most cases be lost as they are re-represented in a journal article or report, and must accordingly be represented in other ways. A possible solution could be to avail segments of video for review through electronic journals or digital platforms, but without exposing the identity of the research participants. As I will discuss in the next section, the confidentiality of the research participants has been kept by restricting access to the video material, which makes this a nonviable option. Rather, in line with Derry and colleagues' (2010, p. 23) recommendations, I have used "more than one method of representation when reporting the research" to increase transparency. For example, transcripts, still pictures, thick descriptions, and various graphics have been used in combination with quantified measures from the video coding to provide thorough re-representations of the video data.

4.5.3 Generalizability

According to Schofield (2002), there is broad agreement among qualitative researchers that generalization in the form of producing universally applicable laws is not a goal for qualitative research. Rather, generalization in qualitative research is best conceptualized as "a matter of the 'fit' between the situation studied and others to which one might be interested in applying the concepts and conclusions of that study" (Schofield, 2002, pp. 198-199). This can be seen in relation to what Kvale and Brinkmann (2009, p. 262) refer to as *analytical generalization*, which "involves a reasoned judgment about the extent to which the findings of one study can be used as a guide to what might occur in another situation. It is based on an analysis of the similarities and differences of the two situations". Analytical generalization thus differs from *statistical generalization*, where "an inference is made about a population (or universe) on the basis of empirical data collected about a sample" (Yin, 1994, p. 30).

In the Budding Science and Literacy project, teachers and classrooms were purposively chosen, as they were part of a local and specific setting that involved the professional development course. In other words, the empirical data were not randomly sampled and, accordingly, findings from the study can only be analytically generalized. This implies that thick descriptions about the situation studied are crucial if such judgments about fit are to be made (Schofield, 2002). In the extended abstract, I have systematically addressed this issue by describing the contexts that informs the data on three central levels: the interactional level, the situational level, and the institutional level (cf. Bishop, 2006). First, the interactional level refers to the interactions with or conversations about text (the classroom). Second, the situational level refers to the specific setting (the professional development course). And third, the institutional level refers to the institutional and cultural factors influencing the data at the time they were collected (the Norwegian school context). In Article IV, these three levels of contexts are also applied to consider the archiving and re-contextualizing of video data for future re-use.

A potential issue related to generalization in this thesis concerns the use of quantitative measures in a qualitative study. According to Maxwell (2010), using numbers to present results in qualitative research can lead to inferences being made (by either the researcher or the reader) about greater generality of the findings than what is actually the case. As previously stated, results from video coding are employed and represented quantitatively in Article I and Article II, but without any intention of generalizing outside the specific context of the Budding Science and Literacy study. Rather, numbers are used to explicate the contexts in which literacy occurs by allowing patterns of classroom activity to emerge from the data (Ødegaard & Klette, 2012) and provide important information on the typicality or atypicality of events in the data material (Erickson, 2012).

4.6 Ethical considerations

Research drawing on video data is confronted with significant ethical challenges that must be carefully managed—before, during and after the data collection process—perhaps more so than with other types of qualitative data.

In Norway, any research involving the recording and storing of video material (or other personally identifiable markers) are required by the Personal Data Act to be reported to and approved by the Norwegian Social Science Data Services[11] prior to data collection. Being the last project member to join the Budding Science and Literacy research group, however, this process was already in progress when I started my PhD. An application was submitted on behalf of the project, where it was applied for secure storage of personally identifiable data until the end of project period (the year 2030), as well as approval of informed consent drafts, which were to be distributed to the research participants. Upon approval, we started the process of informing the six teachers, their students, the students' parents, and the school principals, in accordance with national guidelines (The National Committee for Research Ethics in Norway, 2006). This way, the research participants were informed of the research project, their rights to confidentiality, and that all personally identifiable information would be deleted by the end of the project period. In this phase of the video study, the professional development course acted as a meeting ground between researchers and the participating teachers, where the teachers could ask questions about the study and what they would be

[11] http://www.nsd.uib.no/nsd/english/index.html

consenting to, while we were provided with the opportunity to explain our methodological choices. The research participants were then formally asked to participate voluntarily by signing informed consent forms (see Appendix I). In all, there was one student who did not wish to participate in the study. Special arrangements were then made for her by the researchers and her teacher to make sure she was not video-recorded (i.e., adjusting camera angles and changing seating arrangements).

When being video recorded, research participants may also be put in situations where private or sensitive information is shared and recorded inadvertently (C. Heath et al., 2010). Fortunately, our participants did not find themselves in this type of dilemma when being recorded. The participating teachers were however instructed to turn of the microphones they wore during filming to prevent these kinds of situations if they were to arise. The participating students were similarly told to inform their teacher or us if they wanted to take off the head-mounted camera. Additionally, since these were young children, between the ages of 6 and 11, we also gave specific attention to making the children feel at ease with our presence in the classroom and with the video cameras. For example, we visited most of the classrooms in the autumn of 2010 to inform them about our work, to observe the class in a regular science lesson, and in some cases, to conduct shorter video recordings as some of the teachers taught a single lesson from the Seeds/Roots curriculum material. The students were also given the chance to play a little around with and explore the head-mounted cameras together with us when we were not recording. After the data collection period, we visited the participating classrooms to thank the students for participating and to talk about the videos we had recorded in their classroom. For these meetings, we had created short videos with some footage from the recorded lessons that we showed each class, which were the cause of much excitement in the six classrooms. I also attended a parent-teacher conference at one of the schools in the study to describe the research process and give the parents an update on the work we did with the data we collected in their children's classroom.

Furthermore, it is obvious that video recordings are more sensitive towards maintaining the research participants' anonymity than audio recordings or transcripts. According to Derry et al. (2010, p. 36), "video data are inherently non-anonymous", which requires that researchers protect the confidentiality of those recorded in other ways than simply removing identifying information from the data material (e.g., assigning pseudonyms instead of using the informants' real names). For example, with a video recording, it is possible to mask or blur the faces of the participants, but not without significantly reducing the quality of the data. One possibility for protecting the participants' confidentiality, which has been utilized in the Budding Science and Literacy project, is to restrict the access to the data material (Derry et al., 2010).

Accordingly, all video recordings and other data sources from the classrooms have been stored to a secure server that is only accessible to the research group. Restricting access to the data in this way was the first step in protecting the participants' anonymity. The second step involved finding an appropriate level of anonymization of data and metadata. Metadata coding schemes were developed to include codes for the participating schools, students, and teachers, as well as time, date, and the source of the data material (teacher camera, whole-class camera, head-mounted camera, audio, textual artifacts etc.). All data files were accordingly logged and tagged with these codes to make sure that the names of schools and participants were excluded. As described in Article IV, the ways in which the data were stored and access restricted is particularly relevant for this data corpus, because it has been an objective from the start of the research project to archive data and facilitate for secondary analysis of the data material. However, by restricting access to the research group, secondary researchers must become formally involved in the research project and their access to the data material approved by the Norwegian Social Science Data Service. Through the informed consent forms, the data are also bound by the conditions that were established in the data collection process, which we, the original researchers, were involved in—and secondary analysts need to abide by. Hence, facilitating for re-use of personally identifiable data material, such as video recordings, has important ethical considerations and implications for both the primary and the secondary researchers.

5 Summary of the articles

This chapter provides a summary for each of the four articles that are included in this thesis. Since the articles can be explored in their entirety in Part II of the thesis, these summaries focus on each article's aim, its main findings, and the key arguments being presented.

5.1 Article I

Ødegaard, Marianne, Haug, Berit, Mork, Sonja M., & Sørvik, Gard Ove (2014). Challenges and support when teaching science through an integrated inquiry and literacy approach. *International Journal of Science Education*, 36(18), 2997-3020.

This article, written by the four researchers involved in the *Budding Science and Literacy* project, reports on the variation and patterns of multiple learning modalities and science inquiry phases during integrated science-literacy instruction. The main objective of the study is to explore how the interrelationship between multiple learning modalities and science inquiry might challenge and support the teaching and learning of science. From a sociocultural approach to science education, we investigate this by analyzing video data from the six primary school science classrooms that were recruited from the professional development course.

The six teachers were video-recorded during their implementation, and video coding schemes for multiple learning modalities (reading, writing, talking, doing) and science inquiry (preparation, data, discussion, communication) were developed. The coding schemes were based on extensive review of literature on inquiry-based science education in combination with iteratively reviewing examples from the *Budding Science and Literacy* video material. We then coded 33 hours of video material and explored the frequency of occurrence, co-occurrence and sequential patterns of these codes. In addition, we coded for key concepts, which was applied when the teachers explicitly focused on central science concepts.

The findings reveal that oral activity was the most prominent of the learning modalities in all classrooms, often occurring in combination with the other modalities. Reading activities occurred as plenary and paired readings. Writing activities were mainly individual, but plenary writing also occurred, often for modeling purposes. When coded for inquiry, results indicated that the teachers spent a large amount of time in the preparation and data phases of inquiry, but comparatively less in the discussion and communication phases. Only one of the teachers spent more time in the discussion phase than what was recommended in the teacher guides. Moreover, by combining the codes for learning modalities and science inquiry, we find that reading and writing activities were mainly included in the preparation and data phases. The focus on key science concepts was mostly in the preparation and discussion phase. These findings align with previous studies showing how school science often concerns preparing and doing, with less focus on summing up activities, debating, making inferences, and connecting theory and empirical data (e.g., Furtak & Alonzo, 2010; Newton, Driver, & Osborne, 1999; Ødegaard & Arnesen, 2010). The implications of these findings, however, are that teachers need more support to include activities that help students discuss and communicate their results and ideas. Thus, the findings also suggest that the Budding Science and Literacy teaching model—and professional development in science education—must focus particularly on the consolidating phases of inquiry.

5.2 Article II

Sørvik, Gard Ove, Blikstad-Balas, Marte & Ødegaard, Marianne (2015). ”Do books like these have authors?” New roles for text and new demands on students in integrated science-literacy instruction. *Science Education*, 99(1), 39-69.

This article investigates students' emerging literacy practices in the six integrated science-literacy classrooms. The study combines observational video data and interview data to examine students' encounters with and use of text in specific literacy events, along with their views and experiences related to science and science text in this setting. By doing so, we seek to answer calls on how texts are actually used by students in an integrated science-literacy context. The approach to researching literacy in school science classrooms is based on a sociocultural view of literacy, which involves understanding literacy as embedded in the social practices of the different discourse communities of which they are a part (Barton, 2007; Gee, 2008).

First, we identify 335 literacy events through video coding of approximately 30 hours of video data from the six classrooms in the Budding Science and Literacy study. In total, the duration of these literacy events constituted 53,5 % of the total video recordings; with the students' own writing (31,0%) and informational texts (11,9%) being the most dominant text types that these events were structured around. The most frequently occurring category of literacy events, however, was based on orienting texts (n=132, 2,9%), such as instructions written on blackboards or whiteboards or the teacher pointing to a specific concept on the concept wall. Most of these events lasted for less than a minute and mainly acted as guidance for the students, which help explain the high frequency and the limited amount of time spent on these types of texts. Second, analytic induction (Erickson, 2012) of the coded literacy events revealed how multiple literacies emerged in the six classrooms, which attended to markedly different purposes. On the one hand, students engaged in literacy practices that were typically "schooled", in the traditional sense, such as reading a definition from a concept wall or writing to document a task. On the other hand, students also incorporated informal elements from their everyday literacy practices as valuable resources in the dialogic process of inquiry. In the article, we refer to the former as *school-science-only* literacies, and the latter as *science-in-school* literacies. Whereas the school-science-only category, in most cases, acted as learning structures or typical classroom routines, science-in-school literacies were embedded in the students' inquiry process, which helped situate literacy in contexts that appeared to be meaningful and engaging to the students. Third, we analyzed focus group interviews with 33 students to uncover some of the students' own experiences and views of the integrated science-literacy instruction. Our data indicate that the implemented instruction created new literacy demands on the students that were not always clear to them. Hence, we argue that paying explicit attention to how science texts have both a sender and a receiver, and that they are written for a purpose, is of central importance to situating literacy in the context of school science.

Overall, this study indicates that purposefully embedding literacy in a science inquiry context allows students to go beyond the transmissive reading and writing activities that are common in school science. This requires that we build on students' vernacular or everyday literacy practices, identify what "counts" as literacy in the science classroom, and provide explicit attention to the representational and communicative aspects of science and school science, of which the genres and social languages of science and school science work to fulfill.

5.3 Article III

Sørvik, Gard Ove & Mork, Sonja M. (submitted, 07.12.2014). A social view of literacy for school science. Revisions required by *Nordic Studies in Science Education*, 02.02.2015. Original Manuscript.

In this article, we introduce what a social view of literacy means for science education. Traditionally, texts have been of little concern to most science teachers and educators (Hand et al., 2003; Norris & Phillips, 2003; Pearson et al., 2010; Wellington & Osborne, 2001), which is contrary to the view that students will need to become critical consumers of writing in and about science to actively participate and make informed decisions in a democratic society (Osborne, 2007). Hence, we build on sociocultural studies of literacy to show how a social view of literacy informs our understanding of literacy when the context is school science. We then draw on research related to the role of text in science education to outline what a social view of literacy implies for teachers' educational practice. The latter section is structured according to four main propositions for promoting literacy in science classrooms in accordance with a social view of literacy.

In the first part of the article, we use sociocultural perspectives to argue that literacy in school science is best understood as social practices embedded in cultural and ideological contexts. In this view, literacy becomes something people do in their everyday life, a social activity, which necessarily also involves people's values, talk, social relationships, attitudes and beliefs regarding text (Barton & Hamilton, 1998). Thus, a social view of literacy highlights how reading and writing are situated in particular situations at particular times for particular purposes, whether in or outside the school science classroom. Accordingly, this view of literacy can provide a suitable framework for considering how texts with scientific information function and are used across contexts that are relevant to science education. The most notable of these, we argue, include the daily lives of students and citizens, the school science classroom, and communities of practicing scientists.

In the second part, we rely on the perspectives presented in the first part to present four propositions that we suggest are key to promoting literacy in science classrooms in accordance with a social view of literacy; namely that: i) science texts are written for particular purposes and audiences, ii) school science literacy builds on students' informal literacy practices, iii) science reading and writing activities in school differ in their "authenticity", and iv) school science literacy is embedded in explicit instruction. These four propositions, which rely on research on the role of text in science education, are meant to illustrate what adopting a social view of literacy implies for science teachers and science educators in practice.

Finally, we discuss how a social view of literacy provides science education with the theoretical perspectives to examine the role of literacy in a transcending science subject (cf. Wickman et al., 2012). However, seeing literacy as a social practice also implies that there will always be multiple *school science literacies*—the sociocultural ways in which literacy occurs in science learning environments—related to different conceptualizations of science education and scientific literacy. Accordingly, we suggest that adopting a social view of literacy does not present us with a set of pre-determined literacy practices to promote in science classrooms, but with a means to reflect on how and why scientific information is used in various societal contexts that are important to our vision of scientific literacy.

5.4 Article IV

Andersson, Emilia & Sørvik, Gard Ove (2013). Reality Lost? Re-Use of Qualitative Data in Classroom Video Studies. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* 14(3), Art. 1, 1-25. Available from http://www.qualitative-research.net/index.php/fqs/article/view/1941

The fourth article draws on two illustrative case studies of video-based research in the educational sciences to make an argument for establishing more common practices when conducting classroom video studies. The aim of the article is to use these two cases to document the processes of 1) collecting and archiving video data in the *Budding Science and Literacy* research project and 2) performing secondary analysis on archived video data from the *PISA+* project.

A main characteristic of video data is that they have the potential to capture complex social phenomena that are open to a number of analytical and theoretical perspectives, even by secondary researchers not originally involved in the original data collection (Derry et al., 2010). Re-using archived qualitative data, however, has been heavily debated over the decade.

This debate has largely revolved around contextual and ethical issues concerning re-use, but little has been presented on actual researchers re-using archived data, or on the re-use of video data in particular. However, video data provide both new opportunities and new challenges as opposed to other types of qualitative data. Thus, the two illustrative case studies illustrate how these issues have been addressed from the perspective of the archivists and from the perspective of the secondary analyst. We show that addressing the methodological issues of re-use is not a matter that only concerns the secondary researchers; it necessarily involves the primary researchers as well. This implies that both primary and secondary video researchers should engage in developing more standardized ways of generating and archiving video data in classroom studies if we are to move toward the long-term goal of programmatic research in the field.

Based on these two cases, we argue that establishing more common practices for designing and conducting classroom video studies—a common thread in the *Budding Science and Literacy* and *PISA+*—provides an important ground for researchers in this line of research to fully benefit from the opportunities that new media avails, which may in turn contribute to more cumulative research from the classroom. For the video research communities, this could involve establishing ethical guidelines for re-use and sharing, standardized tools and procedures for generating data, agreed-upon analytical tools, and procedures for logging and archiving video data.

6 Discussion

The overarching aim of this thesis was to explore the literacies of school science in the context of integrated science-literacy instruction. The empirical studies included in this thesis shed light on this aim from two different perspectives. The first article (Article I) maps the time spent on different learning modalities and science inquiry phases in the six participating classrooms. The second article (Article II) explores the emerging literacy practices that students engage in from a sociocultural perspective on literacy. Both studies rely mainly on video data to answer the articles' respective research questions, but Article II also draws on interview data with students (n=33) and textual artifacts from the classrooms. The third article (Article III) builds on these and other studies to introduce what adopting a social view of literacy means for science teachers' educational practice. The last article in this thesis (Article IV) discusses the potential re-use of classroom video data and will serve as a point of departure in section 6.6, where some future directions for research in science education and video-based classroom research will be suggested.

6.1 School science literacies in integrated science-literacy instruction

The two empirical articles included in this thesis (Articles I and II) demonstrate how literacy is interwoven in the daily activities and inquiries of the six participating classrooms. What is common across the classrooms in this study is an emphasis on the beginning phases of students' inquiry and the presence of multiple literacies that attend to markedly different purposes in the classroom. In this section, I will elaborate on these two aspects from the empirical studies to discuss how literacy is embedded in the six classrooms in the Budding Science and Literacy study.

The first article provides an overview of the six Budding Science and Literacy classrooms. More specifically, it explores how different learning modalities (reading, writing, talking, doing) and science inquiry phases (preparation, data, discussion, communication) occur and co-occur in the six participating classrooms. For coding purposes, however, this study does not attempt to show how texts are used beyond plenary, individual or group "reading" or "writing". In other words, the codes do not allow us to consider if the students talk about a specific text in the discussion phase or if they use a figure or a poster when they orally communicate their findings (unless they are actively reading from that poster). Rather, this study reveals specific patterns in the students' inquiries, which provided a starting point for identifying challenges that teachers face when implementing science-literacy instruction. This was also one of the study's main findings; namely, that four of the six teachers considerably downplayed discussion activities in lieu of preparation and data activities (see Article I, figure 1). Reading and writing activities were also more dominant in the preparation and data phases. Thus, the teachers emphasized particular aspects of inquiry, and thereby also the particular ways in which literacy was embedded in these classrooms. For example, in Birgit's classroom, considerably more time was spent on discussing and communicating the students' results than in the other five classrooms (see Article I, figure 2).

Similarly, other studies have shown that inquiry-based science teaching depends on teachers' own preferences and ideas about scientific inquiry (Windschitl, 2004), but also that the role of literacy in integrated science-literacy instruction differs, even with teachers whom hold seemingly similar views about inquiry (Howes et al., 2009). In our study, the teachers were afforded detailed teacher guides, but there were still significant differences when the teacher guides were compared with the actual implementation. Findings like these emphasize the importance of reflecting on how certain literacy practices, or social practices in general, necessarily become more strongly encouraged in the classroom than others. In the article, we point to the possibility that the teachers in our study found it particularly challenging to engage their students in the consolidating phases of inquiry (discussion and communication) or that they perceived scientific inquiry as more about scientific procedures than about developing scientific explanations.

Article II attempts to further explore the literacies of the six participating classrooms by investigating how students in this context actually *use* text. Thus, this study goes beyond codes such as "reading" and "writing". Instead, literacy events were identified whenever the interaction in the classroom revolved around text. These events were then subjected to qualitative analysis in search of emerging patterns and themes. The inherent differences in the two coding approaches can be illustrated when the systematic coding results are compared. Even though two lessons were removed from the data material analyzed in Article II, the duration of coded literacy events from Article II exceed the results for coded reading and writing in Article I. In this way, the two articles can act complimentary to each other, because the first study explicates the interactional context in which reading and writing is embedded in these six classrooms in a different way than the second one.

In Article II, a central distinction that emerged across the six classrooms concerned literacies that were restricted or confined to the context of school science and literacies that trancended the mere context of school science. In the article, we refer to the former category as “school-science-only” and the latter category as “science-in-school”. These two categories distinguished themselves in the participating classrooms, from a sociocultural perspective on literacy, because of the markedly different contexts they related to. Whereas the school-science-only category included literacy practices that were distinctly “schooled” (like students reading a definition from a concept wall or documenting a completed task), the science-in-school category included literacy practices that incorporated students’ everyday ways with words (e.g., adding vivid colors and speech balloons to figures and diagrams or using popular culture texts as prior knowledge) in the dialogic process of school science inquiry. However, many of the “schooled” literacy events, which were based around the use of templates, instructional tasks written on blackboards and whiteboards, and concept walls, helped organize and structure the students’ activities. In their research, Knain, Bjønness and Kolstø (2010) refer to similar practices as support structures, which were important to advance and focus the students in their inquiries. In this sense, school-science-only literacies are also valuable in a school context, but they seem more likely to be meaningful to students in combination with other literacies that are relevant to contexts beyond the classroom.

Taken together, this thesis emphasizes how school science literacies are embedded in the social practices associated with school science. This is elaborated in Article III, in which we argue that a social view of literacy enables science educators to consider contexts that are particularly relevant to our vision of scientific literacy. From a social view of literacy, it also becomes apparent that the literacies of school science rarely transcends the context of school science, but are too often embedded in a transmissive pedagogy (Lyons, 2006). In this mode of science teaching, school science literacies are reduced to practices concerning copying scientific information from expert sources (e.g., Danielsson, 2010) or answering textbook questions (e.g., Driscoll et al., 1994). In contrast, the findings presented in this thesis illustrate how multiple literacies can emerge in an inquiry-based context in primary school science classrooms, which relate to contexts that are relevant and purposeful to students as participants in a school setting and in their daily lives.

6.2 Students' informal literacies as valuable resources for inquiry

"Can't we just get a picture? It's so much easier."

- John Olav, 3rd grade

Researchers that approach literacy from a sociocultural perspective tend to emphasize the differences between literacy in- and out-of-school, mainly because institutions like school have a greater influence on how literacy is generally perceived (Maybin, 2007). In Section 3.1, I described how these kinds of literacies are normally considered as dominant, formal, and academic. On the other hand, informal, everyday, and free-of-choice literacies are often less valued. However, Maybin (2007) cautions that a strict dichotomy easily conflates vernacular or informal literacies with out-of-school literacies. As I have discussed in the previous section, Article II reports a complex relationship of formal literacies and informal literacies in the participating classrooms, which further complicates such a dichotomy.

This was particularly evident in how the students relied on a number of informal or everyday literacy practices in the formal context of school science inquiry. The quote at the start of this section is a good example of how this occurred in one of the classrooms. In that particular event, John Olav suggested several times that the class should use Google Images to settle a dispute on whether or not a humming bird had four or two limbs (the students could not observe this from the video they had watched). Thus, it is John Olav who suggests using a text that is not necessarily valued in their classroom (i.e., Google Images). Eventually the teacher agreed and the class found evidence of humming birds having four limbs from observing pictures online. After this event, using Google Images as a source of data became a valued practice in this particular classroom, which was promoted by the teacher. For example, the class subsequently used Google Images to compare the tails of wolves and foxes. It is particularly interesting that it was a student who initiated the event, but that the teacher assigned value to it in the classroom by picking it up and promoting it later on. Similarly, students' informal literacies became valuable resources as they grappled with a new topic or discussed findings and ideas in the other classrooms. For example, students in Anna's classroom relied on movies and superheroes to make a mind-map for the concept of *force*, while students in Birgit's class referenced a Donald Duck comic book to discuss the function of a turning wheel. In most of the classrooms, the students also included vivid colors, speech balloons, and representations of themselves ("And, that's me!") in diagrams, figures, and posters.

Even though the presence of texts from the students' everyday lives and popular culture represents small amounts of time in the data material—and especially in comparison to longer and more prevalent events promoted by the teacher (i.e., reading informational texts or writing a comparative text)—these literacy events were important because the students were allowed to bear on their own references and backgrounds to advance their inquiries. Moje and colleagues (2004) use Bhabha's notion of "third space" to describe similar hybrid literacies, wherein both everyday and specialized academic language and texts are negotiated to develop new understandings. They especially highlight popular culture texts, because the students in their study relied on these texts as much as they did their own observations for making sense of scientific ideas and concepts. In a recent study, Mestad and Kolstø (2014) provide an interesting example of the importance of making connections between everyday and scientific language in the third space. In their study, the teachers started out by emphasizing theoretical knowledge and language to support the students in correctly interpreting their observations and applying theory during practical activities. According to Mestad and Kolstø (2014, p. 1065), however, "the students felt that the teacher expected them to speak the correct scientific language before they had developed the prerequisite understanding and language competence. Consequently, the students chose not to express their current understanding in their own words". On the other hand, when the teachers explicitly informed the students that they should use their own language, the students attempted to formulate their own emerging understanding that could later be used in a classroom discussion. This body of research (see also S. B. Heath, 1983; Olander & Ingerman, 2011; Varelas & Pappas, 2006) clearly demonstrates the importance of allowing students to build on their informal or everyday ways with oral and written language when moving towards the social language of science. The findings in Article II indicate that paying attention to these aspects might help situate school science literacy in inquiry-based contexts that are meaningful to students and provide them with a sense of ownership over the own science learning experiences.

6.3 What demands do integrated science-literacy instruction place on students and teachers when it comes to literacy?

Central to this thesis is a focus on how teachers and students can be supported in doing more meaningful reading and writing activities in school science. What are the challenges? Where is there a need for more support? For many of the students in this study, data from the focus group interviews indicated that the implemented instruction was accompanied by new literacy demands that were not always clear to them. In Ellinor and Ella's classrooms, for example, the students were asked to write a log after experimenting with various ingredients to make glue. However, the students did not appear to grasp the purpose or conventions for writing a scientific log, and much confusion arose as they started writing. In fact, most of the students started to copy what they had read in a science trade book in the first lesson. The students' confusion' became even clearer in the subsequent focus-group interviews, in which they mentioned the logs to our question about using their imagination in science. This is contrary to the purpose that scientific log writing usually fulfills, namely providing a factual presentation of a certain procedure:

> "Yeah, when we . . . when we had to write logs. I at least used a lot of imagination."
>
> \- Henrik, 3rd grade

A valuable concept to further discuss how the implemented instruction created different or new demands in this context is the notion of *didactical contract* (Brousseau, 1997). Originally developed to describe interaction in mathematics classrooms, a didactical contract refers to the often unspoken and implicit agreement between teacher and students of how particular learning situations are carried out in the classroom, where each participant has her/his expectations and obligations associated with that situation. Thus, Brousseau and Warfield (2014, p. 1) define the term, in the broad sense, as "an interpretation of the set of these expectations and obligations, be they compatible, explicit, and agreed to or not". In light of the present study's findings, it raises the question of what was expected behavior for teaching and learning science in these particular classrooms. As it appears to me, many of the students had expectations of more traditional science teaching, which did not require them to reflect on many of the issues concerning science texts that were raised during the implementation. Thus, in instances when the teachers did not explicitly address these aspects, a new contract would have to be negotiated implicitly between teacher and students. This could very likely be the case with the aforementioned students' confusion about writing scientific logs. When neither Emma nor Ellinor explicitly addressed how and why to write a scientific log to begin with, the students in these two classes had to decide what to do based on prior expectations and practices. Another example was found in Cecilia's class, where Cecilia asked her students to discuss why the author of a science trade book had used images and captions in the book. In this case, however, the mismatch between Cecilia's expectations and at least one of the students became clear when Eivind expressed how he had clearly not even thought about these types of text (i.e., school science texts) in terms of having an author ("Do books like these have authors?). A possible alternative could perhaps have been to acknowledge Eivind's question as a common misunderstanding about textbooks, talk with the class about who they think the senders and receivers of school textbooks are, and discuss what a science textbook is, thereby establishing a new and compatible expectations for talking about science texts in class.

In contrast, the use of Google Images in Cecilia's class is an example when Cecilia explicitly addressed how they had started to use the search engine to collect data on the characteristics of several animals after John Olav initially suggested it. It could thus be said that the students and Cecilia eventually came to agree on a new didactical contract, in which using Google Images was considered a valued practice in the classroom to collect data of this kind.

As mentioned in Section 6.1, a specific challenge the teachers faced when implementing integrated science-literacy instruction was identified in Article I. The video analysis of learning modalities and inquiry phases showed that most of the teachers spent a lot of time on preparation and data, but comparably less on discussion and communication. This was also the case for reading and writing activities. In line with the study by Howes et al. (2009), findings such as these point to the fact that teacher knowledge about literacy teaching in science is key to supporting students in engaging with science texts in more authentic ways. Pearson, Moje and Greenleaf (2010, p. 462) point especially to the need to move beyond what Street (1984) calls an autonomous model of literacy, which has traditionally been prevalent in many science classrooms (Norris & Phillips, 2003):

> Many science teachers hold misconceptions, or at the very least, limited conceptions, of literacy teaching and learning; they tend to think of reading and writing as basic and universal skills that are developed in elementary or middle school or down the hall in the English

> department. They do not expect to teach science reading and writing to students, yet they are confronted with students who do not comprehend science texts, their specialized language, or the many ways science ideas are conveyed through print, diagrams, images, models, graphs, and tables.

Hopefully, the framework presented in Article III might provide a first step for many science teachers and educators to consider how a social view of literacy (what Street calls an ideological model) influences how we think about language and literacy in an educational context. This shift in focus seems particularly important when the evaluations of the current Norwegian national curriculum indicate that the introduction of basic skills in all subjects has not led to notable changes in the classroom (Ottesen & Møller, 2010). Similar to the review by Pearson et al. (2010), the Norwegian evaluations show that it is reading that has received the most attention of the basic skills in primary school, but largely in language arts lessons (Hertzberg, 2010). These studies add to the conclusion that literacy should be a prioritized aspect when teaching about inquiry-based science and scientific practices in science teacher education programs and in the professional development of science teachers if we are to take the demands of becoming scientifically literate in today's society seriously.

6.4 Limitations of the present study

Before this extended abstract draws to an end, there is a need to make clear some of the limitations of the study. First, the research is based upon a small sample of six primary school science classrooms in the greater Oslo area, with teachers who attended a particular professional development course on integrated science-literacy instruction. Thus, the findings should not be generalized beyond analytical generalization (see Section 4.5.3). Rather, the studies' findings serve to illustrate how reading and writing can function in the context of school science inquiry in primary school, and provide grounds for comparison in similar situations and contexts. Furthermore, because the thesis's empirical findings are concerned with literacies in primary school science classrooms, many of the documented ways in which literacy was used in these classrooms was also embedded in social practices that we often associate with primary school. For example, we found mostly plenary and paired reading (Article I), few instances of Internet use or multiple information sources (Article II), and no writing of individual lab reports. At secondary school levels, however, recent studies of science classrooms have documented a wider use of learning resources and texts (both digital and analogue) than what have traditionally been the case (Furberg, Dolonen, Engeness, & Jessen, 2014), as well as the use of multiple texts and informational sources, in combination with the textbook, when dealing with complex socio-scientific issues (Knain, Byhring, & Nordby, 2014). The lab report is also a central practice at higher grade-levels than those explored in this study (Af Geijerstam, 2006; Knain, 2005b).

In retrospect, I would also have liked to go further into detail around specific texts and specific literacy events during the focus group interviews with the students. Failing to have done so has to do with the fact that the research focus has changed over time along with repeated viewings and analyses of the video data. According to Erickson (2012), this is often a necessary step in a working qualitative analysis if we are to find out something we could not have known prior to our research process. A different solution might have been to perform video-stimulated interviews with the students wearing the head-mounted cameras, but because of the students' young age, it was decided to prioritize group interviews, in which they would most likely be more at ease, and to perform these interviews immediately after the implemented instruction. Because the student interviews also had to reflect the objectives of the overarching research project, it would have been difficult to decide which video segments were the most relevant to use in interviews. In a smaller study, however, this would be particularly interesting in order to gain even more information about the students' personal decisions and beliefs about science and science texts and how these relate to specific literacy events.

6.5 Future directions

With some of the limitations of the present study outlined in the previous section, we are able to turn to the implications that this study might offer for future research on school science literacy and for educational practice.

In Article IV, it is argued that more common practices for conducting classroom video studies will help contribute to more cumulative research in the field of educational research. In light of the present study, the theoretical perspectives taken imply that literacy must be studied in the context in which it occurs. Thus, classroom video studies across various school science contexts (e.g., grade-levels, local contexts, interventions etc.) will be valuable to further understand how literacy influences and is influenced by various science teaching and learning contexts. A common practice along this line of research might center on the use of multiple video cameras, including head-mounted video cameras, and systematic coding of video data to help determine how the different contexts can be analytically compared. In turn, with the use of multiple video data sources and rigorous contextual data, other researchers might investigate the same data material with new aims and from different theoretical perspectives—if the ethical challenges associated with re-use of personally sensitive data, such as video recordings, are properly dealt with by both the primary and the secondary researchers.

Moreover, in a time when new media and Web 2.0 are constantly altering the ways in which we use language and information (Barton & Lee, 2013), it seems particularly important to explore how digital media and online environments influence school science practices. For example, people interact and share information in new ways through blogs, video sharing platforms, social media etc., you can comment and make changes to texts instead of just reading, and intertextuality, multimodality, and interactivity have become central characteristics. This line of inquiry could include research into actual uses of scientific information in society at large, as well as within the classroom, for instance with regards to how online communication and texts influence our engagement with science and complex socio-scientific issues on a daily basis. In a transcending science subject for scientific literacy (Wickman et al., 2012), this will be an important aspect to address for researchers if science education is to prepare students for making informed decisions in their own lives. In this regard, literacy studies can provide an interesting path for researching how such science-related literacies emerge across social and cultural contexts in everyday life. In turn, such studies might help science educators to further promote and acknowledge new literacy practices in the science classroom that are becoming increasingly important to students outside the classroom.

Finally, it feels appropriate to end this thesis with a focus on what the research presented here might imply for educational practice in school science, because this has been an important issue to me personally throughout the period spent working on this project. First of all, this thesis emphasizes a view of literacy as situated social practices, not as a set of universal skills that can be applied independent of the context in which they are situated (i.e., the ability to read and write), which has long been the prevalent view among science teachers and educators (Norris & Phillips, 2003; Pearson et al., 2010; see also Section 6.3). In a social view of literacy, reading and writing cannot be seen as additional elements to inquiry-based science education (or to scientific inquiry), but must be regarded as constitutive of its practice (Gee, 2004; Osborne, 2002). Not only does this challenge how reading and writing in school science are often reduced to copying scientific information (e.g., Lyons, 2006; Osborne & Collins, 2001), it also questions why experimentation tends to be taught in isolation from the specialized ways of reading, writing, and talking science in many inquiry-based approaches to science education (National Research Council, 2012). In this sense, the findings of the empirical studies provide science teachers with illustrative examples of how literacy is interwoven in the practices of six specific inquiry-based science classrooms, and how multiple school science literacies can emerge when teachers explicitly emphasize disciplinary literacy practices during inquiry-based science instruction at primary school levels. Furthermore, the third article attempts to develop a framework for science educators and teachers to consider how science reading and writing in school can relate to relevant contexts beyond the context of formal schooling from a sociocultural perspective on literacy. Hopefully, this thesis will help shed light on how literacy is inextricably linked to the social practices of science classrooms, and provide science teachers with some tools and examples to support their students in reading and writing more and more meaningful texts in contexts that are meaningful and relevant to their science education and to their daily lives.

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Appendices

Appendix I: Informed consent forms for teachers and students, and letter of information for school principal

Appendix II: Interview guide for focus group interviews with students in the Budding Science and Literacy project

Appendix III: Coding scheme for the Budding Science and Literacy project

Appendix I: Informed consent forms for teachers and students, and letter of information for school principal [translated by the Budding Science and Literacy research group].

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To teacher at XXXX school Oslo, XXXX 2010

The research project «Budding science and literacy»
Budding science and literacy is a project that aims to develop a teaching program that integrates inquiry-based science and literacy and facilitates teaching and learning for Norwegian teachers and students. The research project is carried out by the Norwegian Centre for Science Education, University of Oslo, and is funded by the Norwegian Research Council. We are pleased that you have volunteered to contribute in the project.

In the project, researchers and teachers will collaborate to develop and improve science teaching and learning. This involves following you and students when planning, doing, and discussing science activities. We will video- and audiotape the lessons, and researchers will be present during instruction. Furthermore, there might be video recorded interviews with you and some of the students after the lessons. This study follows various teachers and students over time, and the data material might be used in later studies. Only researchers who are connected to the project and familiar with this agreement have access to the material. The researchers' presence in the classroom will take place as agreed with you. We will visit the school several times throughout the school year. Scheduled time for data collection for this project is fall 2010-spring 2012.

Registration, storing and reporting of data will be according to the guidelines of the law of personal information storage. The collected information will be treated confidentially, and only by persons employed at this project. The results from this investigation will be presented in a way that makes it impossible to trace the information back to the participating students, teachers, class or school. Some video recordings may be presented at research conferences and for educational purposes, in those cases; participants will be asked for additional consent. Recordings will never be available on the Internet. The project is registered in the Data Protection Official for Research, Norwegian Social Science Data Services (NSD).

Participation is voluntarily, and it is possible to withdraw at any time without having to provide an explanation. If someone withdraws, information regarding this person will be anonymized as soon as possible. The recordings will be deleted and all information will be made anonymous by the end of the project in December 2030.

We ask for your consent to collect audio- and video recordings and to perform interviews. Agreement of participation requires that you sign this letter.

Best regards

Anders Isnes	Marianne Ødegaard	Sonja Mork
Leader	Project leader	Associate professor

□ I give my approval to take part in the research project. I am aware that this involves being audio- and videotaped.

Date, place Teacher's name and signature

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To students at XXXX school Oslo, XXXX 2010

Invitation to participate in the research project «Budding science and literacy»
Budding science and literacy is a project that aims to develop teaching materials in science in which practical activities is combined with reading, writing and oral competencies. The research project is carried out by the Norwegian Centre for Science Education, University of Oslo, and is funded by the Norwegian Research Council. We have invited teachers at your school to contribute and help us increase our knowledge on successful teaching and learning in science subjects.

In the project, researchers and teachers will collaborate to develop and improve science teaching and learning. This involves following teachers and students when planning, doing, and discussing science activities. We will video- and audiotape the lessons, and researchers will be present during instruction. There will also be video recorded interviews with teachers and students after the lessons. This study follows various teachers and students over time, and the data material might be used in later studies. Only researchers who are connected to the project and familiar with this agreement have access to the material. The researchers' presence in the classroom will take place in agreement with the teacher. We will visit the school several times throughout the school year.

Registration, storing and reporting of data follow the guidelines of the law of personal information storage. The collected information will be treated confidentially, and only by persons employed at this project. The results from this investigation will be presented in a way that makes it impossible to trace the information back to the persons that participate in the research. Some video recordings may be presented at research conferences and for educational purposes, in those cases; participants will be asked for additional consent. Recordings will never be available on the Internet. The project is registered in the Data Protection Official for Research, Norwegian Social Science Data Services (NSD).

Participation is voluntarily, and it is possible to withdraw at any time without having to provide an explanation. If someone withdraws, information regarding this person will be anonymized as soon as possible. The recordings will be deleted and all information will be made anonymous by the end of the project in December 2030.

We ask for your consent to collect audio- and video recordings and to perform interviews. Agreement of participation requires that both the student and a parent/caretaker sign this letter.

Best regards

Anders Isnes	Marianne Ødegaard	Sonja Mork
Leader	Project leader	Associate professor

□ I give my approval to take part in the research project. I am aware that this involves being audio- and videotaped.

Student name and signature Parent/caretaker signature

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To the principal at XXXX school

The research project «Budding science and literacy»
Budding science and literacy is a project that aims to develop a teaching program that integrates inquiry-based science and literacy and facilitates teaching and learning for Norwegian teachers and students. The research project is carried out by the Norwegian Centre for Science Education, University of Oslo, and is funded by the Norwegian Research Council. We have been introduced to the specific teachers at your school through the professional development course "Integrating science and literacy" provided by the Norwegian Centre for Science Education/University of Oslo, we have been introduced We are pleased that the teachers have volunteered to contribute in the project.

The research project is part of a longitudinal study over 7 years and involves measures towards teachers and students in science education. The project is funded by the Norwegian Research Council's «Programme for Norwegian Educational Research towards 2020».

The project can be described as an intervention study in which researchers and teachers collaborate to develop and improve science teaching and learning. We consider the professional development course as the intervention. This involves following the teacher and students when planning, doing, and discussing inquiry-based science activities. As part of this work, we will video- and audiotape the lessons, and researchers will be present during instruction. Furthermore, there might be video recorded interviews with the teacher and some of the students after the lessons.

Our presence in the classroom will take place in agreement with the teacher. It is preferable to visit the school several times throughout the school year. Scheduled time for data collection for this project is fall 2010-spring 2012.

Registration, storing and reporting of data will be according to the guidelines of the law of personal information storage. The collected information will be treated confidentially, and only by persons employed at this project. The results from this investigation will be presented in a way that makes it impossible to trace the information back to the participating students, teachers, class or school. Some video recordings may be presented at research conferences and for educational purposes, in those cases; participants will be asked for additional consent. Recordings will never be available on the Internet. The project is registered in the Data Protection Official for Research, Norwegian Social Science Data Services (NSD).

We want to emphasize that the quality of the study depends on teacher and students allowing researchers access to the classroom activities. Our intention is that the teachers, students and school will find this collaboration interesting, informative and useful for further development.

Best regards

Anders Isnes	Marianne Ødegaard	Sonja Mork
Leader	Project leader	Associate professor

Appendix II: Interview guide for focus group interviews with students in the Budding Science and Literacy project [my translation].

Interview guide for focus group interviews with students in the Budding Science and Literacy project

Introduction:

Now we're going to talk about the science lesson(s) you have just had *(provide additional information if needed)*. We are curious to know what you think about the lesson. There are no right or wrong answers when we talk and we will not talk to your teacher about what each of you say here.

Introductory question related to a specific artifact from the lesson:

1. This (*hold up text or practical equipment*) is a *(name of artifact)* from your science lesson. We wonder how you experienced this lesson. Could each of you tell us a bit or show us about what you did? *(Provide additional information about the lesson if the students have a hard time remembering.)*

Probing questions 1 (Learning):

2. What is this *(hold up artifact)*?
3. Why do you think that you used this in class today?
4. What did you learn from doing that?
5. Is this something you like to do?
6. When do you feel like you're learning the most in science?
7. What does it really mean to learn?
8. Did you explore anything today?
9. How does the work you do at school resemble what scientists do?

(Provide examples or specifics related to the topic at hand if needed. The interviewer must have acquired insights into the different ways to understand the subject matter that was taught in the lessons)

Probing questions 2 (Concepts and argumentation):

10. Did you learn any new words today?

11. What words did you learn?
12. What do they mean?
13. What made you understand those words?
14. Do you think that there are many difficult words in science? *(e.g., observation or conclusion)*.
15. Do you talk a lot in your science lessons?
16. How do you agree on something when you talk in groups?

(If the students have not mentioned specific key concepts from the lesson related to inquiry and argumentation, ask the students about them at this point)

17. We have a concept chart for that word here *(i.e., a key concept from the lesson)*. Could you fill it out together? *(Ask the students to think aloud while filling out the chart)*

Probing questions 3 (Literacy):

18. We're also curious to know what you think about the texts you read today? They are brand new in Norway, and few students have read them. *(Present a copy of a Seeds/Roots trade book if the students used them.)*
19. Why do you think that you read this text in class today?
20. Is there any connection between this text and the other things you did in the lesson?
21. How did you like to read these texts?
22. Are there any differences between these texts and your regular science textbook?
23. Do you read science texts in the same ways that you read other types of text? If not, what is different?

Probing questions 4 (Imagination and creativity):

24. Did you use your imagination in class today? *(If no, ask about a specific episode.)*
25. What did you use it for?
26. How do you use your imagination to learn science?

Appendix III: Coding scheme for the Budding Science and Literacy project

BUDDING SCIENCE AND LITERACY

A CLASSROOM STUDY ON INQUIRY-BASED SCIENCE AND LITERACY

Categories for video analysis of science lessons

by Marianne Ødegaard, Sonja M. Mork, Berit Haug & Gard Ove Sørvik.

Oslo, 2012.

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BUDDING SCIENCE AND LITERACY
Do it! Talk it! Read it! Write it!

1 Coding Scheme: Activity Type

Activity Type

- **Oral activities**
  - Plenary
  - Group or pair talk
  - Student presentation
  - Inner speech
- **Reading activities**
  - Reading aloud
  - Group reading
  - Paired reading
  - Individual reading
- **Writing activities**
  - Shared writing
  - Group writing
  - Individual writing
  - Drawing
- **Practical activities**
  - Whole-class doing
  - Group or pair doing
  - Individual doing

BUDDING SCIENCE AND LITERACY

Do it! Talk it! Read it! Write it!

Table 1. Activity Type Coding Scheme - Budding Science and Literacy

Oral activities	Description of code
Plenary	Teacher-led whole-class talk
Group or pair talk	Students are asked to talk in groups or in pairs about something subject-specific.
Student presentation	Students present their own work.
Inner speech	Teacher asks students to reflect on something or think about something.
Reading activities	
Reading aloud	Reading aloud in classroom by teacher or student, or choral reading.
Group reading	Students read in groups.
Paired reading	Students read in pairs, for example by reading every other line aloud to each other.
Individual reading	Students read silently.
Writing activities	
Shared writing	Teacher and students collaboratively compose a piece of writing. The code also covers modelled writing by the teacher.
Group writing	Students collaboratively compose a piece of writing.
Individual writing	Students individually compose a piece of text.
Drawing	Students make charts, figures, diagrams etc.
Practical activities	
Whole-class doing	Teacher and students do practical work as a part of the whole-class setting. This may involve a teacher demonstration or the teacher and students working together on a larger experiment.
Group or pair doing	Students do practical work in groups or in pairs.
Individual doing	Students do practical work individually.

2 Coding Scheme: Science Inquiry

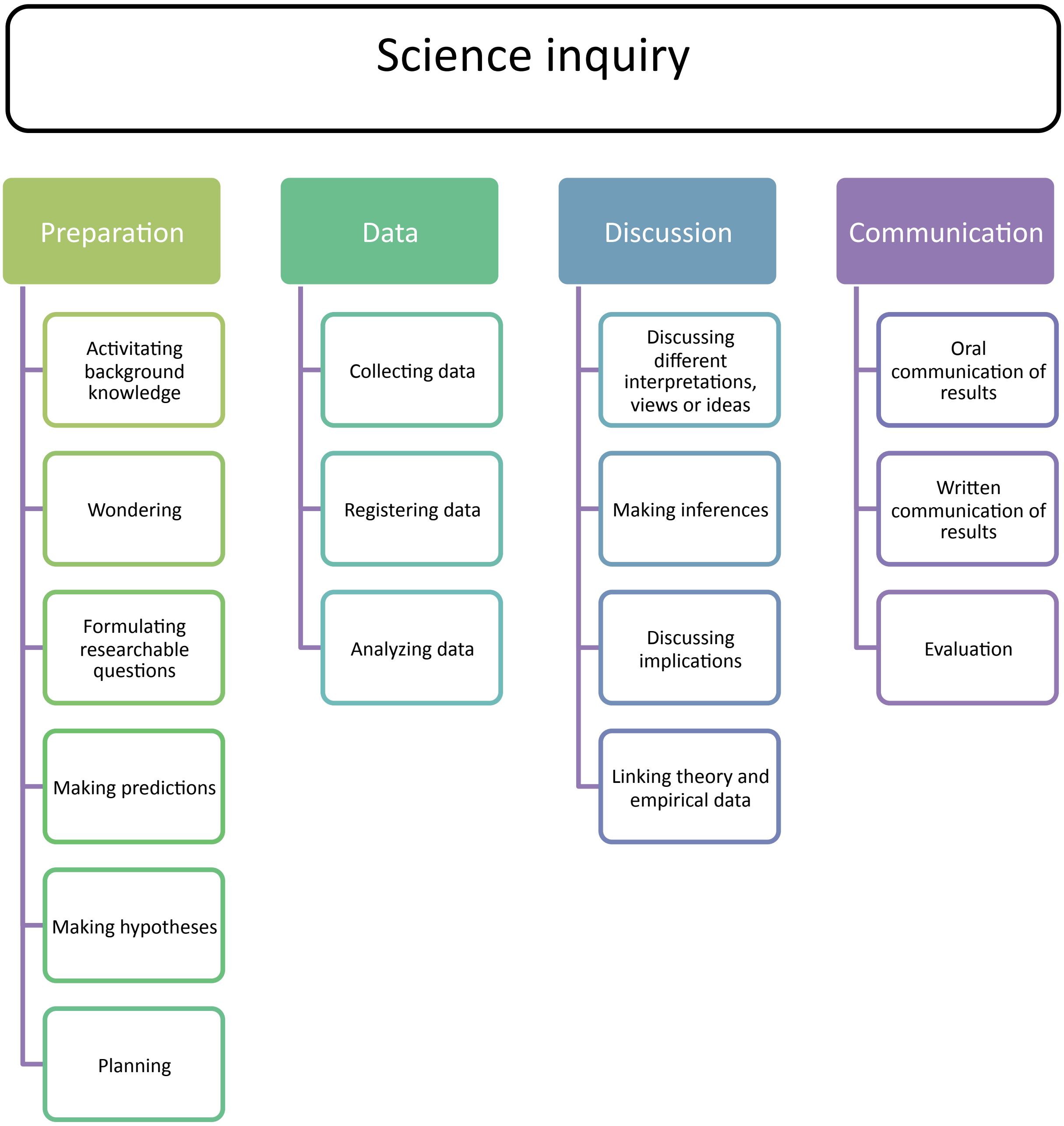

Figure 2. Overview of Science Inquiry Coding Scheme - Budding Science and Literacy

Table 2. Science Inquiry Coding Scheme - Budding Science and Literacy

Preparation	Description of code	Teacher utterances that might initiate the code
Activating background knowledge	Teacher-initiated activities, in which the teacher makes links to previous science lessons, everyday experiences or students' prior knowledge, or enables the students to do so.	"Do you remember when we…?" "How many senses do we have?"
Wondering	The teacher initiates an activity to cause wonderment. For example by showing the students a cherry pitter and asking them "What do you think this is used for?"	"How can you separate the blue balls from the yellow balls?" "What do you think this is?"
Formulating researchable questions	The students (or in co-operation with teacher) formulate researchable questions.	"Is this something you want to find out about?" "What can we find about about animals by watching a video? Try to make your own questions."
Making predictions	The students make a prediction.	Which of these types of glue will be the most effective?
Making hypotheses	The students explicitly make a hypothesis—a tentative explanation that can be tested with further investigation.	"Why do you think that?" «Write down why you think that this glue is the strongest."
Planning	The students (or in co-operation with teacher) plan how they are going to investigate something.	"Make a plan for how you are going to sort the different ball sizes."
Data		
Collecting data	The students (or in co-operation with teacher) collect data through firsthand or secondhand investigations. They make observations, do practical activities, or gather data from text.	"Use the picture of page 4 to make observations on how the sea turtle moves" "Begin testing out your system for sorting balls of different sizes"
Registering data	The students (or in co-operation with teacher) review or register data from their inquiry.	"What did you observe? " "Write down your observations"
Analyzing data	The students (or in co-operation with teacher) work with and organize data by categorization.	"Which observations could you make for all the animals you observed?"

Discussion		
Discussing different interpretations, views or ideas	The students (or in co-operation with teacher) discuss different interpretations of the data they have collected or analyzed. The students discuss different views or exchange ideas.	"What is the structure of this wheel?"
Making inferences	The students (or in co-operation with teacher) make inferences based on data/evidence.	"What can this tell you about its function?" "What can you say about these two animals based on the observations we've made?"
Discussing implications	The students discuss implications of their findings, or of their different interpretations. They come up with new questions as a result of their inquiry.	"Would a bicycle wheel without its spokes work?" "But what if…?"
Linking theory and practice	The students link findings from their inquiry to theoretical perspectives. This may include scientific laws and theories, published research results, or information from their textbook or other informational science texts.	"What is the function of the tube in the system you have made?"
Communication		
Oral communication of results	The students communicate their findings orally to other students in the class or another recipient. Results are here taken to include both process and product of the students' inquiry.	"Present the system you've made and how you thought of making it"
Written communication of results	The students communicate their findings through text. There is a clear aim for writing and a viable reader in mind.	"You are now going to communicate your findings to someone who has not been working with this topic the way you have" "Make a brochure that shows…"
Evaluation	The students evaluate their investigation and results. Could anything be done in a different way? Did they face any obstacles along the way? What effort did they put into the work? In which ways did they work like scientists? Evaluation may be both oral or in writing.	"Was there any challenges along the way?" "Why did you choose to do this instead of that?" "How does this compare to how scientists work?"

3 Additional codes for NOS and key concepts

Table 3. Code description for the code Nature of Science (NOS).

Nature of Science	Description of code	Teacher utterances that might initiate the code
	The code is used every time the teacher or the students makes reference to working like scientists or to "the" Nature of Science (NOS).	"How do scientists work? "

Table 1. Code description for the code Key Concepts.

Key Concepts	Description of code	Teacher utterances that might initiate the code
	The code is used every time the teacher or the students explicitly talk about the meaning of a concept or about how words and concepts are used.	"Observation means using all of your senses"

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PART II

ARTICLES

ARTICLE I

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Routledge
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Challenges and Support When Teaching Science Through an Integrated Inquiry and Literacy Approach

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In the Budding Science and Literacy project, we explored how working with an integrated inquiry-based science and literacy approach may challenge and support the teaching and learning of science at the classroom level. By studying the inter-relationship between multiple learning modalities and phases of inquiry, we wished to illuminate possible dynamics between science inquiry and literacy in an integrated science approach. Six teachers and their students were recruited from a professional development course for the current classroom study. The teachers were to try out the Budding Science teaching model. This paper presents an overall video analysis of our material demonstrating variations and patterns of inquiry-based science and literacy activities. Our analysis revealed that multiple learning modalities (read it, write it, do it, and talk it) are used in the integrated approach; oral activities dominate. The inquiry phases shifted throughout the students' investigations, but the consolidating phases of discussion and communication were given less space. The data phase of inquiry seems essential as a driving force for engaging in science learning in consolidating situations. The multiple learning modalities were integrated in all inquiry phases, but to a greater extent in preparation and data. Our results indicate that literacy activities embedded in science inquiry provide support for teaching and learning science; however, the greatest challenge for teachers is to find the time and courage to exploit the discussion and communication phases to consolidate the students' conceptual learning.

Keywords: *Inquiry-based science; Literacy; Video analysis; Multiple learning modalities*

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Introduction

Inquiry and literacy are important elements of science education. We wanted to explore how an integrated inquiry-based science and literacy approach may challenge and support the teaching and learning of science in six Norwegian primary school classrooms. Our understanding of inquiry is concurrent with Crawford's (in press) definition that

> teaching science as inquiry involves engaging students in using critical thinking skills, that includes asking questions, designing and carrying out investigations, interpreting data as evidence, creating arguments, building models, and communicating findings, in the pursuit of deepening their understanding by using logic and evidence about the natural world.

We consider literacy necessary to engage in science inquiry and acknowledge that literacy, in the fundamental and derived senses (Norris & Phillips, 2003), is a crucial part of scientific literacy. The fundamental sense is based on the essential role of text in science and involves reading and writing and being fluid in the discourse patterns and communication systems of science. The derived sense is taken from the fundamental sense and involves being knowledgeable and educated in science and being able to take a critical stance on information.

Inquiry and literacy have a twofold role of providing structures that support science content learning as well as being important areas of content knowledge of the science curriculum (Knain & Kolstø, 2011; Norris & Phillips, 2003; Wellington & Osborne, 2001). Pearson, Moje, and Greenleaf (2010) claimed that science and literacy are each in the service of the other, and that a curriculum based on the two will give synergy effects. Science learning benefits from embedded literacy activities, since literacy learning benefits from being embedded within science inquiry. However, there have been calls for more research in order to understand the challenges teachers encounter in the classroom when they integrate science and literacy (Howes, Lim, & Campos, 2009). Accordingly, there is also a need for research on how teachers' practice can be supported to successfully integrate inquiry-based science teaching and literacy (Hand et al., 2003; Howes et al., 2009; Pearson et al., 2010). In this article, we address two main research questions: (1) What challenges do primary teachers encounter in classrooms when the teachers use an integrated inquiry-based science and literacy approach? (2) What conclusions can be drawn from such results regarding the support teachers may need to integrate this approach more successfully? The questions are investigated through video-based observation of six primary school classrooms.

Norwegian Context

In Norway, there were two prominent changes in the 2006 national curriculum reform (Ministry of Education and Research, 2006). First, inquiry was emphasized in grades 1–11 through the introduction of a main subject area of inquiry (named the Budding Scientist). This included a focus on the processes and nature of science. Second, a new cross-curricular demand for integrating subject literacies, denoted as basic skills, in all subjects (reading, writing, arithmetic, oral, and digital competence) was introduced. Thus, the Norwegian national science curriculum facilitates synergy effects between science inquiry and literacy. However, research conducted on the curriculum implementation showed that the demand to focus on basic skills does not seem to be understood and thus is not perceived as meaningful by teachers (Møller, Prøitz, & Aasen, 2009). The researchers claimed that curriculum reform has not led to notable changes at the school level. Based on this research, the Ministry of Education and Research has now revised the national curriculum (Ministry of Education and Research, 2006/2013) to emphasize literacy as an aspect of scientific inquiry (Mork, 2013).

Motivated by the national curriculum reform in 2006, we developed a teaching model, Budding Science and Literacy (Ødegaard, Frøyland, & Mork, 2009), inspired by the Seeds of Science/Roots of Reading[1] (Seeds/Roots) teaching program (Barber et al., 2007). Similar to the Seeds/Roots program, Budding Science and Literacy focuses on systematic use of multiple learning modalities (reading, writing, talking, and doing) when enacting inquiry-based science. As part of the curriculum development, primary school teachers were invited to participate in a professional development course that focused on inquiry-based science and literacy. With our support, the participating teachers tried out and adapted teaching materials from the Seeds/Roots units in their own science classrooms. Six teachers from the professional development course volunteered for the present research project.

Research on Science Literacy Integration

Over the past 20 years, a research agenda has emerged in science education and literacy research communities to integrate language and literacy instruction in the context of science inquiry (Hand et al., 2003; Pearson et al., 2010; Yore et al., 2004). The long-standing research program Concept-Oriented Reading Instruction (CORI) was one of the first research initiatives to promote reading engagement through content-area learning in grades 3 and 5 (Guthrie et al., 1996; Guthrie, Wigfield, & Perencevich, 2004). The CORI framework emphasized the role of science and science inquiry as a setting to provide students with various types of interaction with a topic that facilitates reading (Barbosa & Alexander, 2004). Results from small-scale CORI studies showed positive outcomes for science concept learning, reading comprehension, reading strategy use, and reading motivation (Guthrie et al., 2004).

Palincsar and Magnusson (2001) developed the Guided Inquiry Supporting Multiple Literacies research program. In this program, two forms of investigation were combined to support teachers' and students' participation in science inquiry: firsthand investigations (hands-on) and secondhand investigation (consulting the text to learn from others' interpretations). The researchers designed 'the scientist's notebook' genre, which models a scientist interpreting data and making inferences based on evidence, inviting students to engage in the interpretation along with the scientist in the text. In a quasi-experimental study, Palincsar and Magnusson (2001) found that students with notebook-based instruction learned more than the comparison group that used more traditional text. Classroom observations further showed that the classroom talk reflected the inquiry process when the text was used.

More recently, Cervetti, Barber, Dorph, Pearson, and Goldschmidt (2012) investigated the effects of an integrated science literacy approach compared to content-comparable science-only teaching. The science and literacy approach used stems from the Seeds/Roots teaching program that has inspired the development of the teaching model used in our study. Ninety-four fourth-grade teachers participated in Cervetti et al.'s (2012) study, and they reported that the students in the integrated science literacy group made significantly greater gains in science understanding, science vocabulary, and science writing.

These studies together with several other studies on science and literacy integration (Fang & Wei, 2010; Romance & Vitale, 2012) have shown increased gains in student learning in science and literacy. A suggested explanation is that when science content is addressed through a combination of inquiry and literacy activities, students learn how to read, write, and talk science simultaneously since these literacy activities support the acquisition of science concepts and inquiry skills (Cervetti, Pearson, Bravo, & Barber, 2006; Cervetti et al., 2012; Hand et al., 2003; Norris & Phillips, 2003).

However, few studies have examined what science and literacy integration actually looks like in the classroom. Howes et al. (2009) conducted a classroom study in which they provided detailed descriptions of how three primary school teachers linked science and literacy. The researchers found that in some cases literacy learning was favored over science learning. This led the researchers to conclude that not all forms of integration equally support students' engagement in science inquiry. In light of these findings, Howes et al. (2009) called for further research 'to understand more clearly what challenges teachers' encounter in employing science–literacy integration and how we can support teachers to practice such integration successfully in their inquiry science teaching' (p. 214).

The present study aimed to answer this call by mapping time spent on reading, writing, talking, and hands-on activities throughout different phases of inquiry in six primary school classrooms. This study will contribute information on the variation and patterns of multiple learning modalities and phases of inquiry and help illuminate areas of instruction where integrating science literacy is challenging for teachers and requires support.

Theoretical Background

In the following, we present theoretical perspectives on science inquiry and language and literacy in science central to our analyses. Our analytical framework, presented in the 'Methods' section, builds on these perspectives.

Science Inquiry

Many national reform efforts and policy documents worldwide stress that inquiry should be a guiding principle for science education (Abd-El-Khalick et al., 2004;

Millar & Osborne, 1998; Ministry of Education and Research, 2006/2013; National Research Council, 1996; Rocard et al., 2007). Calls for students to engage in science inquiry can be traced back to Dewey (1910), who advocated science learning through extended experiences with authentic problems. In addition, a recent review of research trends in science education from 2003 to 2012 (Lin, Lin, & Tsai, 2013) indicated that scientific inquiry has become the influential research concentration of science education researchers. An understanding of scientific inquiry and the nature of science is fundamental to the development of scientific knowledge.

In the literature, three uses of inquiry in classrooms are usually described: (1) a set of skills to be learned by students (how to do science), (2) an understanding of the processes of science (the nature of scientific inquiry), and (3) a pedagogical strategy in which students learn science by doing science (Gyllenpalm, Wickman, & Holmgren, 2010; Lederman, 2006). There is no consensus regarding how inquiry is related to science teaching and learning. The difficulties in defining inquiry science have led to debate on the merits of inquiry-based science education (Anderson, 2007; Hmelo-Silver, Duncan, & Chinn, 2007; Kirschner, Sweller, & Clark, 2006). At times, inquiry science has been grouped with problem-based learning and discovery learning as minimally guided instructional approaches. However, there is strong agreement that the role of the teacher in teaching science as inquiry is central to support students in making sense of data and scaffold their personal understandings of scientific knowledge (Crawford, 2000). In the present study, science inquiry implies that students search for evidence to support their ideas and engage in critical and logical thinking (Barber, 2009). We map the time spent in different phases of inquiry (preparing, collecting data, discussing data, and communicating data), and we examine teacher involvement based on how the instruction was organized.

Science inquiry is often described as a ‘multifaceted activity’ (National Research Council, 1996) that involves posing questions (Chinn & Malhotra, 2002), exploring (Bybee et al., 2006), testing hypotheses (Gyllenpalm et al., 2010), designing and carrying out investigations (Crawford, in press), analyzing data (Krajcik et al., 1998), making explanations based on evidence (Barber, 2009), and debating, and communicating findings (Wu & Hsieh, 2006). Bell, Urhahne, Schanze, and Ploetzner (2010) emphasized that these processes do not appear in a fixed order and should not be interpreted as steps in a linear fashion. Many studies focus on one or two features of science inquiry (Furtak, Seidel, Iverson, & Briggs, 2012). We wanted to examine the entire inquiry process at the classroom level, and we relied on several of the features listed here in our analytical framework.

Language and Literacy in Science

Increased interest in socio-cultural perspectives on teaching and learning has emphasized language as the central form of mediational means in science learning (Leach & Scott, 2003; Lemke, 1990). Thus, the emphasis on learning the language of science is vital for student learning, as a structure that supports science content learning as well as an area of content knowledge of the science curriculum (Knain & Kolstø, 2011;

Norris & Phillips, 2003; Wellington & Osborne, 2001). Additionally, as Wellington & Osborne (2001, p. 3) stated: 'for many pupils the greatest obstacle in learning science—and also the most important achievement—is to learn its language'. Learning the language of science involves more than mere word learning, yet word knowledge is essential to science understanding since learning the language of science involves using words as labels that allow one to communicate about the ideas and processes of science (Bravo, Cervetti, Hiebert, & Pearson, 2008; Lemke, 1990; Wellington & Osborne, 2001). Norris and Phillips (2003) argued that science would not be possible without text and our socially meaningful ways of dealing with these texts. The scholars also defined scientific literacy as including the fundamental sense and the derived sense of scientific literacy. The fundamental sense involves reading and writing and being fluid in the discourse patterns and communication systems of science, while the derived sense involves being knowledgeable and educated in science and being able to take a critical stance toward information. In our study, when we map the time spent on reading, writing, and oral activities, we focus mainly on the fundamental sense of scientific literacy. However, when we identify the variation and patterns of literacy activities in different phases of inquiry, it implies that the content of the talk, the reading, and the writing is closely linked to understanding the processes of science and mastering the science content. Thus, the study also comprises the derived sense of scientific literacy.

Despite the focus on inquiry in science reforms, and the understanding of literacy in science as central to what it means to do science, texts have usually not been considered sources to support experiences acquired in hands-on science (Norris & Phillips, 2003; Pearson et al., 2010). According to Cervetti et al. (2006), a text can provide a meaningful context for investigations and extend the inquiry by being closely connected to hands-on activities. Literacy is at the core of scientific practice, and through language and text, scientific knowledge develops (Norris & Phillips, 2003). Constructing, interpreting, selecting, and critiquing texts are as much a part of science as collecting, interpreting, and challenging data (Norris & Phillips, 2003). Therefore, when the students in our study engaged with science texts in a scientifically literate way, they did more than simply recognize words and locate information.

Methods

Context

The present study was part of a larger project, The Budding Science and Literacy project, in which the aim was to provide support for teachers when they implemented inquiry and basic skills in science. The project was inspired by the Seeds of Science/Roots of Reading (Seeds/Roots) program (Barber et al., 2007), and we developed a teaching model that integrated inquiry-based science and literacy adapted to the Norwegian school culture. We also developed a professional development course for primary school teachers. The course focused on teaching science according to the teaching model, with an emphasis on inquiry, reading and writing in science, and doing practical activities. In addition, the teachers were asked to adapt and implement a Seeds/Roots unit in their own classroom.

A Seeds/Roots unit consists of a detailed teacher guide, several short student textbooks in various genres, student investigation notebooks, and materials for hands-on activities. Available units cover a range of topics (e.g. body systems, designing mixtures, gravity and magnetism, and variation and adaptation) adjusted to grades 2–5 using the do it, talk it, read it, and write it approach. The teacher guides for each unit urged teachers to expose students to these multiple learning modalities while learning central concepts (e.g. *system*, *structure*, and *function* in the 'Body systems' unit, and *observation*, *evidence*, and *inference*, included in all units). At the same time, the students practiced their reading, writing, and discussion skills in an inquiry-based setting. The teachers were free to choose the unit most appropriate for their science class (topic and age level). Although the teachers were encouraged to follow the teacher guide closely, this was not required.

Participants

Teachers who attended the professional development course volunteered for the present video study. We ended up studying 6 teachers and their students, age 6–11, at 4 schools. The six teachers were selected based on practical reasons: scheduled lesson plans and the accessibility of the schools. Ellinor and Emma, for example, were selected because they were at the same school doing the same unit in two parallel third-grade classes. All teachers were generalists, teaching all subjects, and had little formal education in science. They were video recorded during a sequence of 5–10 science lessons per teacher, depending on how much time the teachers could allocate according to their classroom schedule. The video-taped lessons were in consecutive order (Table 1).

Data Material

In the present study, rich and robust data (e.g. several parallel videos from the same lesson) allowed us to enhance the trustworthiness of the video observations (Derry et al., 2010). The data material from each class consisted of *observational data*, which included video and audio recordings of whole-class settings, video and audio recordings of the teacher, and videos and audio recordings from two head-mounted cameras worn by students. Additionally, the Seeds/Roots teacher guides were used as *reference data* since the guides provided detailed descriptions of the different activities, including suggested time spent on each activity.

Development of Coding Schemes

The aim of this study was to identify challenges primary school teachers encounter in their classrooms during the inquiry science and literacy integration, and the support

Table 1. Overview of background information about participating teachers, schools, and recordings

Teacher	Years of teaching	Science credits[a]	Grade	No of students	School location	Theme	Total video rec. (in min.)
Anna	0–5	16–30	5	14	S	Gravity and magnetism	343
Betsy	11–15	16–30	1	18	R	Body systems	165
Birgit	11–15	16–30	4	24	R	Body systems	426
Cecilia	20+	16–30	3	19	S	Variation and adaption	540
Ellinor	11–15	31–60	3	16	R	Designing mixtures	224
Emma	20+	16–30	3	21	R	Designing mixtures	269
					(Suburban rural)		Σ 1967

[a]Generalist teacher education includes 16–30 ECTS credits in science (60 credits is one year full time study).

that teachers might need in an integrated approach. To identify these challenges, we first needed to identify the central features of inquiry-based situations in science classrooms. Therefore, we developed a coding scheme for science inquiry based on an extensive review of the literature and recent research into inquiry-based science education, the nature of science, and current models of inquiry cycles or frameworks, for example, 5E (Bybee et al., 2006) and the Seeds/Roots inquiry cycle (Barber, 2009). The coding scheme was developed in an iterative process between reflecting on theory and watching video examples of classroom activities. We distinguished between two levels of analysis consisting of four overarching phases of inquiry (categories): preparation, data, discussion, and communication, which again were operationalized by what we have identified as central inquiry processes (specific codes) (Table 2). We concur with the argument made by Bell et al. (2010) that science inquiry in school science classrooms does not have to take form in a fixed order, nor does it have to 'fulfill' every process to be classified as inquiry-based. As part of the preparation phase (Bell et al., 2010; Chinn & Malhotra, 2002; Gyllenpalm et al., 2010; Knain & Kolstø, 2011; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003), we identified background knowledge, wondering, formulating researchable questions, making predictions and hypotheses, and planning. Specific codes of the data phase (Bell et al., 2010; Krajcik et al., 1998) involved collecting data, registering data, and analyzing data. For the discussion phase (Bell et al., 2010; Duschl & Osborne, 2002), the following were coded: discussing different interpretations, views, and ideas; making inferences; discussing implications; and linking theory and empirical data. Finally, as part of the communication phase (Bell et al., 2010) we identified oral communication of results, written communication of results, and evaluation.

Table 2. Coding scheme for video analysis (Ødegaard, Mork, Haug, & Sørvik, 2012). The inquiry categories are labeled after inquiry phases, and the multiple learning modalities are from the Seeds/Roots (Barber et al., 2007)

Category		Specific codes
Inquiry	Preparation	Background knowledge/wondering/researchable questions/prediction/hypothesis/planning
	Data	Collection/registration/analysis
	Discussion	Discussing interpretations/inferences/implications/connecting theory and practice
	Communication	Orally/in writing/assessing their work
Multiple learning modalities	Oral activities	Whole class/group/pair/individual
	Writing activities	Whole class/group/pair/individual
	Reading activities	Whole class/group/pair/individual
	Practical activities	Whole class/group/pair/individual
	Focus on key concepts	

To get an overview of how the multiple learning modalities were integrated in the different phases of inquiry, we developed an additional coding scheme for reading, writing, oral, and practical activities (Table 2). These activities correspond with the multimodal activities 'Read it! Write it! Talk it! Do it!' in the Seeds/Roots units (Barber et al., 2007). We included specific codes for instructional organization as well, in order to examine the degree of teacher involvement throughout the lessons. These codes were inspired by the PISA+ study (Pluss: Project on Learning and Teaching Strategies in School) (Klette, et al., 2005; Ødegaard & Klette, 2012).

An additional code, *key concept*, was used when the teaching focus was explicit in learning topic-specific science vocabulary (e.g. system, function, or structure) or inquiry-specific vocabulary (e.g. observation, predict, or evidence). The Budding Science and Literacy teaching model emphasizes learning a set of pre-selected key concepts that are important for understanding the scientific idea being taught. We consider explicit teaching of science and inquiry vocabulary vital for students' conceptual learning (Haug & Ødegaard, 2014). Thus, a focus on key concepts is an important support structure, and the lack of focus is a challenge.

Data Analysis

To identify the teachers' challenges and reveal areas that required support when teaching an integrated science inquiry and literacy curriculum, we searched for activity patterns of the coding schemes by analyzing the following aspects: (1) the variation of multiple learning modalities during an integrated science approach, and whether they are evenly distributed or some modalities dominate; (2) the distribution of different phases of inquiry throughout an integrated science literacy approach; and (3) the inclusion of multiple learning modalities and the focus on key concepts in different inquiry phases.

Data analyses were conducted with Interact coding software.[2] We first coded all the classroom videos for multiple learning modalities and instructional organization. The categories oral, writing, reading, and practical activities were not mutually exclusive, but the organizational codes for each category were. This means that an incident could be coded as an oral and a reading activity, but whether the incident was conducted in plenary, as a group, or individually could be assigned only one code. For the next layer of coding, we applied the coding scheme for science inquiry, in which the various inquiry phases were defined as mutually exclusive. The third layer of coding focused on key concepts. We coded the occurrence of each code, and investigated the co-occurrence of codes within the different layers.

To get an overview of the classroom activities, we used software that allowed us to code the videos directly without transcribing the dialogue (Mangold, 2010). When we started the coding, all four coders (authors) collaborated in coding two randomly selected lessons and agreed on when to apply the different codes. Later, we coded individually, and approximately 20% of the videos were double-coded. The inter-rater reliability varied between kappa values of 0.75 and 0.80, which is satisfactory according to Banerjee, Capozzoli, McSweeney, and Sinha (1999).

Even though this study was qualitative, at this stage we chose to quantify our results. We emphasize that we do not intend to generalize from the results, but quantifying opens up additional patterns of classroom activity that emerge from the data (Ødegaard & Arnsen, 2010). In the present study, we do not aim to explain the phenomenon we observed, but to illuminate and discuss the implication of its occurrence. Further in-depth studies based on our results might come closer to explanations.

Results

Multiple Learning Modalities

The analyses show variation in the learning modalities. Summing up all video-taped and analyzed lessons, oral activity was the most dominant modality in terms of the time spent, which is not surprising since it naturally occurred together with the other modalities (Table 3). The variation in the modalities largely agreed with the modalities recommended in the teacher guide in the Seeds/Roots material. However, when each teacher was studied, individual discrepancies were identified, indicating that the teachers made individual adjustments to the plans in the teacher guide. This implies that teachers make room for variation even though the teacher guide provides a specified plan.

When we examined how the different activities were organized (Table 3), we saw that practical activities were mostly conducted in group or pair settings, often combined with an oral activity. Plenary, practical activities were few, and when we checked each incident, they were usually demonstrations by the teacher or students. The most individual activity was writing, although some writing activities were conducted in plenary, either for modeling or as part of an oral activity. Only 9% of the

Table 3. Variation of learning modalities. Summary of video analyses

	Plenary (%)	Group/pair (%)	Individual (%)	Σ (%)
Oral activity (Talk it)	54	8	0.50	62.50
Writing activity (Write it)	6	3	20	29
Reading activity (Read it)	6	3	0	9
Practical activity (Do it)	4	8	1	13
Σ	70	22	21.10	

time coded for multiple learning modalities was coded as reading; however, we chose to strictly code only the events when actual reading took place. Most of the reading activities in our video recordings were plenary and intertwined with oral activities. Thus, to make the coding as reliable as possible, we decided to strictly code the actual reading. However, we have a broad perspective on reading, including getting ready to read, modeling reading, etc., which is explored in another study (Mork, 2013).

To sum up the results of the coded learning modalities, we found that oral activities in plenary dominated. The oral activities occurred with plenary reading, writing, and practical activities. Comparing these plenary sessions, we saw that they were often used to model reading, writing, or hands-on activities for the students. This indicates that teachers supported the students' activities by modeling them first in plenary before the students tried the activities on their own.

Inquiry Phases

We analyzed the inquiry activities according to the codes in Table 2. In the overview of all coded materials in Figure 1, the most striking feature is that the teachers used considerably more time in the beginning inquiry phases than in the consolidating inquiry phases. The time allocated to the different activities does not in itself say anything about the quality of the activity, and practical activities often take more time than discussions. However, this pattern seems to agree with previous studies that showed how school science is mostly concerned with preparing and doing, with less focus on summing-up activities (Ødegaard & Arnesen, 2010), debating (Newton, Driver, & Osborne, 1999), making inferences, and connecting theory and empirical data (Furtak & Alonzo, 2010; Ødegaard & Arnesen, 2010).

The specific inquiry codes for each inquiry phase (Table 2) were mainly used to determine which inquiry phase the coded incident belonged to, in addition to labeling incidents in order to make our data material searchable for further research. The specific codes were naturally connected to activities recommended in the teacher guides. The overall picture of the six teachers revealed that the most frequent activities in the preparation phase were activating students' prior knowledge and wondering. When we coded for the data phase, it was difficult to differentiate between collecting, analyzing, and registering data, so these codes overlap, with an emphasis

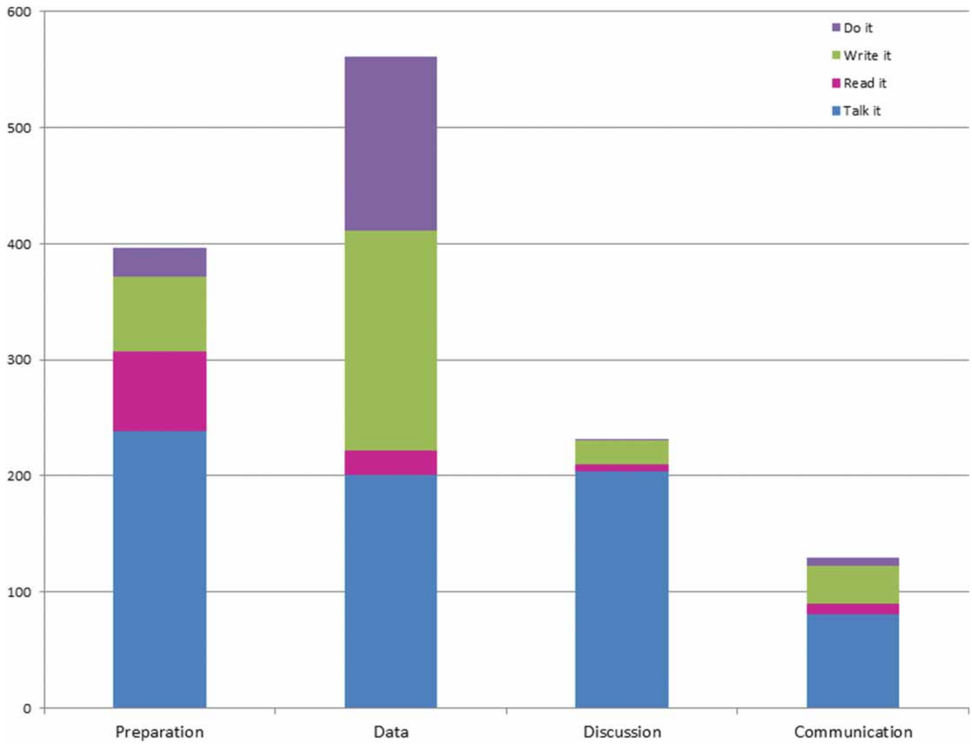

Figure 1. Variation of the multiple learning modalities during the inquiry phases, summarized for all teachers and displayed in coded minutes

on collecting and registering. In the discussion phase, discussing interpretations and connecting theory and empirical data were most frequently coded for. Making inferences and discussing implications occurred more seldom. When students communicated their inquiry findings, this was mainly an oral activity but also conducted in writing. The students assessed their own work and their peers' work for almost one-fifth of the communication phase. We applied the code *Focusing on key concepts* in about 11% of all coded time. This code is independent and thus overlaps with several other codes.

This quantitative summary of six teachers' inquiry activities in school science gives us an indication of how much time the students were engaged in the different inquiry phases. If the students are less engaged in the discussion and communication phases than the preparation and data phases, this might indicate a significant challenge for the teachers. The understanding of science concepts is made deeper and richer through discussing different interpretations, making connections between own data and theory, and making inferences; therefore, it is important to use time on these activities (see also Haug & Ødegaard, 2014). Even though the teachers taught different grade levels, all teachers seemed to have adjusted the discussions to their students' age.

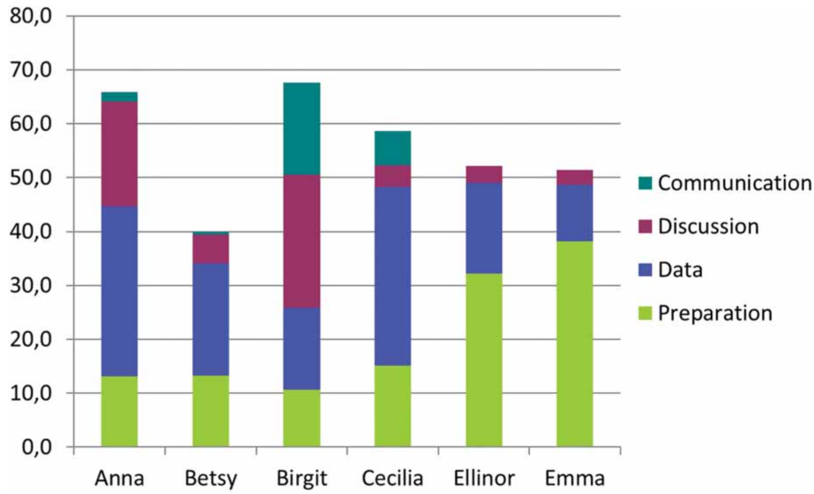

Figure 2. Durations of the inquiry phases for the six teachers in percent of coded time

Analyses of lesson sequences using inquiry features showed progression with preparation first, work with data, and often alternation between discussion and communicating results. Occasionally, a small inquiry, for example, using a text for collecting and discussing data, was used as preparation for a more extensive investigation. When we examined the time each teacher spent on the inquiry phases (Figure 2), we saw considerable variation. Birgit's profile stands out from the other teachers in the study in terms of the time spent on discussion and communication phases. Anna also spent considerable time on discussions. Even though Cecilia, in line with Betsy, Ellinor, and Emma, spent most of her time on preparation and data activities, she also had a pronounced communication phase.

Use of the Teacher Guide

The teachers chose different Seeds/Roots units (Table 1). However, all units are built on the same principles of integrating inquiry-based science and literacy. To understand more about the challenges the teachers faced when they implemented this teaching approach, we compared the amount of time the teachers spent on different inquiry phases to what is recommended in the teacher guides. Each lesson in the teacher guide had a recommended time schedule for the different learning activities. The activities were analyzed, grouped according to the inquiry phases, and analyzed to illuminate the teachers' emphasis on the different phases.

When we compared the teachers in our study with the activity schemes in the teacher guides, we perceived a discrepancy between what the teachers were encouraged to do and how they actually implemented the learning activities. However, all the teachers spent more time on each session than recommended. Therefore, to compare the emphasis on the different inquiry phases, the results are shown in percent of coded time. Figure 3 illustrates the amount of time each teacher and her

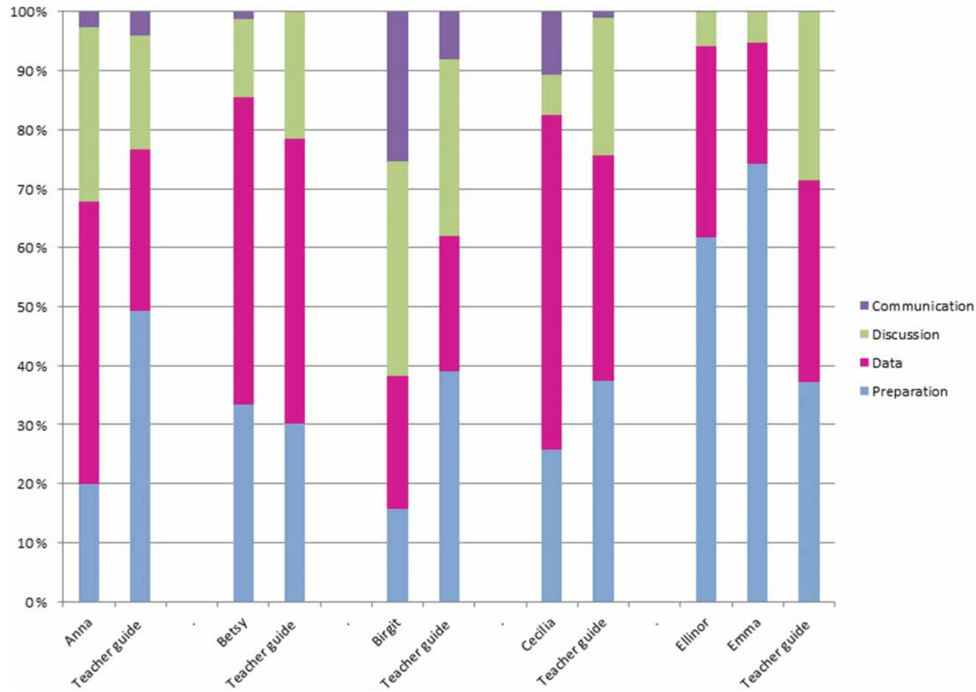

Figure 3. Comparison of inquiry phases between teachers' implementation and the teacher guide. To compare the teachers' implementation with the teacher guide, the duration of the inquiry phases was converted to 100%

students spent on the inquiry activities in the different phases, compared to the teacher guide recommendations. We saw that four of the six teachers spent less time in the discussion phase than suggested. Ellinor and Emma, who taught the same grade at the same school and followed the same teacher guide, interpreted and implemented the learning activities slightly differently, but both decreased the discussion phase. The teacher guide recommended discussion activities of approximately 50 minutes, whereas the analyses showed that Ellinor and Emma used 7 minutes. There was also a tendency to spend more time in the communication phase. There was little emphasis on the communication phase in the teacher guides for the lessons observed; thus, the information from this phase of inquiry is limited in this study.

Multiple Learning Modalities in the Inquiry Phases

One of the fundamental ideas of the Budding Science and Literacy project is the synergy effects of integrating inquiry-based science and literacy. Pearson et al. (2010) expressed it as follows: 'Science learning entails and benefits from embedded literacy activities ... literacy learning entails and benefits from being embedded within science inquiry' (p. 462). Researchers have also shown how literacy activities can provide structure to inquiry processes (Knain, Bjønness, & Kolstø, 2011). Therefore, it was crucial to explore the connections between the inquiry codes and the multiple learning modality codes, which were coded independently in two layers of coding. When we combined the inquiry coding and the multiple learning modalities, we saw, for instance, that the data were collected and handled using the entire range of modalities (Figure 1). Data might be collected when the teachers performed practical activities, but also by doing literacy activities such as reading or writing. One-third of the data phase was also coded as writing. Registering data was typically a writing activity and constituted a major part of the phase; thus, writing helped to structure the data phase. When we coded the data material, we saw that in most cases when data were collected during reading, the students actively studied a text, for example, by observing pictures to collect information that was later used in discussions.

Combining the layers of coding also revealed that the entire range of learning modalities was used to implement the preparation phase, indicating that preparing for data collection provided students with rich and varied experiences. Conversely, the discussion and communication phases were mainly dominated by oral activities, which revealed the potential for including a greater range of learning modalities in these consolidating phases.

Key Concepts

Focusing on a limited number of key concepts in each unit is a central principle in the Budding Science and Literacy project. Gaining active conceptual understanding (Pearson et al., 2010) is an essential learning goal for the students. Therefore, it is also vital to explore our material to detect patterns involving key concepts. Our video analyses showed that the teachers focused on key concepts mainly in the preparation and discussion phase. Further analyses disclosed that the concepts were introduced during the preparation phase, and that the discussion phase was used to re-address the concepts (Haug & Ødegaard, 2014). However, the time spent emphasizing key concepts was unequally distributed among the teachers. Anna and Birgit excelled by using more time than the other teachers (Haug & Ødegaard, 2014), which indicates that focusing on key concepts could be a challenge to some and that the teacher guides should provide more support on that point.

The Use of Data in the Discussion Phase: An example

Birgit's class differed from the other teachers' classes in that her class spent more time in the consolidating inquiry phases of discussion and communication, as well as focusing more on key concepts. Therefore, it was interesting to examine her class more closely (Haug, 2014; Haug & Ødegaard, 2014). Here, it is used as an example for the readers of how the teacher managed to engage the students in inquiries about systems using the Budding Science and Literacy teaching model (Table 4).

During a sequence of several lessons, the focus in Birgit's class changed between the different phases of inquiry. The data phase was mainly followed by discussion or communication, systematically guided by the teacher. In the discussions, the students interpreted their own data, made inferences about their findings, discussed the implications of their results, and connected theory and practice. All these activities are central for learning, indicating that the discussion phase has the potential for valuable learning situations (Table 4).

In the discussion phase, the teacher ensured that the students used the data they collected, either from studying a picture (excerpt 3,Table 4) or doing a firsthand investigation (excerpts 9–10). In this way, the discussion was empirically grounded in the students' own experiences. The key concepts for this learning sequence about body systems were system, function, and structure, and these concepts were also systematically brought into the discussion. In the first discussion, the students used their observations of a picture as data (excerpts 4–6). They interpreted the picture of a wheel, made inferences, and discussed the implications of its structure and function. This small inquiry can be seen as preparation for the next more extensive inquiry. The students collected data through experimenting with different ways to make a ball-sorting system (excerpts 9–10). To connect theory and practice about the functions and systems, the teacher asked the students: 'Which function did the tube have in the system you just made? Talk to your peer about that for 10 seconds!' (excerpt 13). In this way, she made sure that the students' data and engagement from their experiment were brought into the discussion, and that all the students expressed

Table 4. Excerpts (1–13) from a 2-hour session in Birgit's class during the Seeds/Roots unit Body Systems showing how the teacher initiates and guides the students' activities through different inquiry phases

Category of inquiry	Code	Teacher's initiation
(1) Preparation	Prior knowledge	Which five senses do we have?
(2) Preparation	Prior knowledge	What do we mean by function?
(3) Data	Collecting	Observe the wheel on page 4
(4) Discussion	Interpretations	What is the wheel's structure?
(5) Discussion	Inferences	Can you say something about its function?
(6) Discussion	Implications	Can a wheel without spokes roll?
(7) Preparation	Wondering	How can we sort the yellow balls from the blue?
(8) Preparation	Planning activity	Make a plan for sorting them
(9) Data	Collecting	Start to investigate how you could make a ball-sorting system
(10) Data	Organizing	Make the system you decided on
(11) Communication	Oral communication of results	Present your system and what you were thinking about during the process
(12) Communication	Assessing own work	What were the challenges you encountered?
(13) Discussion	Connecting theory and practice	What was the function of the tube in your system? Talk to your peer about that for 10 seconds

their thoughts about it. Afterwards, the students shared their ideas in a whole-class discussion.

Summing Up the Results

Several large-scale studies have shown that integrated inquiry-based science and literacy activities give increased learning outcomes in pre- and post-tests with a control class (Cervetti et al., 2012; Fang & Wei, 2010). However, the present small-scale study aimed at describing what happens at the classroom level during the implementation of an integrated inquiry-based science and literacy curriculum. Thus, our research contribution is to provide an overview of literacy and inquiry activities in our material and offer an insight into the integrating processes that occur.

Our analysis revealed that multiple learning modalities (read it, write it, do it, and talk it) were used in the integrated approach; oral activities dominated. This is connected to the fact that a high number of plenary activities often play the role of scaffolding, modeling, or summing up the other modalities. Thus, oral activities overlapped with the other activities. The inquiry phases shifted throughout the students' investigations, but less time was allocated to the consolidating phase of discussion. Discussion activities were actually under-used compared to the teacher guides (Figure 3). The multiple learning modalities were integrated in all inquiry phases, but mainly in preparation and data, while the discussion and communication phases included mostly oral activities.

Discussion

Before we offer reflections and discussion, we feel it is important to recognize some of the limitations of the present work. First, we emphasize that this is a small qualitative study, and even though we report our results as quantities of time applied on classroom activities, the results cannot be generalized directly. The reason for quantifying our video observations is to search for variations and patterns in our analysis (Ødegaard & Klette, 2012), and to be able to compare the implementation of activities with suggestions from the teacher guide. The quantification is also used to provide an overview of our data and form a foundation for further in-depth studies connected to the Budding Science and Literacy project (Haug, 2014; Haug & Ødegaard, 2014; Sørvik, Blikstad-Balas, & Ødegaard (in press).

Concomitant to claiming that the quality of an activity is more about how it is accomplished than the amount of the activity, we still believe that our quantitative results are useful and interesting. The analyses are qualitative interpretations of classroom activities. All coding of the discussion phase, for instance, are ascribed incidents where students and the teacher discuss their own data using special strategies that we consider central for scientific thinking (e.g. linking empirical data and theory, making inferences, discussing implications). When our results show that the quantity of these codes are less than anticipated from the teacher guides, we can assert that there are fewer opportunities for the students to consolidate their knowledge. However, our present study does not include individual student comprehension and reasoning outcomes, so it is not possible to report on the learning effects from our analyzed classrooms. Our main contribution to the research community is to present an overview of how science inquiry and literacy activities are distributed within an integrated approach, as called for by Howes et al. (2009), and offer considerations of the challenges teachers may encounter.

In the following, we structure the discussion around challenges we identified in the implementation of inquiry phases and integrating science inquiry and literacy. Furthermore, we discuss implications for the Budding Science and Literacy project in particular and for science education in general.

Challenges in the Inquiry Phases

When we analyzed our data, we saw interesting patterns, especially connected to the inquiry data phase. Our video analyses showed that collecting data encourages various learning modalities (Figure 1), and these modalities supported students in exploring science issues. Students not only collected data (by observation or experimenting) but also were guided to organize and analyze the data, in order to answer their specific inquiry question. The ownership of scientific data that emerged through the data phase provided the basis for the students' engaged discussions, and the students were challenged by the teacher to make inferences and connect their results to theory. Several studies of inquiry in science lessons have shown that there has been an overemphasis on the 'hands-on' part of inquiry and that this is not sufficient for learning science (Duschl & Gitomer, 1997; Minner, Levy, & Century, 2010; Ruiz-Primo & Furtak, 2007). However, we elucidated that even though collecting data might not be essential in itself, it seems essential as a further driving force for engaging in science learning in future consolidating situations.

Our perhaps most interesting results show that, on average, little time was spent in the discussion phase. This also coincided with the profile of each teacher with one exception; see Figure 2. Compared to the teacher guides, most of the teachers spent less time than suggested in the discussion phase. This indicates that the students experienced less emphasis on discussing the meaning of their findings. Other studies (Duschl & Gitomer, 1997; Ruiz-Primo & Furtak, 2007) have also reported that teachers seem to focus more on tasks, activities, and procedures than on conceptual structures and scientific reasoning. Crawford (2007) stressed that teachers' conceptions of science may influence how they teach science as inquiry. Thus, if teachers see science mostly as an empirical endeavor, they might spend less time discussing and communicating results. The primary teachers in our study have little science background; therefore, they may have found discussions in science very challenging. Teachers with a low level of content knowledge are less likely to know what questions to ask of students, which conceptual difficulties to anticipate, what inferences to make of student answers, and what actions to take to adjust instruction toward scientifically accepted ideas (Ball & Hill, 2009; Bell, 2000; Harlen & Holroyd, 1997). If teachers know science only from their own schooling, they may conceive science as more about scientific procedures than developing scientific explanations, and might not understand the importance of the discussion and communication phases. In any case, teachers need more support and encouragement to use the discussions to foster the students' disciplinary comprehension and engagement.

The findings in a meta-analysis examining the effects of classroom discussion on students' comprehension of text support the significance of discussions (Murphy, Wilkinson, Soter, Hennessey, & Alexander, 2009). We concluded that especially discussions designed to acquire information from texts increased students' talk and their comprehension. Merely increasing the amount of student talk, however, did not increase their comprehension. Several of the teachers in our study decreased the amount of time they spent on the discussion phase compared to the teacher guide recommendation. Consequently, the students were provided with fewer opportunities to engage in discussion strategies, including how to connect their experiences from the data phase to science content knowledge.

Challenges for Integrating for Including Multiple Learning Modalities in Inquiry Phases

Howes et al. (2009) found that one of the challenges teachers experienced when they integrated inquiry-based science and literacy was that the literacy learning became privileged to learning science. In our study, we found no indications of a similar evolution. The literacy activities (coded as reading, writing, and oral) almost always occurred coincidentally with inquiry codes, indicating that the activities were part of the science inquiry processes and functioned as supporting structures, like drawing and writing diagrams of a system the students have explored, registering their own data in a table, or gathering data from a text.

However, the combined analysis of multiple learning modalities and different inquiry phases revealed that the read it, write it, talk it, and do it modalities were not evenly distributed. We observed that the discussion and communication phases included fewer modalities than the other phases and that oral activity dominated. This was also reflected in the teacher guides. The oral domination is not necessarily a challenge, since it can be naturally explained (overlaps with the other modalities; see 'Results'), but the deficiency of reading, writing, and doing in the discussion and communication phases tells us that there is potential to use more from the range of learning modalities as supporting structures, as well as in the consolidating phases.

Implications for the Budding Science and Literacy Project

Our results indicated that the Budding Science and Literacy teaching program provided support for teaching and learning science, but that there was also room for improvement. We saw that various learning modalities and inquiry activities were integrated, but the teachers encountered the challenge of finding time and courage, especially to use the discussion phase, to consolidate the students' conceptual learning. Teachers' conceptions of science and low level of content knowledge may influence how they teach inquiry (Crawford, 2007). Introducing inquiry-based science teaching is challenging, and Crawford called on science teacher education to take responsibility.

The teachers we studied followed a teacher guide and a professional development course. Still, the majority of the teachers under-used the discussion phase. This implies that the Budding Science and Literacy teaching program needs improvement to support and encourage teachers to arrange for students to discuss and understand the meaning of their data. Additional reading and writing assignments could be designed with the goal of discussing interpretations and linking data to theory. It is also possible to include more structured do it and talk it activities, for instance, as suggested by Knain et al. (2011): conducting student research meetings or using wikis. Role plays that simulate research conferences may also structure the discussion phase by emphasizing literacy practices that are meaningful to science (e.g. writing applications, designing a poster session, and discussing with other 'scientists'; Ødegaard, 2003; Mork, 2005).

Based on our findings, another implication for the Budding Science and Literacy project is that teachers should also have complementary professional development that focuses on the nature of science issues, for instance, the importance of discussing and communicating for developing scientific knowledge.

Implications for Integrating Inquiry-Based Science and Literacy

In the introduction, we pointed to the assertion agreed upon by several researchers that science and literacy are each in the service of the other and that science learning benefits from embedded literacy activities (Cervetti et al., 2012; Norris & Phillips, 2003; Pearson et al., 2010). Our study implies that an integrated approach may be effectively accomplished (the learning modality codes were similar to inquiry codes). However, this requires supporting structures. Thus, our findings concur with Schneider, Krajick, and Blumenfeld's (2005) suggestion that lesson descriptions should be supplemented with educational support and professional development.

These results were further confirmed by an in-depth study as part of the present Budding Science and Literacy project. Haug & Ødegaard (2014) showed that students need to actively apply the key concepts through all inquiry phases to increase their conceptual understanding. When students became familiar with the key concepts in the preparation and data phases, the students use the key concepts in the discussions phase to consolidate their new knowledge. Therefore, to support conceptual learning, students must spend time in the discussion phase.

Beyond the Budding Science and Literacy project, this article offers an overview of classroom activities during an integrated literacy and inquiry-based science approach. We compared different layers of analyses for multiple learning modalities and inquiry, searching for interesting variations and patterns that were not obvious through observations alone. These patterns showed how students use their data in the discussion and communication phases, how various modalities are used in the different inquiry phases, and how teachers supported the students' conceptual understanding.

We consider these results interesting and useful for other science education researchers involved in inquiry-based science, science and literacy, or both. The results draw attention especially to the discussion phase of inquiry, reminding us of its importance and how challenging this phase might be when teaching science.

Notes

1. http://scienceandliteracy.org/about
2. http://www.mangold-international.com/software/interact/what-is-interact.html

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ARTICLE II

Science
Education

"Do Books Like These Have Authors?" New Roles for Text and New Demands on Students in Integrated Science-Literacy Instruction

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ABSTRACT: We report on research that explores students' literacy practices in six Norwegian primary school science classrooms during integrated science-literacy instruction. The study combines observational video data and interview data to examine students' encounters with and use of text, along with their views and experiences related to science and science text. Drawing on New Literacy Studies perspectives—seeing literacy as a situated social practice—our analysis reveals how multiple literacies emerged in the context of integrated science-literacy instruction, where elements of students' informal literacies became valued resources in the dialogic process of inquiry. More specifically, the students engaged in literacy practices that transcended the contexts of science and school science to incorporate texts and literacy practices from the students' everyday lives as well as practices that were confined to a school-only context. On the basis of their talk about text in the classroom and data from focus group interviews, we also identify some of the challenges that these students faced in their encounters with science texts in this setting. © 2014 Wiley Periodicals, Inc. *Sci Ed* **99:**39–69, 2015

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INTRODUCTION

A critical engagement with science texts is fundamental to the social practices that make science possible, and consequently, for informed participation as scientifically literate citizens in a democratic society (Linder, Östman, & Wickman, 2007; Norris & Phillips, 2003; Pearson, Moje, & Greenleaf, 2010). There is thus a need to promote literacy practices in the classroom that attend to the communicative and representational aspects of science when developing science learning environments, especially if we are to focus on the social and epistemic dimensions of science education (Duschl, 2008). Yet, reading and writing in school science have often been downplayed by science educators in favor of "hands-on" activities, thereby neglecting the integral role of written language in science (Wellington & Osborne, 2001). Goldman and Bisanz (2002) claim that this may be a result of the lack of authentic roles for text in school science, where reading and writing are often at risk of supplanting experiences from practical activities, rather than being connected to the dynamic and dialogic process of scientific inquiry. This has led researchers in science education and literacy research communities to propose that explicitly integrating literacy into science instruction provides students with both tools and contexts to inquire about the natural world and supports them in developing scientific literacy (Hand et al., 2003; Pearson et al., 2010; Yore et al., 2004). Even though there is a growing empirical evidence base in favor of integrated approaches, in-depth studies on how text is actually used to support students remain scarce (Cervetti, Bravo, Hiebert, Pearson, & Jaynes, 2009; Pappas, 2006).

This article thus reports on a classroom video study of primary school students' literacy practices in an integrated science-literacy context. The study combines observational video data from six classrooms with focus group interview data collected through the *Budding Science and Literacy* research project (Ødegaard, 2010), in which teachers attended a 1-year in-service professional development course on inquiry science and literacy. In turn, we examine the literacy events that students in these classrooms took part in, along with their views and experiences related to science and the texts they encountered. This is done by investigating the variation of texts that were present in these science lessons and the contexts in which these texts were being used. Our approach to researching school science literacies has a sociocultural view of literacy as an underlying tenet, which involves understanding literacy as embedded in different social and cultural contexts, and in the social practices of the different discourse communities of which they are a part (Barton, 2007; Gee, 2004; Lemke, 2004). In our case, these contexts are framed within school science lessons in six different Norwegian primary school science classrooms where teachers specifically focused on science inquiry and literacy.

In Norway, the focus on scientific literacy and science inquiry has been accentuated through the introduction of the main subject area, *The Budding Scientist*, on all levels of the national science curriculum, combined with a cross-curricular demand for integrating reading, writing, oral, arithmetic, and digital competences across all subjects (Ministry of Education and Research, 2006). However, the introduction of competences, such as reading and writing in every subject—and the intention behind them—does not appear to be understood by teachers and little actual change appears to have occurred in the classroom (Møller, Prøitz, & Aasen, 2009; Ottesen & Møller, 2010). Recent revisions of the national science curriculum has therefore put further emphasis on the role of literacy within the main subject area *The Budding Scientist* to help clarify the meaning of integrating literacy in science for teachers (Ministry of Education and Research, 2013; Mork, 2013). The Norwegian context is in this way similar to the many international efforts and perspectives centered on scientific literacy, science inquiry, and the nature of science (Abd-El-Khalick et al., 2004; National Research Council, 2012).

THEORETICAL PERSPECTIVES

The Fundamental and Derived Senses of Scientific Literacy

Language, and written language in particular, is an integral part of doing and learning science, alongside the more hands-on aspects of seeking information about the natural world (Gee, 2005; Halliday, 1998; Hand et al., 2003; Lemke, 2004; Norris & Phillips, 2003; Pearson et al., 2010; Wellington & Osborne, 2001; Yore et al., 2004). Clearly, when scientists engage in scientific inquiries, they use text to frame their investigations in various ways, depending on the particular conventions and practices within the subdisciplines of science they adhere to (Bazerman, 1988; Latour & Woolgar, 1986; Lynch & Woolgar, 1990; Tenopir, King, Edwards, & Wu, 2009; Yore, Hand, & Prain, 2002). For example, peer-reviewed journal articles (digital and in print) offer background knowledge for generating research questions, design, and investigations, and offer ways to communicate research findings to other scientists. Scientists engage in reading and writing systematic and targeted reviews, grant applications, and lab and field notes, as well as constructing or interpreting figures, charts, models, and information from various inscription devices. The work of Bruno Latour has also shown how scientists engage with textual resources in a variety of informal ways during the research project, which are only later formalized through published research literature (Latour, 1987; Latour & Woolgar, 1986). Scientists also communicate scientific knowledge to nonexpert audiences for educative purposes and to the general public for informed decision making. Furthermore, scientific information is regularly reported in media and used for different purposes in society (Kolstø, 2001). As such, it is clear that science is partly constituted by text and our socially meaningful ways of dealing with them (Lemke, 2001; Ziman, 2002). It follows that students must become active and critical readers of science text to truly become scientifically literate.

In their reconceptualization of scientific literacy, Norris and Phillips (2003) make the distinction between the fundamental and derived senses of scientific literacy. The fundamental sense refers to fluency in the language, discourse patterns, and communication systems of science, whereas the derived sense refers to being knowledgeable, learned, and educated in science. Norris and Phillips (2003, p. 233) contend that "[w]ithout text, the social practices that make science possible could not be engaged," and by extension, science as we know it today would not exist. Conceiving of scientific literacy without paying attention to the fundamental sense, which has long been the case in much of the literature on scientific literacy, thus runs the risk of overlooking central aspects of the substantive, epistemic, and social dimensions of science and scientific literacy. Furthermore, a sociocultural perspective on literacy suggests that the two senses are necessarily interrelated and inseparable. It is through language that the social practices of science (and school science) are enacted, and gaining access to these socially recognized ways of using language is central to scientific literacy in both its fundamental and derived senses (Kelly, 2007; Sadler, 2007; Yore, 2012).

By acknowledging the role of literacy in science, it becomes clear that interpreting, analyzing, and critiquing texts are as central to the practices of science as making observations, experimenting, and testing hypotheses (National Research Council, 2012; Norris & Phillips, 2003). Pearson et al. (2010, p. 460), for example, claim that "[s]cience literacy instruction should engage children and youth in making sense of scientific texts as one form of scientific inquiry." Moreover, they argue that by making inquiry the common core of reform, literacy practices associated with science support the advancement of inquiry rather than being a substitute for it. From our perspective, it is clear that inquiry-based science instruction entails interacting with text and other means of communicating scientific information as one way of engaging with the norms, values, reasoning, and practices of science. For the purpose of this study, we therefore refer to inquiry science as a set of interrelated practices by which scientists and students pose questions about the natural world and investigate phenomena (Crawford, 2007), many of which are mediated through written text (Goldman & Bisanz, 2002).

Researching School Science Literacies: Literacy as Social Practice

To analyze how text is used in the context of integrated inquiry science and literacy instruction, we draw on New Literacy Studies (hereafter, NLS) perspectives on literacy, in which literacy is regarded as a critical social practice that involves the written word (Barton, 2007). As emphasized by Jewitt (2008, p. 244), this view of literacy "marks a shift in focus from the idea of literacy as an autonomous neutral set of skills or competencies that people acquire through schooling and can deploy universally to a view of literacies as local and situated." As a local and situated practice, literacy needs to always be studied in context; research on literacy must therefore have *actual practices* as a starting point.

It is common within NLS to distinguish between formal, dominant literacies and informal, vernacular literacies (Barton, 2007; Barton & Hamilton, 1998; Street, 1995). Even though this is not a strict dichotomy, it highlights the differences between literacies that are voluntary, informal, or vernacular and officially sponsored constructions of literacy. In our case, the interesting tension is between the formal literacy practices that are valued within the context of school science and the student-initiated informal practices that they bring with them to school. It is within a school context that the students learn what "counts" as scientific literacy. A key point in this article is that there is great pedagogic potential in bridging not only the language of science and the students' everyday language (Gee, 2005) but also the formal literacy practices of school science and the vernacular and informal literacy practices that students draw on at home and in the community (Alvermann, 2002; Hand et al., 2003).

Within the NLS approach, there are two central concepts in studying the social nature of literacy, namely *literacy event* and *literacy practice*. Together, events and practices are the two basic units of analysis of the social activity of literacy (Barton, 2007, p. 37). In this analytical framework, literacy events are empirically observable activities in which text plays a role, whereas literacy practices are regarded as the general cultural ways of utilizing literacy, which people draw upon in a literacy event. The idea is that to understand literacy in a given context, one should examine all the events in which text plays a role before looking at more general patterns that indicate literacy practices. In NLS, practices, events, and texts constitute the conceptual framework used to explore literacy, because the social practices of literacy are "observable in events which are mediated by written text" (Barton & Hamilton, 2000, p. 9). Thus, text "can act as a fixed point in interaction and can be a starting point for analysis" (Barton & Lee, 2013, p. 26).

Framing our research of school science literacies within NLS has some implications. For instance, approaching literacy in this way goes beyond the texts themselves to what people do with these texts, where and how they do it, and for what purpose (Barton & Hamilton, 1998; Duke, Purcell-Gates, Hall, & Tower, 2006). It also involves taking into account how schooling (and school science) is constructed, whereby certain texts are more valued than others, and that effective disciplinary literacy instruction builds on elements of both formal and informal literacies (Alvermann, 2002; Hand et al., 2003). Another important aspect concerns the fact that science ideas are not represented through written language alone; rather, science is a multimodal discipline in which different modes of representation (i.e., talk, visual images, gestures, mathematical formulae, sound) are used to make meaning (Kress, Jewitt, Ogborn, & Tsatsarelis, 2001; Lemke, 1998).

Review of Related Research

In the following sections, we review two areas of research that are of interest to the present study: research on the role of text in school science classrooms and research on recent developments in integrating science and literacy through inquiry.

Research on the Role of Text in Science Classrooms. Goldman and Bisanz (2002) identify three major roles for science communication through the medium of text in society: communication among scientists, popularization of scientific information, and the provision of formal education that prepares individuals for future careers in science or as scientifically literate citizens. These three roles serve the needs of the distinct discourse communities, and genres arise to accomplish the goals that are regarded as important to each community. For schooling purposes, Duke, Pearson, Strachan, and Billman (2011) emphasize that students should be exposed to a varied range of genres to support them in making sense of the texts that we want them to understand. This may be narrative genres (e.g., fairy tales or realistic fiction), informational genres (e.g., typical science textbook texts, descriptions, explanations, or research reports), or hybrid text genres that are not as easily classified as narrative or informational (e.g., the scientist's notebook genre; Palincsar & Magnusson, 2001). For the purpose of this review section, we mainly focus on the texts of formal science education, which have been heavily researched, but it should be emphasized that even though a distinct text has an intended audience, an incidental audience may use it for different purposes. Maybin (2007), for example, illustrated how the distinction between vernacular and formalized school literacies, which is prominent within NLS, is not always so clear-cut when it comes to students' literacy activities in the classroom.

In school science classrooms, the textbook has a long tradition of being the dominant genre, as well as the major influence on instruction (Nelson, 2006; Yore, 1991; Yore, Bisanz, & Hand, 2003). This is also the case for Norwegian primary school science classrooms today. For example, the 2011 TIMSS science report showed that 83% of Norwegian fourth-grade students have science teachers who report to using the textbook as the basis for their instruction (Martin, Mullis, Foy, & Stanco, 2012, p. 402). Furthermore, classroom-based studies on how text is used in school science have reported that students rarely engage in practices consistent with that of the scientific community or of scientifically literate citizens; rather, the textbook is mainly used as a reference tool for looking up facts and definitions (Driscoll, Moallem, Dick, & Kirby, 1994). For instance, in an examination of literacy events in an eight-grade Finnish-Swedish chemistry classroom, Danielsson (2010) found that the students came across a number of texts, but that longer running text was neither read nor written and that there were almost no metatextual discussions. Even though the textbook was present most of the time, it was usually kept on the desk in front of the students, often spread open to show the periodic table. Af Geijerstam (2006) investigated students' writing in Grades 5 and 8 to find that there was little talk about the purpose of the students' writing and the audiences of their texts. A number of studies on students' experiences of school science also report that classroom practices connected to students' copying of information from the blackboard or from a page in the textbook are common (e.g., Lyons, 2006; Osborne & Collins, 2001). As Lyons (2006) argues, this is troublesome because it contributes to students viewing school science as simply a body of knowledge to be transmitted, memorized, and reproduced.

Reading school science texts is, however, by no means an easy task for most students. School science texts typically present students with a number of challenges due to the formal and academic language in which they are written, as the language of science needs to be concise, precise and authoritative (Snow, 2010). Fang (2005, 2006), for example, demonstrated how middle school science texts are usually characterized by topics far removed from students' everyday language and experiences, as well as being technical, dense, impersonal, abstract, and hierarchically structured. School science texts are also fundamentally multimodal, meaning that multiple representations are incorporated to communicate scientific information, such as graphical displays, tables, symbolical notations and mathematical formulae (Kress et al., 2001; Lemke, 1998). Fang (2006) thus argues that the specialized language demands of school science texts require explicit attention from teachers to support students in becoming scientifically literate.

There are also the differences between textbook science and frontier science to consider, as textbooks often focus on uncontroversial, established, and "factual" scientific knowledge, whereas the frontier science that is reported in science communications or news media is often debatable and subject to change (Bauer, 1994; Penney, Norris, Phillips, & Clark, 2003; Phillips & Norris, 1999). In a study by Penney and colleagues (2003), findings showed that nine of 10 statements made in Canadian junior high school textbooks were presented as truths. These texts were generally expository and lacked argumentation. This implies that such texts do not support the development of scientific reasoning with students, and the aspect of tentativeness in science is lost (Norris, Phillips, & Osborne, 2007). As well as presenting the products of science, science textbooks usually present the processes of science to some degree. However, Knain (2001) showed how most Norwegian eight-grade science textbooks reflected individualistic images of science where the scientist discovers "truth" through experiments, whereas "the scientific method" was, in most cases, described in idealized steps. Such stereotypical images of science (e.g., as an individual enterprise and a body of factual knowledge) have also been shown to be dominant in the views of many young school science students (Driver, Leach, Millar, & Scott, 1996).

To sum up, it is clear from our review on the role of text in school science classrooms that the science textbook has been and continues to be the dominant genre, often in relation to transmitting scientific "truths" or as a reference tool (e.g., Driscoll et al., 1994). Furthermore, student writing is often reduced to reproducing scientific knowledge being written for assessment purposes, coupled with little metadiscussion around the texts that are written (Af Geijerstam, 2006; Osborne & Collins, 2001; Yore et al., 2003). These are practices that rarely reflect the integral role of language and literacy in science nor provide explicit attention to the specific language conventions of science. This has caused researchers to call for students to increasingly engage with texts in ways that reflect the social practices of science (e.g., Goldman & Bisanz, 2002).

Research on Integrated Approaches to Science and Literacy. A number of experimental and quasi-experimental studies have documented increased science and literacy outcomes from integrated science-literacy approaches at primary and middle school levels, in contrast to more traditional or content-only science teaching (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Fang & Wei, 2010; Guthrie et al., 2004; Palincsar & Magnusson, 2001; Purcell-Gates, Duke, & Martineau, 2007). For example, Fang and Wei (2010) examined the effects of an inquiry-based science curriculum that integrated explicit reading strategy instruction and quality science trade books in 10 sixth-grade science classes over the course of two semesters. The participating students were randomly assigned to either inquiry-based science plus reading or inquiry-based science only. Students in the inquiry-based science plus reading group performed significantly better on standardized assessments to test scientific literacy—in both the fundamental and derived sense—compared to students in the inquiry-based science only group. This led the researchers to conclude that "the improvement in the students' reading ability (i.e., the fundamental sense of scientific literacy) might have contributed to the improvement in their derived sense of science literacy" (Fang & Wei, 2010, p. 270). Moreover, in a recent study by Cervetti and colleagues (2012), a wide range of literacy measures were applied to test their model of integration, which relied on engaging students in literacy practices directly linked to their firsthand investigations. They demonstrated favorable effects of their treatment model on science understanding, vocabulary use, and writing, but no effects on reading comprehension. Positive effects on reading comprehension have, however, been found in several similar studies (e.g., Guthrie et al., 2004).

In the *Guided Inquiry Supporting Multiple Literacies* (GisML) study, Palincsar and Magnusson (2001) engaged primary school teachers and students to inquire about natural phenomena through firsthand (hands-on) and secondhand (text-based) investigations. In their study, conversations with the participating teachers revealed concerns that the use of text might supplant learning that could be experienced firsthand (Palincsar & Magnusson, 1997). As a consequence of the teachers' concerns, a hybrid text genre called "the scientist's notebook" was developed to support students in making sense of their firsthand experiences. Comparing instruction from the notebook genre and instruction with that of more traditional text, Palincsar and Magnusson documented positive effects on measures of learning outcomes with the notebook group.

The work of Varelas and Pappas (Pappas, Varelas, Barry, & Rife, 2003; Varelas & Pappas, 2006) has explored dialogic inquiry in read-alouds of information books in two urban primary school science classrooms, paying particular attention to the intertextual links that students make during these read-alouds. Applying a broadly defined view of text, they found that intertextuality allowed students to draw on their everyday funds of knowledge and move toward scientific understanding and language, as they negotiated ideas in hybrid discourse patterns that resembled scientific argumentation and explanation. In another descriptive study, Howes, Lim, and Campos (2009) followed three primary school teachers, as part of a collaboration research project, in their efforts to integrate literacy into their inquiry-based science teaching. While all three teachers had similar views on scientific literacy and science inquiry, the role of literacy in their teaching differed. More specifically, the integration of science and literacy could, in some cases, result in the privileging of literacy learning over science learning, leading the researchers to conclude that not all forms of integration were equally supportive of students' involvement in inquiry. In light of these findings, they argued that "in linking literacy practices and science inquiry in the primary classroom, it is best to keep the focus on the scientific inquiry and place literacy practices within that inquiry" (Howes et al., 2009, p. 214).

Several studies further suggest that children's trade books may also be worthwhile tools for inquiry in the classroom (Ford, 2006; Norris et al., 2008; Pappas, 2006). Pappas (2006), for example, analyzed informational science books written for children and identified both typical informational text and atypical hybrid text categories in her selection of books. Moreover, she found that the typical informational texts were the best resources to help children learn science, as they were careful about expressing the distinctive social language of science, but that hybrid or atypical informational texts may also be useful, "depending on the extent to which they are used" (p. 246). Furthermore, Norris et al. (2008) concluded their study of Canadian commercial reading programs by acknowledging that it is the teacher who "is key to fully developing the potential offered by these selections" (Norris et al., 2008, p. 795). Their findings are consistent with those of Ford (2006), who examined how children's trade books represented the nature of science and scientists. Ford (2006) concluded that it may be more appropriate to think of trade books as potential resources for inquiry science curricula, where they become connected to the practices of science, rather than being transmitters of knowledge about the nature of science. We draw on this line of research to emphasize the importance of *how* a text is used to support science teaching and learning through inquiry, in addition to what kind of text is being read.

Recent research on integrating science and literacy through inquiry in primary and middle school supports the claim that students benefit from engagement with text as an integrated part of inquiry-based science instruction. However, there are few in-depth studies of how integrated science-literacy curricula is actually implemented, how these teachers and students engage with written text in the context of science inquiry, and how multiple literacies emerge in these settings (Cervetti et al., 2009; Hand et al., 2003; Pappas, 2006). Indeed, as Hand and colleagues (Hand et al., 2003, p. 609) point out,

> Various goals need to be shared on the agenda of the curriculum and instruction, educational psychology, language education, and science education research communities if we are to achieve Science Literacy for All. These include identifying the subsumed literacy practices in science literacy and the exemplary pedagogical practices when using literacy practices in science, understanding the cognitive benefits for students across different literacy practices, assessing students' understanding of science as a result of such literacy practices, and implementing literacy practices within science classrooms.

The Present Study

The present study seeks to answer the calls on how integrated science-literacy curricula is actually implemented within the classroom and used in the context of school science. To do so, we draw on NLS perspectives to investigate the literacy events and practices that students in six primary school science classrooms engage in during integrated inquiry-based science and literacy instruction. Empirically, we combine video observations from six classrooms, at four schools in the greater Oslo area and semistructured focus group interview data with 33 students to examine their encounters with and use of text in this setting. Textual artifacts (such as textbooks, assignments, student notebooks) have also been collected from the classrooms.

Specifically, the present study addresses the following main research questions:

- What are the prominent literacy events that students engage in during integrated science-literacy instruction?
- What do the students do with text in these events, and how do their vernacular and informal literacy practices influence the formal literacy practices of school science in this setting?
- What are the students' views of science and the role of text in science in this setting?

METHODS

To answer the research questions, a thorough analysis of video recordings from the six participating classrooms was conducted to identify literacy events in the material and the social purposes of using text in these events. Lately, the use of observational video data has become an increasingly powerful tool for investigating classroom practices in the educational sciences (Derry et al., 2010). In turn, we provide descriptive statistics of the literacy events in the data to show the full range and frequency of literacy events in our data—both typical and atypical (Erickson, 2012)—as a backdrop for examining how these events were embedded within the students' inquiry. We then combine interview data

TABLE 1
Information About Teachers and Students in the Study

Teacher	Grade	Years of Teaching Experience	ECTS Credits in Science	Number of Students in the Class	Interviewed Students From Group	School Location[a]	Time of Video Recordings (in minutes)
Anna	5	0–5	16–30	14	5	S	260
Betsy	1	11–15	16–30	18	4	R	165
Birgit	4	11–15	16–30	24	8	R	426
Cecilia	3	20+	16–30	19	4	S	455
Ellinor	3	11–15	31–60	16	8	R	224
Emma	3	20+	16–30	21	4	R	269

[a]S, Suburban; R, Rural.

and observational video data to gain information on the students' views about science and science text in light of the literacy events that they engaged in.

Participants and Context

Six teachers were selected for the Budding Science and Literacy research project from an in-service professional development course on inquiry science and literacy that took place over the course of a school year. The teachers were approached to participate in the video study based on their educational background, school locations, what grade levels they taught, and years of teaching experience, to provide a varied sample. Upon acceptance by teachers, the principals of the respective schools confirmed their schools' participation, following which the students in each class were asked to participate on the basis of parental consent. All participants in the study signed informed consent forms before the data collection commenced.

The six teachers in the study were all generalist teachers, i.e., teaching all or most subjects in primary school, with little formal science background (see Table 1). During the time of the data collection, they taught at primary grade levels ranging from first grade (6–7-year-old children) to fifth grade (10–11-year-old children), with three of the teachers teaching the third grade (8–9-year-old children). The participating schools were located in both rural and suburban areas of the greater Oslo area, but the students still come across as a relatively homogeneous group in an international perspective (cf. Kjærnsli & Lie, 2002). Table 1 summarizes information on the six teachers and their students.[1]

We then followed these teachers, and their students, near the end of the professional development course, when they were to teach a sequence of five to ten science lessons based on the *Seeds of Science/Roots of Reading* program (Cervetti, Pearson, Bravo, & Barber, 2006). The teachers were given access to instructional resources, detailed teacher guides, and translated reading materials from *Seeds of Science/Roots of Reading* through the professional development course, from which they could use or draw on in their teaching. The teachers were free to choose different instructional units to best adapt their teaching to the local curriculum, grade level, and students, but all were expected to include reading, writing, oral and practical activities from the curriculum material in their lesson sequences. All teachers used reading materials from the *Seeds of Science/Roots of Reading* material, but Anna also used the school's regular science textbook in her lessons.

[1]All of the names used in this research are pseudonyms.

Data Collection

The first author and third author along with two other researchers and two research assistants in the Budding Science and Literacy research project collected the data during the spring of 2011. The video data were generated from a four-camera setup designed to capture the events of the entire classroom, consisting of a whole-class camera, a camera that continuously followed the teacher, and two head-mounted student cameras. In this regard, the design of the Budding Science and Literacy research project builds on the design of prior video studies, such as the PISA+ video study (Klette, 2009). Student focus groups were selected in cooperation with the participating teachers to include both high-achieving and low-achieving students. The teacher then suggested a student in each of the two focus groups who was asked to wear a head-mounted camera. These cameras provided both audio and video from the focus groups and offered a unique glimpse into the experience of the student wearing the camera. Additional sound recorders recorded audio in both focus groups in case of camera malfunction. The use of head-mounted cameras has also been applied in other recent empirical studies to provide information on students' digital literacy practices during teacher instruction (Blikstad-Balas, 2012), and how upper secondary students applied theoretical knowledge of rocks and relative dating during geoscience fieldwork (Remmen & Frøyland, 2013). For a discussion on strengths and limitations associated with head-mounted cameras in school literacy research, see Blikstad-Balas & Sørvik (2014).

The total duration of video recordings used for the present study amounts to approximately 30 hours, with the duration of video recordings for each classroom presented in Table 1. To provide a more homogeneous sample, we chose to remove two lessons (83 and 85 minutes) from the total number of video recordings in the Budding Science and Literacy research project (cf. Ødegaard, Haug, Mork, & Sørvik, 2014), with teachers Anna and Cecilia, as they were recorded prior to the main lesson sequences. By doing so, we reduced the variation between the lesson sequences captured on video. The two lessons in question were also conducted as part of the professional development course, but differed in science topic from the rest of the lessons.

Semistructured focus group interviews were conducted with 33 students following the video observations. The interviewed students were mainly selected on the basis of being a part of the classroom focus groups (i.e., a student wearing a head-mounted camera or in the same sitting group as a student wearing a head-mounted camera). As the seating arrangements varied from classroom to classroom, the number of students interviewed from each school differed along with how they were seated. In most cases, students sat in pairs or in groups of four. Group interviews were conducted to ensure an open atmosphere and were given particular emphasis due to the young age of some students. The interviews were structured around artifacts (e.g., a science text or book, practical equipment, or texts produced by students being interviewed) that the students had encountered in the observed science lessons to help elicit their views and experiences regarding science, school science and science texts, as well as their conceptual understanding. For this particular study, we used the interview data to support our interpretations of prominent literacy events in the classrooms, and to gain information on students' views, attitudes, and feelings toward science and science text. The interviews were audio and video recorded and transcribed verbatim.

Finally, the aforementioned textual artifacts were also collected from the classrooms in the study. By textual artifacts, we refer to the physical objects used or produced in the classroom (cf Borko, Stecher, Alonzo, Moncure, & McClam, 2005). These could be textbooks, concept maps, digital presentations, written assignments etc. However, as textual artifacts, by themselves, do not necessarily provide information on how they were used, their main function in the present study was to complement the video analysis by identifying the texts involved in the events, and in some cases, as a stimulant in the student interviews.

Data Analysis

The data analysis was performed in three main steps. First, the first author coded the video data with Mangold Interact coding software[2]—a tool for the systematic logging of observational events with onset and offset times for each coded event—to identify *literacy events* that occurred in the six classrooms in the study. Coding the video data thus allows for close attention to be paid to specific literacy events in our data material with regard to their typicality (or atypicality) and context within the material as a whole. The video analysis was mainly performed on video data from the whole-class camera, while the teacher camera and head-mounted cameras were consulted in situations where the whole-class camera could not provide accurate information.

Within any study examining the use of literacy in the classroom, the question of what constitutes a literacy event is crucial. For the purpose of this study, we operationalized literacy events as observable episodes in which social interaction revolved around written text (Barton & Hamilton, 1998). Accordingly, we also took this to include *talk about texts* (Wells, 1990), as well as other means of communication, such as gestures, that involved text (e.g., holding up a piece of writing in front of the class or pointing to a word on a concept wall as that word is being spoken; Lemke, 1998). We defined the start of a coded literacy event as the occasion when a text was first referenced, verbally or nonverbally, and the end-time as the end of the last connected utterance that made reference to the same text.

To identify and categorize literacy events in the data material, we used the texts that were present in the classrooms as a fixed entry point for our analysis. Based on repeated viewings of the video data and the collected textual artifacts, coding categories (e.g., *informational text* or *graphs, figures and models*) were then developed in accordance with relevant literature on school science texts (e.g., Duke et al., 2011; Pappas, 2006). These coding categories are described in Table 2. For coding purposes, we chose to define the coding categories as mutually exclusive. As such, a code was applied on the basis of the primary characteristic of the observed text (e.g., only the code, *Student writing,* was applied if the students produced a text (individually or in cooperation with the teacher), whether or not they constructed a graph or wrote an informational text). This worked well in relation to our data material, but might become more problematic in other school contexts (e.g., higher grade levels) if students are interacting with different or multiple texts at the same time. Furthermore, to ensure the reliability of our coding categories, the first and second author each coded a subset of the material, which yielded a kappa value of 0.81. According to Banerjee, Capozzoli, McSweeney, and Sinha (1999, p. 5), kappa values "greater than 0.75 or so may be taken to represent excellent agreement beyond chance" whereas values between 0.4 and 0.75 represent fair to good agreement.

There are two additional aspects of the coding categories that require further clarification. First, our coding categories distinguished between *fictional narratives* and *informational texts*, but also *hybrid informational texts*, to cover a range of text genres that students may encounter in the classroom (cf. Duke et al., 2011). Hybrid informational texts were here used to refer to atypical informational texts that incorporate elements from different genres,

[2]http://www.mangold-international.com/software/interact/.

TABLE 2
Subcategories Within the Main Coding Category Text

Subcategory	Description of Subcategory
Fictional narratives	Narrative text that does not aim to communicate scientific information (e.g., story books or fictional films)
Hybrid informational text	Atypical informational text that incorporates elements from different genres (e.g., narrative, poetry) to communicate scientific information
Informational text	Typical informational text, such as traditional science textbook texts and authentic science texts
Internet	Text that is accessed online in the classroom
Orienting text	Concept walls, learning goals on blackboard, work plans, written instructions, etc.
Graphs, figures, and models	Explicit focus on visual representations of scientific information
Student writing	Texts produced by the students. This subcategory also includes texts co-produced by teacher and students (e.g., if the teacher constructs a text on the blackboard in cooperation with the students)
Other	Texts not included in the previous subcategories (e.g., digital quizzes)

such as stories, biographies, or poetry, to communicate scientific information (Pappas, 2006). Second, the subcategory *Internet* might also be somewhat problematic in terms of coding. For example, what would happen if students read an informational text online? Owing to the central role of the Internet for young people's lives today (Livingstone, 2009), we chose to apply this code whenever a text was accessed online in the classroom (see Table 2), regardless of the text they accessed.

The second analytical step involved analyzing the coded literacy events, through *analytic induction* (Erickson, 2012), in search of emerging patterns and themes across and within literacy events. In other words, we iteratively reviewed the video-recorded literacy events captured by the whole-class camera and the head-mounted student cameras to consider how the students used text, and progressively evaluated our interpretations and assertions along the way. Drawing on sociocultural perspectives on literacy, we began by considering the contexts that were relevant to the students' interactions with text in the identified literacy events, most notably those of students' daily lives, school, and science. This led us to search for events in which the students relied on elements of informal literacies in the formal context of school science, as well as events that were more typically "schooled," and come up with tentative categories for school science literacies in these classrooms. Comparing literacy events in and across the six classrooms gradually developed these categories and further informed our understanding of the role of text in these classrooms.

In the third and last step, we analyzed the interview transcripts, using *meaning condensation* (Kvale & Brinkmann, 2009), to uncover some of the attitudes, feelings, values, and social relationships toward science and science text among the students. These are central aspects to the concept of literacy practices (Barton & Hamilton, 1998; Street, 1995), but not necessarily readily observable from observational video data. We then triangulated the interview data with data from the video observations and textual artifacts to get a fuller understanding of the students' literacy practices in the context of integrated science-literacy instruction.

Finally, it should be noted that the inclusion of quantified measures to describe the texts that students encountered in the six participating classroom is not an attempt to generalize findings (cf. Maxwell, 2010). Rather, counting literacy events is used to show the range of texts students encountered and to be able to discuss the relative frequency and typicality of specific literacy events (Erickson, 2012). The six classrooms in the study were purposefully chosen, and the resulting findings cannot be statistically generalized, only *analytically* generalized, which is a central limitation to the study. This means that "the findings of one study can be used as a guide to what might occur in a another situation" (Kvale & Brinkmann, 2009, p. 262) in relation to theory and based on a thorough analysis of the contexts and similarities of the two situations, but not generalized to a larger sample.

RESULTS

Literacy Events in the Data Material: What Texts Did the Students Encounter?

The primary video analysis showed that the students in these classrooms engaged in literacy events centered around a wide range of texts, including science textbooks, trade books with typical science informational text, atypical science trade books that utilized poetic devices (such as repetition and thought experiments), texts and diagrams posted on concept walls, digital quizzes, charts and tables for registering and analyzing data, models of the digestive system, labels on cans of baking soda and other dry goods, Google and Google Images, teacher notes on blackboards or interactive whiteboards, fictional narratives in the form of movies, a fable and a *Donald Duck* comic book, and their own writing produced in class. Table 3 presents the frequency and duration of the coded literacy events for all of the

TABLE 3
Frequency of Occurrence and Duration of Coded Literacy Events: All Classrooms

Text Type	Events	Time	Percentage of Total Time	Mean	Maximum Duration	Minimum Duration
Fictional narratives	4	00:02:13	0.1	00:00:33	00:00:57	00:00:07
Hybrid informational text	15	01:01:19	3.4	00:04:05	00:27:33	00:00:12
Informational text	57	03:34:04	11.9	00:03:45	00:45:22	00:00:03
Graphs, figures and models	21	00:37:08	2.1	00:01:46	00:09:37	00:00:06
Internet	4	00:03:01	0.2	00:00:45	00:01:08	00:00:23
Orienting text	132	00:52:12	2.9	00:00:24	00:03:31	00:00:01
Student writing	95	09:17:20	31.0	00:05:52	00:38:34	00:00:06
Other	7	00:33:51	1.9	00:04:50	00:12:56	00:00:20
Total	335	16:01:08	53.5	00:02:52	00:45:22	00:00:01

classrooms in the study. The most prominent texts in the six classrooms were the students' own writing (31.0%), along with typical informational texts such as textbooks or trade books (in print or projected onto whiteboards) (11.9%). The most frequently occurring texts, however, were orienting texts, such as assignments written on the blackboard or key concepts and questions written on concept walls. These events were often limited to short intertextual connections as students engaged in practical activities, before reading and writing sequences, or at the beginning and end of the lessons. This could be the teacher pointing to a note with a key concept written on it as she pronounced that word or the teacher reminding students of the class rules for peer discussion. The limited amount of time spent on these orienting tasks explains the high frequency ($n = 132$) and low percentage of time (2.9%) related to these events. In total, text use accounted for 53.5% of the total time of video observations.

While there were individual variations between the six classrooms, we mainly rely on the primary video analysis to be able to discuss particular literacy events in the larger context of our data material. Individual variations between the six classrooms in the study are, however, listed in the Appendix.

Emerging Literacy Practices: What Did the Students Do With These Texts?

Analysis of the 335 coded literacy events revealed two main sets of emerging literacy practices that the students took part in: *science-in-school* and *school-science-only*. These two categories distinguished themselves, from an NLS perspective, in terms of the contexts in which these ways of using written language gain meaning. Here, we use *science-in-school* to refer to practices that shared characteristics with literacy practices associated with science; but, being in a school setting, they were also clearly influenced by the students' informal literacy practices and their idiosyncratic backgrounds. *School-science-only*, on the other hand, is used to refer to literacy practices that were typically restricted to the context of formal schooling and school science and included few opportunities to transcend this context. The complex presence of both formal and informal elements in the school science literacies documented here, especially within the category science-in-school, recalls Maybin's (2007, p. 517) study, in which "official literacy activities were not necessarily 'schooled' and the unofficial activities were not completely vernacular." In our case, however, the inclusion of scientific knowledge and practices adds another dimension to this relationship (i.e., whether an activity is formal or informal to science, as well as to "school"). It should also be noted that there were a few occurrences of primarily unofficial literacy practices in our data material, where students were simply off task (e.g., scribbling or writing in the margins of their notebooks). This was, however, quite rare and only identifiable from the head-mounted cameras or, indirectly, from the textual artifacts. In what follows, we describe and provide examples of school science literacies that emerged in the six classrooms in the study, with emphasis on how both informal and formal literacies were central to the category science-in-school. An overview of the two main categories is presented in Table 4.

Within the category science-in-school, four practices involving text emerged as dominant across all or most of the participating classrooms: (i) establishing a collective knowledge base, (ii) reading for evidence, (iii) visually representing scientific information, and (iv) communicating findings to an authentic receiver. In the classrooms of the study, these practices could be said to transcend the contexts of home, school science, and science, based on how elements of formal and informal school science literacies were combined in the dialogic process of inquiry.

TABLE 4
Emerging Literacy Practices in the Classroom: Examples of Science-in-School and School-Science-Only Categories

Category	Emerging Literacy Practice	Example of Literacy Event	Example of Formal Element	Example of Informal Element
Science-in-school	Establishing a collective knowledge base	A2–A4: Teacher and students are making a mind map on the concept of forces.	Teacher and students include what they did in the last science lesson or have read in the textbook.	Students include information from movies, TV shows and their everyday experiences.
	Reading for evidence	C31: Student suggests using Google Images as a source of data to consider whether hummingbirds have two or four limbs.	Students use data as evidence to make an inference.	Teacher and students use a student-initiated and everyday way of locating information, i.e., Google Images, to collect data.
	Visually representing scientific information	Bi30: Students design ball sorting systems in groups.	Students design a system to address a problem, add labels, and draw on knowledge generated from a practical activity in a previous science lesson.	Students add features based on personal experience and play into figures, e.g., themselves, vivid colors, speech balloons.
	Communicating findings to an authentic receiver	Bi31–Bi35: Student groups present ball sorting systems to the other groups.	Students present posters with ball sorting systems to their peers, and discuss the ideas presented.	Students place emphasis on what was the most fun, or discuss the ideas presented in light of their everyday experiences.

(*Continued*)

TABLE 4
Continued

Category	Emerging Literacy Practice	Example of Literacy Event	Example of Formal Element	Example of Informal Element
School-science-only	Daily routines	C6–C7: Teacher writes the date and day of the week on the blackboard. Students write it in their notebooks.	Students copy the week day and date into their notebooks.	Few or no informal elements.
	Learning structures	A21: Teacher advices students to look at the concept wall if they need help to answer a question.	Students read the explanation of a scientific concept from the concept wall.	Few or no informal elements.
	Documenting a task	E35: Teacher asks her students to write a log ("What you need to write is what we did yesterday")	Students write what they did in the previous school lesson.	Mainly unofficial or off-task informal elements.

The most prominent pattern across all classrooms was how students built on and produced a wide range of texts *to establish a collective knowledge base* in the classroom. Whereas scientists predominantly rely on background knowledge of their field of research and peer-reviewed journal articles to generate research questions and design studies (Bazerman, 1988; Yore et al., 2002), these students used school scientific knowledge and texts, their everyday experiences, and relevant texts from outside the context of school science, often in collaboration with their teachers, for a similar purpose. For example, students in Anna's classroom (see Excerpt 1) introduced fictional narratives in the form of movies, TV shows, and a fable to the making of mind maps on *forces* and *evidence*. In these events, the students built on texts that were clearly not intended for science or school science, but instead were relevant to the students to make important connections between their own experiences and the scientific ideas being introduced in the classroom.

Excerpt 1:

Teacher:	Is there anything else you think of when you hear the word force, or forces? You can say whatever you want. [Pause] What do you think of when you hear that word? Emilia.
Emilia:	Eh, superheroes.
Teacher:	A superhero, alright. Superheroes [Writes *superheroes* on whiteboard]. Anyone else? Andreas.
Andreas:	Star Wars.
Teacher:	So you think of Star Wars [writes *Star Wars* on whiteboard].

(A4-A5)[3]

In Excerpt 1, it was a student, Andreas, who introduced and connected *Star Wars* to the scientific idea of forces. In Ellinor's and Emma's classrooms, however, the students were asked to read a specifically designed hybrid text to support them in thinking about their everyday experiences in a new way (cf. Cervetti & Barber, 2008). Thus, this text was "sponsored" by the teacher, but used in a way that elicited talk and ideas that concerned students' home worlds and everyday experiences around certain scientific concepts (e.g., after reading about the properties of different materials, one student said how he had noticed that "during winter, glass is cold, and during summer, glass is warm"). Again, there was a combination of formal and informal elements involved in the reading of this text, but, in this case, it was the talk around a text introduced by the teacher that allowed for the students' own experiences and ways with words to be incorporated into the classroom discourse.

A second central practice in the participating classrooms concerned how students used text *to read for evidence*, by seeking and evaluating information or by making observations from pictures in the texts. This was mostly done in scaffolded read-alouds or paired readings with texts suggested by the teacher, and accordingly relied mainly on formal elements. In Cecilia's third-grade classroom, however, there was a sequence of events that was initiated by one of the students. The student, John Olav, suggested that they could use Google Images to search for evidence of whether a hummingbird has four limbs, something the class was unable to determine from watching a video the teacher had played for them. At first, the teacher hesitated and replayed the video. In the excerpt below (Excerpt 2),

[3]References related to transcripts and interview quotes in this article refer to the specific literacy events from the video coding and to the codes assigned to each focus group interview.

we see how John Olav once more suggests that they find an image of a hummingbird as evidence:

Excerpt 2:

Teacher:	Are there any legs here?
Students:	[Indistinct chatter] Yes ... No ...
John Olav:	Can't we just get a picture? It's so much easier.
Teacher:	We're going to ...
John Olav:	... get a picture of it.
Teacher:	... try what John Olav suggested.
Lars:	What did John Olav suggest?
Teacher:	To see if we can find a picture of it. [Turns to the computer and types *hummingbird* in the Google search bar] Hum-ming-bird. Then we go to Images.
Kine:	Oh, what lovely pictures.
John Olav:	It has legs.
Erlend:	They're so small.
John Olav:	Yeah, they're like really skinny and small.
Emilie:	It has legs.
Erlend:	Yeah, but I did see that ... hello ... you could hardly see it. It went like this [imitates a hummingbird by quickly flapping his arms], inside the flower. (C31)

From this point on, the class continued to use Google Images as a source of information to gather data (e.g., on the different characteristics of wolf and fox tails) and discussed how they had used Google to search for evidence. This made it a prominent sequence of literacy events in this particular classroom, even though the events were atypical to the data material as a whole. What is especially interesting about this sequence of events is that it represents an informal and student-initiated literacy practice that was picked up and reinforced by the teacher, thereby making the informal somewhat formal in this particular classroom. By being picked up by the teacher, it also became a valued practice in the classroom for the purpose of locating information to use as evidence. This demonstrates particularly well how disciplinary literacy instruction builds on elements of both informal and formal literacy experiences, where many practices have value across contexts (Hand et al., 2003).

A third practice across the classrooms focused on the multimodal literacies that the students took part in, as the students regularly used, constructed, and revised figures and models *to visually represent scientific information* in different stages of their inquiry. For example, students made figures of the physical models or the natural phenomenon they worked with, constructed models of different systems, filled in worksheets and tables to organize and represent the data they collected, and revised or built on these texts to communicate their findings. Hence, the students used a wide range of inscriptions both in the process of meaning making and as a representational tool for others (Windschitl, Thompson, & Braaten, 2008). Even though the students produced texts that are typical to science representation and communication, the texts were clearly shaped by the students' diverse backgrounds and personalities. This was evident in how the students incorporated elements of play and art in the making of these school science texts, for example, by applying vivid colors, excitedly including miniature representations of themselves or other students ("And that's me!"), or adding speech balloons, while also being less attentive to formal issues such as scale.

Figure 1. Four still photographs from head-mounted cameras. (A) A student in Birgit's class produces a figure of a physical model they made in class. (B) One of the student groups in Birgit's class prepares their model of a ball sorting system. (C) A student in Betsy's class looks at her figure of the stomach and the esophagus. (D) A student in Cecilia's class draws a hummingbird on the back of an assignment sheet.

On the basis of their engagement with these texts, we interpret these aspects of the students' own multimodal texts as indications of them taking ownership over the work and disciplinary problems they were pursuing—a central feature to Engle and Conant's (2002) idea of productive disciplinary engagement. In Figure 1, four still photographs from head-mounted cameras are used to illustrate some of the aspects present in the students' own texts. In Figure 2, a student text from Betsy's class is presented to illustrate how one first grader added more personal and informal—but highly relevant—elements (i.e., a toilet bowl) to the formal practice of making a visualization of the digestive system. While these findings represent only part of our focus on the school science literacies that emerged in the participating classrooms, they invite more in-depth study into the ways in which students' creativity and informal practices can support science learning in both material and literate school science practices.

The fourth, and final, practice in the science-in-school category involved students' producing and using text to *communicate their findings to an authentic receiver*, who in most of the classrooms were their peers. For instance, the students used a variety of multimodal texts (e.g., posters, written scientific comparisons, tables) in oral presentations to the other students in the class, or, in Betsy's first-grade class, to the principal. As the students used their own multimodal texts to communicate their findings, many of the same informal elements that were present in the making of these texts played a part in the oral communication

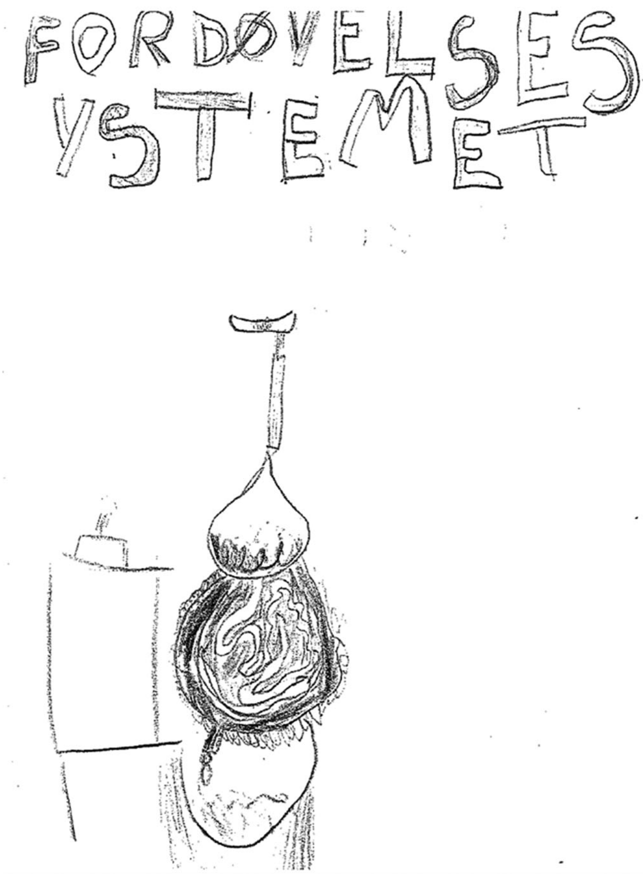

Figure 2. A student text from Betsy's first-grade classroom: "The digestive system." Betsy's students were given the task of making figures of the digestive system. One of her students used his figure to connect the digestive system with the cross section of a toilet bowl and the toilet's water tank.

of them as well (e.g., pointing out their own place and function in the ball sorting systems if they had included miniature representations of themselves). In Birgit's class, more emphasis was given to communication and discussion compared to the other classrooms (see Ødegaard et al., 2014, for a detailed description), and each oral presentation was followed by a whole-class discussion. Similar to how the students' idiosyncratic backgrounds and informal literacies influenced how they established a collective knowledge base, it was also clear that Birgit's students incorporated various funds of knowledge into the discussion and argumentation around these posters and ideas. For example, the students put much emphasis on what they considered the most fun, but also connected their models to practical work and concepts from previous science lessons. In one of the more interesting examples from these discussions, Birgit and her students talked about a turning wheel in one group's design, which Markus then connected to the depiction of a watermill's water wheel from a comic book: "They have them in Donald [Duck comics], those drawings, that was what Alexander talked about. There are these drawings of a big river and then there's a wheel that revolves somehow." Guided by the teacher, they went on to talk about the function of a waterwheel and what the function of the turning wheel in the ball sorting system had to be.

While the source of Markus's information is distinctly informal to science, his contribution still helped advance the argumentation for how a turning wheel had to function in the ball sorting system that was presented, and helped link the discussion to the students' everyday lives.

Somewhat in contrast to the science-in-school literacies, students also engaged with text for what we refer to as *school-science-only* literacies—ways of using text that were typically restricted to the context of formal schooling in science. Most of these events were related to the frequent use of orienting text in the classrooms (see Table 3). This included the *daily routines* of a primary school classroom, such as going over the class schedule or writing the day and date on the blackboard, but also the various *learning structures* that the students interacted with during the lessons. The most notable of these were the use of concept walls in five of the six classrooms, but various templates, afforded to the students to support them in different tasks during their inquiry, were also common (e.g., working with an anticipation guide before reading a text). The concept walls mainly contained key concepts, sentences, and questions, which were often read aloud, or referenced throughout the investigations. Although these literacy events rarely transcended the formal context of schooling, we do not believe that the students' encounters with these texts should be interpreted as being without value to their engagement with inquiry. Rather, in our opinion, they represented literacy practices that are distinct and often confined to school or school science, but also provided explicit attention to the concepts, practices, and nature of science, and were thus important learning and support structures for the students in making sense of these practices of science and their findings.

There were also events in our material that resembled more traditional school science literacy practices, which focused on reproduction of scientific knowledge. In the most prevalent of these the students wrote *to document a task*. These events were often decontextualized and without a clearly stated audience or purpose for the activity. For example, in Ellinor's and Emma's classrooms, students were asked to write logs at the end of their investigation into which ingredients make the best glue, but there was little talk about what constitutes a log in science. The two teachers later reported to us that log writing was a common practice at their school, so they had decided to incorporate it into their students' inquiry. However, without a clear purpose for writing logs at this point in their inquiry, most of the students started to copy the hybrid texts they had read in the first lesson into their logbooks. In this way, the lack of framing of the activity did not provide opportunities to transcend the context of school science, as it was neither a meaningful scientific practice nor was it meaningful for the students' everyday lives. Events like these further emphasize the importance of embedding literacy activities purposefully within students' inquiry.

To sum up, it is clear that there was a complex relationship of informal and formal elements making up the school science literacies that emerged in these six school science classrooms. In the category science-in-school, students' informal ways with written language became potential resources in the dialogic process of inquiry, which allowed these literacy practices to transcend the contexts of home, school science, and science. In the category school-science-only, students engaged with text in ways that are rare outside a school setting. Many of these practices were, however, still important structures for learning and for guiding the students in their inquiry. We believe that this makes the complex relationship of formal and informal elements in the literacies of school science important to consider when discussing what literacy is in school science and what "counts" as the fundamental sense of scientific literacy at a classroom level.

Student Views About Science and Science Text in an Integrated Science-Literacy Setting

Prior research has shown that students in these age groups often portray science as a body of "factual" knowledge, and the work of scientists as "that of the individual scientist undertaking his or her work in isolation" (Driver et al., 1996, p. 140). What was especially of interest in this study, due to the explicit focus on literacy and science inquiry in these classrooms, was how the students reflected on the role of formal science texts in science and school science, and how this compared with their own notions of science. In the following, we combine interview data and video observational data to report on the students' views and experiences in light of the literacy events reported in the two previous sections.

In their talk about text from video observations, as well as in the following interviews, most students showed signs of stereotypical images of science and scientists. However, about half of the students also identified aspects of the social practices that scientists take part in. In the semistructured focus group interviews, we asked the students how their recent work at school resembled the work of scientists, to elicit their views related to science and the work of scientists after working in an inquiry-based setting with explicit focus on literacy in science. One of the students in Anna's fifth-grade class, Andreas, demonstrated the expectation he had of scientists prior to the integrated science-literacy lesson sequence.

Andreas: I actually thought that scientists would work in a different way, but . . . I thought more of, like, mad professors who worked with chemicals and stuff.
(A-2, 5th grade)

The most strongly articulated feature, in all focus groups, to this question was still the emphasis that students placed on practical activities. For example, students commonly suggested how they "checked to see if it works," "mixed and tested things," or "looked at [mounted] animals." Besides practical activities, students' comments also reflected the social and literate practices of scientists to some degree. While their comments clearly indicated that they did not view science as an individual enterprise, they mainly related their own ways of working to the work of scientists in terms of the more local social practices that scientists engage in—like working in teams—or in the way that reading and writing are central to their work, but not necessarily acknowledging science as a larger discourse community. For example,

Markus: We designed different systems [to sort different ball sizes] and agreed on one system.
(Bi-2, 4th grade)

Maria: They [scientists] read to find things out, and so did we today.
(A-2, 5th grade)

Ingrid: We talked a lot.
Anand: That's something that scientists do.
(Bi-2, 4th grade)

The collaborative aspect that Markus commented on in the interview was also prevalent from the classroom video data when his group was asked about the ball sorting system they had designed:

Excerpt 3:

Sara:	Was it fun [making the ball sorting system]?
Sofie:	Yeah.
Sara:	What did you have the . . .
Sofie:	. . . but it took a long time.
Sara:	What did you have the most fun doing?
Markus:	Finding things out.
Alexander:	Drawing.
Sofie:	Yeah, because we used . . . used . . . everyone's ideas to . . . Alexander had the idea about the pipe, I had the idea about that pump up there, and Markus had the idea about this [points to boxes with differently sized filters on top].

(Bi32)

Even though most students in the focus group interviews recognized that reading, writing, and talking are central to science and the work of scientists, they were less certain of the purposes for which scientists read and write, as well as why they themselves, in some cases, had written or read certain texts. In two of the classrooms in the study, Ellinor's and Emma's, the students wrote logs after having investigated and examined different ingredients to make glue. In the focus group interviews, however, it soon became clear that the students had not understood the purpose for writing these logs—at least not a scientific purpose for writing them. To our surprise, it was when we asked students in these two classes about creativity in science and school science that several of them mentioned writing logs; Henrik, for example,

Henrik: Yeah, when we . . . when we had to write logs. I at least used a lot of imagination.

(E-1, 3rd grade)

Henrik's comment illustrates how the students in these two classes did not grasp the purpose of writing logs in a scientific context. This interpretation was further reinforced in the video observations, as the students continually questioned what they should write in their logs, and many started copying information from the hybrid text they read in the first science lesson on the topic. With a clearly stated purpose, however, writing logs can, for example, be used for expressive writing of the inquiry process, where students can include their thoughts and reflections as a way of documenting and making sense of their experiences. Expressive writing is considered an important phase in the meaning-making process and can be used to scaffold more formal science writing, like a report or a procedural text (Keys, 1999). However, as these students started writing their logs after they had finished testing their four types of glue, it might have been a more sensible choice to support them in writing a text that, at this stage, aimed to communicate the results of their inquiry to a clearly defined audience (e.g., to their peers, to compare and discuss their results).

A distinct aspect of students' views about school science texts and textbooks, which became clear from the video observations, was how school science textbooks can be perceived as authorless. This was particularly evident in one episode in Cecilia's third-grade classroom. The episode took place at the beginning of a lesson, as Cecilia explained to her students that they were going to talk about why illustrations and captions are used in science and school science texts. As illustrated in the excerpt below, one of her students, Eivind, interrupted her to voice his astonishment that there were actually authors writing science textbooks. Unfortunately, in this case, it was a missed opportunity for Cecilia to address this misconception:

Excerpt 4:

Teacher: And now we're going to talk about something called illustrations or captions . . . *and* captions [holds a trade book up in the air and points to the whiteboard where the book is also projected]. And we are going to talk about why the author thought it was important to have all these pictures in this book . . .

Eivind: [interrupts] Do books like these have authors?

Teacher: [waits] And if we turn to pages ten and eleven.

(C81)

The surprise that Eivind expressed in this episode might be interpreted as an indication of his experiences with a more traditional school science teaching practice, in which the textbook is mainly used as an apparently neutral transmitter of established scientific knowledge. School science textbooks are also often written in impersonal and authoritative language (Fang, 2006), which may contribute to such a view of science textbooks. It is also clear from the excerpt that Eivind knew that books are usually written by an author (as he uses the term *author*), but that this book—and others like it (i.e., school or science textbooks)—was something different from books written by authors. Such a view of science texts and textbooks, which fails to recognize that they are, in fact, written by authors educated in science, usually with the purpose of communicating scientific information for formal education, is noticeably at odds with what is at the heart of scientific literacy. We see this example as another indication that being explicit about the audience of a text and the purposes for reading and writing scientific texts is key for scientific literacy instruction in its fundamental sense. It should also be mentioned that even though Cecilia saw Eivind's question as a disruptive outburst, the entire lesson actually centered on specific textual features of science text and why the author had chosen to illustrate information with pictures and captions as well as running text. This episode does, however, emphasize the importance of taking account of students' views on the role of text in science and school science, particularly if students eventually are to use scientific information from a range of sources in their inquiries at higher grade levels in school or for dealing with scientific information in their daily lives.

DISCUSSION AND CONCLUSIONS

It is clear that students use literacy in a myriad of different ways in the context of school science. In the present study, we saw how multiple literacies emerged during integrated science-literacy instruction, where elements of students' informal literacies became valued resources in the dialogic process of inquiry. More specifically, the participating students engaged in literacy practices that transcended the contexts of home, school science, and science—in what we have called *science-in-school* literacies. They also engaged in literacy practices confined to the context of school science—or *school-science-only* literacies—that were more "schooled" in the traditional sense. These two categories reflected a key aspect of how school science literacy was framed in the observed lesson sequences, namely that they attended to markedly different purposes in the classroom. Whereas examples of the latter category, in most cases, acted as learning structures or typical classroom routines, such as reading definitions from a concept wall, the former category was embedded in the students' inquiry process, which helped situate literacy in contexts that appeared to be meaningful and engaging to the students.

In contrast, prior research on the role of text in school science classrooms has shown that students mostly use text in practices associated with formal schooling, such as copying information from the textbook and blackboard or answering textbook questions (e.g., Danielsson, 2010; Driscoll et al., 1994; Osborne & Collins, 2001). In terms of the present study, these are further examples of practices that are mainly confined to the context of school science (i.e., *school-science-only*). Not only are these types of reading and writing activities largely undemanding and potentially disengaging (Osborne & Collins, 2001), they also neglect the epistemic and social dimensions of using written language in science (Norris & Phillips, 2003). Hence, the findings in this study illustrate new potential roles for text in primary school science, and ways of engaging with these texts, that extend beyond the mere context of school science. This does not mean that literacy practices confined to a school-science-only context are without value; rather, it depends on the purposes these practices serve in the classroom (e.g., learning structures, assessment). Still, science education for scientific literacy needs to be relevant to students' daily lives and transcend their idiosyncratic experiences, as well as the academic disciplines of science (Wickman, Liberg, & Östman, 2012). In light of the present study's focus on literacy, this indicates that it is central for students to engage in multiple literacies in school science and for teachers to consider how different literacies emerge in their local classrooms.

Furthermore, Maybin (2007) has previously argued how students' literacy practices in school cut across the school/vernacular distinction that is prevalent within NLS. This was also the case in our material, but the focus on integrated science-literacy instruction further complicated and opened up this distinction. For example, within the science-in-school category, students in these classrooms suggested and shaped literacy practices that were incorporated into their inquiry and classroom discourse (such as searching for images on Google Images). Other studies have pointed to the emergence of similar hybrid discourse patterns that share characteristics with scientific reasoning and argumentation as primary school students engage in dialogic inquiry around informational texts (Varelas & Pappas, 2006). In this study, such patterns regarding primary school students' use of text were prominent as the students engaged in school science inquiry. In line with Varelas and Pappas (2006), we consider it crucial to include and acknowledge students' everyday funds of knowledge and their experiences with literacy outside a school context. Allowing students to build on their vernacular and informal literacy practices, when moving toward the literacy practices and language of science, might make this move easier—and perhaps contribute to diminishing students' perceived difference between their vernacular literacy practices and the practices that are valued in school science and science.

Because developing digital competencies is an explicit part of the Norwegian curriculum at all levels, in addition to the immense influence of information and communication technology on young people's lives today (Livingstone, 2009), we found it a bit surprising that the Internet was almost completely absent in the participating classrooms. However, it was not specifically emphasized in the curriculum material provided to the teachers. The Internet was only present in Cecilia's classroom, in which a student initiated a sequence of events around Google Images, even though it could be expected that the Internet, in some ways, is visible in any classroom or curriculum material in today's digital media age. In Cecilia's classroom, the use of Google Images first became a valued practice after being picked up by Cecilia, but this particular sequence of events illustrates well how it is possible to bridge literacy practices that are relevant to students' daily lives and to science in primary school settings. Moreover, digital media has become integrated in most aspects of students' daily lives outside of school and is central to their everyday experiences with literacy. In Norway, for example, 2009 marked the first year that Norwegian youth (ages 16–24) spent, on average, more than 9 hours per day with various media (Erstad, 2010). Science communications and media reports of science are increasingly being made available and accessible online as well, which must then be evaluated and judged by the reader (Julien & Barker, 2009; Kolstø, 2001). This implies that supporting students in making sense of scientific information across both media and contexts will be central to scientific literacy in the 21st century. We therefore believe it is important to further explore the possible connections between digital literacy, scientific literacy and school science inquiry across grade levels as one area of future research in school science classrooms.

New roles for text and new ways of engaging with text also bring about new demands on students as they negotiate the inherent meaning of these texts and practices in the classroom. The students in our study expressed stereotypical or naïve views about science and science text, but many also acknowledged certain social aspects of language use in science. The case of Eivind, however, who questioned whether or not the science trade book used in Cecilia's classroom actually had an author, illustrates how text in school science can be perceived by students if we do not explicitly address the social aspects of language use in science. This was also the case with students in Ellinor's and Emma's classrooms, who did not appear to differentiate between scientific log writing and writing in other subjects. We fully agree with Wickman et al. (2012) that engaging with scientific information in a critical and scientifically literate way involves recognizing that science texts have both a sender and receiver, and that they are written for a purpose. Our data indicate that paying explicit attention to these aspects is key to situating literacy in the context of school science, as they were not always clear to the students in our study. Moreover, literacy activities in which students read or write for "authentic" purposes have been shown to be "impressively related" to primary school students' degree of growth in their abilities to comprehend and produce informational texts (Purcell-Gates et al., 2007, p. 41).

In closing, this study emphasizes a view of literacy in school science classrooms that is embedded in the social practices associated with school science, and by extension, science (Lemke, 2004). It is in these contexts that the texts, language and discourse of science most easily makes sense, and in these contexts that critical and scientifically literate engagement with science text attend to central aspects of the social and epistemic dimensions of science. Hence, we argue that if we are to support students in developing literacy practices that are meaningful for becoming critical consumers of science, we must support them in identifying and engaging in these practices as an integral part of engaging with science and scientific practices in school. This includes building on students' informal literacy practices and experiences with literacy and science in their daily lives, identifying what "counts" as literacy in school science, and providing explicit attention to the representational and communicative aspects of science and school science, of which the genres and social languages of science and school science work to fulfill.

APPENDIX: FREQUENCY OF OCCURRENCE AND DURATION OF CODED LITERACY EVENTS IN INDIVIDUAL CLASSROOMS

	Teacher/Classroom											
	Anna		Betsy		Birgit		Cecilia		Ellinor		Emma	
Text Type	Events	Time	Events	Time	Events	Time	Events	Time	Events	Time	Events	Time
Fictional narratives	3	00:01:16	–		1	00:00:57	–		—		–	
Hybrid informational text	–		–		–		–		8	00:29:50	7	00:31:29
Informational text	14	01:10:20	3	00:18:58	3	00:05:16	31	01:47:00	4	00:08:22	2	00:00:28
Graphs, figures and models	5	00:15:10	4	00:13:07	6	00:05:29	4	00:01:29	1	00:00:43	1	00:01:10
Internet	–		–		–		4	00:03:01	–		–	
Orienting text	36	00:11:38	1	00:03:31	25	00:13:05	50	00:15:20	11	00:05:07	9	00:03:32
Other	2	00:16:00	–		–		2	00:12:21	–		3	00:05:29
Student writing	7	00:26:41	6	00:26:23	18	02:32:21	34	02:56:25	16	01:18:17	14	01:40:53
Total	67	02:21:05	14	01:01:59	53	02:57:08	125	05:15:36	40	02:02:19	36	02:23:01

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ARTICLE III

A social view of literacy for school science

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Abstract

This article provides an introduction to what it means to adopt a social view of literacy when the context is school science. This view of literacy builds on the idea that reading and writing are best regarded as situated social practices involving text, not as a set of decontextualised and universally applicable skills. First, we draw on sociocultural perspectives on literacy to show how these perspectives inform our understanding of literacy in school science. Second, we use related research literature, mainly concerning the role of text in science education, to present four main propositions that we claim are key to promoting literacy in science classrooms. Finally, we discuss how a social view of literacy enables us to consider how literacy occurs in contexts relevant to a transcending science subject for scientific literacy.

Introduction

Written language has a constitutive and integral role in the social practices that make science possible (Bazerman, 1988; Knorr Cetina, 1999; Latour & Woolgar, 1986; Norris & Phillips, 2003). Without text, and the socially meaningful ways of dealing with these texts, science would simply not exist in the way we know it today. In school science, however, texts have traditionally been of little concern to most science teachers and science educators (Hand et al., 2003; Norris & Phillips, 2003; Pearson, Moje, & Greenleaf, 2010; Wellington & Osborne, 2001). This is contrary to the view that students will need to become critical consumers of writing in and about science to actively participate and make informed decisions in a society that is “deeply influenced and shaped by the artefacts, ideas, and values of science” (Osborne, 2007, p. 177). Therefore, the way we approach literacy in a school science context is central to both educational practice and research.

The aim of this article is to introduce what a sociocultural perspective on literacy means for science education. From this perspective, literacy is regarded as situated social practices involving text (e.g. Gee, 2008), rather than the decontextualized notion of “the ability to read and write”. First, we will build on sociocultural studies of literacy to show how a social view of literacy informs our understanding of literacy when the context is school science. Second, we will draw on research concerning the role of text in science education and science to consider the ways in which teachers and students can use text as an integrated part of science teaching and learning. While written text, digital and in print, is central to this article, we also include under the concept of text, “any instance of communication in any mode in any combination of modes” (Kress, 2003, p. 48). This is particularly important in science, because science is not done or communicated through language alone, but in combination with other semiotic modes of representations (such as figures, animations, video, images, mathematical formulae, inscriptions, and gestures) (Lemke, 1998).

Literacy as social practice: Implications for school science

Norris and Phillips (2003) argue that a “simple view of reading” has pervaded much of the science education literature in general and the literature on scientific literacy in particular. In this view, reading is seen, more or less, as a set of universally applicable skills or competencies (i.e. decoding print and comprehension) to be applied independent of the text or context in which that text is read. Literacy, then, is reduced to a neutral entity that concerns "the ability to read and write", which is often presupposed to be something you acquire through formal schooling. Brian Street (1984) refers to this view as an "autonomous" model of literacy, where literacy in itself—autonomously—will have specific cognitive effects regardless of the context in which these skills are applied. Hence, a simple view of reading ignores readers' diverse backgrounds and the social and cultural conventions that are embedded within a text, even though these dimensions of reading significantly influence readers' understanding (e.g. Norris & Phillips, 1994; Samuelstuen & Bråten, 2005).

In contrast to an autonomous model of literacy, sociocultural studies of literacy (often referred to as the "New Literacy Studies") have focused on how reading and writing can only be understood in the contexts of the particular social practices of which they are a part (Barton, 2007; Barton & Hamilton, 1998; Barton & Lee, 2013; Gee, 2004, 2008; Heath, 1983; Jewitt, 2008; Lankshear & Knobel, 2006; Street, 1984). This approach to literacy is based on what Street (1984) calls an "ideological" model of literacy, which attempts to understand literacy as a social practice embedded in cultural and ideological contexts. It then becomes clear that literacy involves much more than simply decoding a word or a sentence to make meaning; it involves engaging and participating in "particular ways of thinking about and doing reading and writing in cultural contexts" (Street, 2003, p. 79). In this view, literacy becomes something people do in their everyday life, a social activity, which necessarily also involves people's values, talk, social relationships, attitudes and beliefs regarding text (Barton & Hamilton, 1998). It follows that literacy is not just one thing; rather, there are multiple literacies just as there are multiple "social practices and conceptions of reading and writing" (Street, 1984, p. 1). From a science education perspective, this means that the literacies of science and school science necessarily co-exist alongside a range of other literacies.

Ultimately, different literacies help us make and communicate meanings to and from other people in different contexts, whether in or out of schools or other institutions. Take for example a research team of glaciologists writing a research article to be submitted to the journal *The Cryosphere*, two friends text messaging each other to make plans, or youth making fanzines in a DIY ethic to sell online or in independent bookstores. They all adhere to the different conventions and socially recognized ways of using written language within the particular social group or discourse community in which they participate; in other words, they take part in local and situated social practices involving text (Barton & Hamilton, 1998).

Hence, for science educators, adopting a social view of literacy means to first approach reading and writing (and all the other things we may do with text) as embedded in the social practices that are associated with school science and, by extension, science. It is in these contexts that the texts of school science and science make the most sense (Lemke, 2004). This aligns well with Aikenhead's (1996) characterization of school science and science as two interrelated and closely aligned subcultures of Western society. Whilst science has its own aims, practices, norms, conventions, values and languages that are shared by communities of scientists, school science also has its own sets of aims and practices—many of which strive, but often fail, to reflect those of science in an accurate manner. In the context of science, for example, Bazerman (1988, p. 235) noted how "[t]wentieth-century physicists read articles in physics within the activity and structure of twentieth-century physics. Their reading is motivated and shaped by their participation in that communal endeavor". Similarly, when a student reads a text in the context of a school science lesson, that reading is framed within a particular situation at a particular time for a particular purpose. Most often, however, those purposes appear to reflect a transmissive pedagogy, which stresses memorization of well-established scientific knowledge (Goldman & Bisanz, 2002; Lyons, 2006).

Figure 1. A social view of literacy highlights how reading and writing are situated in particular situations at particular times for particular purposes.

Students also encounter texts with scientific information in a number of ways in their daily lives as well as within the classroom. It is in this regard important to acknowledge that certain socially powerful institutions, such as school or the workplace, exert a greater influence on how literacy is perceived by the general public than other domains in everyday life (Barton, 2007). When approaching literacy from the perspective of school science, it thus becomes purposeful to consider which literacy practices are usually formal, dominant and valued in the context of school science, and which are informal, everyday and of personal choice (Barton & Hamilton, 1998; Gee, 2004; Street, 1993). In a school science context, or in any educational context, school-related or academic literacy practices (e.g. reading a science textbook or copying down notes from a blackboard or an interactive whiteboard) tend to be supported, privileged and regulated by others (i.e. the teacher), whereas everyday and student-initiated literacy practices are usually not (Alvermann, 2002). Indeed, as Alvermann (2002, p. 190) argues, "[t]his privileging elevates the importance and value of academic reading but tells teachers little about their students' everyday uses of language and literacy". Since certain texts and certain ways of using text in the science classroom will always be foregrounded and more dominant than others, the role of text in school science will inevitably influence how students perceive literacy in science and in their daily lives. Moreover, it becomes evident that the ways in which language and literacy are framed in school science are packed with ideology and highly significant to consider for all science educators (Knain, 2001; Wickman, Liberg, & Östman, 2012).

Taking a sociocultural perspective on literacy also has implications for how we approach the broader notion of scientific literacy—a term that is often used, albeit with a wide variety of meanings, to refer to "what we expect students to know and be able to do as a result of their science learning experiences" (Sadler & Zeidler, 2009, p. 910). Although literacy is somewhat inherent in the term, it has not been a specific focus in the literature on scientific literacy until recent years. Most notably, Norris and Phillips (2003)—in a highly influential article—theoretically positioned literacy, in its literal meaning, as the fundamental sense of scientific literacy (being able to read and write science text) to the derived sense of scientific literacy (being learned, knowledgeable and educated in science). A social view of literacy further broadens the ways in which we consider literacy in relation to science by paying specific attention to the contexts in which scientific information is used and produced.

A move towards recognizing the situated nature of literacy is also paralleled in Roberts' (2007) two competing visions of scientific literacy: Vision I and Vision II. Whereas Vision I is seen as looking "inward" at the products and processes of science, from the perspective of the professional scientist, Vision II looks "outward" at situations that students are likely to encounter in daily life where science plays a role, in combination with other considerations (e.g. values, aesthetics, politics). In Vision I, there is thus a presumption that science, in itself, is valuable and transferable to situations later in life (reminiscent of the autonomous model of literacy). In contrast, Vision II questions whether scientific knowledge is directly useful in everyday contexts beyond the context of science (e.g. Layton, Jenkins, Macgill, & Davey, 1993). From our perspective on literacy, the contexts that shape and are shaped by literacy cannot be disregarded. Thus, it could be said that a social view of literacy presupposes a context-sensitive approach to scientific literacy that is more aligned with Vision II. Wickman, et al. (2012) build on a Vision II approach to make a strong argument for what they call a transcending science subject. They argue that school science needs to transcend not only the context of science, but also the idiosyncratic backgrounds and experiences of students to prepare them for making personal decisions on matters involving science in their daily lives. In a transcending science subject, a social view of literacy can provide a suitable framework for considering how texts with scientific information function and are used across these contexts: in the daily lives of students and citizens, in school science classrooms, and in communities of practising scientists.

A framework for promoting literacy in school science

In what follows, we draw on research related to the role of text in science education to outline what a social view of literacy implies for teachers' educational practice. The framework is structured around four main propositions that we suggest are key to promoting literacy in science classrooms in accordance with a social view of literacy; namely that:

1) Science texts are written for particular purposes and audiences
2) School science literacy builds on students' informal literacy practices
3) Science reading and writing activities in school differ in their "authenticity"
4) School science literacy is embedded in explicit instruction

These propositions are suggested and discussed in light of the theoretical perspectives presented in the previous section, and meant to support science teachers and science educators in developing reading and writing activities in school that are meaningful and relevant to their students and their vision of scientific literacy.

1 Science texts are written for particular purposes and audiences

In this framework, science texts act as a natural starting point for considering the wider social practices and contexts in which these texts are used, produced, and accordingly gain meaning. Goldman and Bisanz (2002) suggest that there are three main roles for science communication through the medium of text in society today: 1) communication among scientists; 2) popularization of scientific information; and, 3) the provision of formal education that prepares individuals for future careers in science or as scientifically literate citizens. These three roles, and the audiences for whom these texts are written, will here be used to examine the texts of science.

Science In science, professional scientists read and write in their day-to-day practices for purposes that reflect the culture, values and beliefs of the scientific community (see e.g. Latour & Woolgar, 1986; Knorr Cetina, 1999 for detailed accounts of scientific practice). Even the laboratory appears as "a system of literary inscription" (Latour & Woolgar, 1986, p. 52), where scribbled notes, images, graphs, numbers and texts from inscription devices continually frame the material practices scientists engage in. Their research is formalized through research reports, most notably the experimental journal article, which is written within the traditions of their scientific discipline and subjected to the scrutiny of their peers (Bazerman, 1988). These, and other central texts (e.g. conference presentations, conceptual overviews, and procedural texts) normally contain specialist language and multiple representations that provide scientists with a means to produce, organize, and communicate knowledge about the natural world (Fang, 2005; Halliday & Martin, 1993; Lemke, 1998). In this way, it can be said that "scientific knowledge relies upon the cumulative discourse made possible by text" (Norris & Phillips, 2003, p. 233). As scientists find new ways of understanding and communicating knowledge, the specialized texts of science also develop to fit the needs of the scientific community (Halliday & Martin, 1993; Mork & Erlien, 2010). Over the past two decades, however, the most influential change has arguably been the shift from print to online journals in combination with an increasing amount of Open Access journals, which is making scientific research literature ever more available to persons outside the scientific community (Willinsky, 2006).

Popular science Scientific information is also popularized to inform the general public, by journalists or the scientists themselves, and incorporated into popular culture through media such as television, literature, blogs, and advertisements (Norris & Phillips, 1994; Weingart, Muhl, & Pansegrau, 2003). When science is reported in the news, it is often journalists who transform scientific information from primary literature to fit with conventions for reporting the news. This might involve using controversial statements, prioritizing results over the robustness of the research, or reporting on frontier science that may still be disputed. Thus, readers are often required to evaluate the scientific arguments, question the biases, and judge the trustworthiness of the knowledge claims presented, on insufficient information (Zimmerman, Bisanz, Bisanz, Klein, & Klein, 2001). Controversial socio-scientific issues, in particular, are typically reported in the news and likely to be issues that students are confronted with in their daily lives (Kolstø, 2001; Mork, 2005).

Science education Whereas science communication among scientists and popular reports of science tend to focus on controversial or ground-breaking “science-in-the-making”, texts designed for formal education in science deal mostly with consensual and established scientific knowledge, or “ready-made-science” (Latour, 1987). This is perhaps best exemplified by the science textbook, which is—and has long been—the dominant genre in science classrooms (Nelson, 2006). In a literature review on science textbook use, Nelson (2006) summarizes how textbooks often collect statements of fact about the natural world, which make them timesaving for teachers, but also have a major influence on their instruction. As a consequence, many science educators and teachers have been hesitant towards reading and writing in school science, especially those related to the inquiry tradition of science education (Cervetti & Barber, 2008). Teachers’ main concern is often that their students might defer to the authority of the text, rather than investigating and generating answers based on their own first-hand experiences (Palincsar & Magnusson, 1997). However, as emphasized by Nelson (2006), what matters most is *how* a textbook is used, not necessarily the structure and content of the textbook itself. In later years, science educators interested in the authentic ways in which scientists read, write, and talk science, have therefore developed a range of novel texts and text genres specifically designed to support students at different stages in their inquiry processes (e.g. Cervetti & Barber, 2008).

In sum, an understanding of various science texts and the purposes for which they are written is crucial not only to understand science as a social process, but also to actively participate in societal issues and debates with a scientific dimension. Thus, a transcending science subject requires “a considered use of text”, as Cervetti and Barber (2008, p. 105) call it, where a wide range of texts are used in meaningful educational contexts to prepare students to critically engage with the issues and texts we expect them to understand as scientifically literate citizens.

2 School science literacy builds on students’ informal literacy practices

While literacy is often associated with formal schooling and academic ways of reading and writing, a social view of literacy implies that literacy in school is just part of the picture (Barton, 2007). School is simply one context in which literacy is embedded and used by those connected to school through their various roles and power relations (e.g. teachers, students, principals, janitors). What is specific about school, however, is that schools have “distinct ways of doing things, and particularly a set of practices around language use and around literacy” (Barton, 2007, p. 176), which contribute to construct and shape students’ literacy practices at school (Jewitt, 2008). This relates to what we have described as a distinction between formal or dominant literacies and literacies that are informal, of individual choice, and rooted in everyday life (cf. Barton & Hamilton, 1998). As made clear in the previous section, when the context is school science, we also deal with some of the most formal and specialized ways of using written language (Fang, 2005; Halliday & Martin, 1993). Thus, for many students, the differences between how they use literacy at home and the practices valued in the science classroom may not be easily reconcilable, and sometimes even in conflict (Aikenhead, 1996; Heath, 1983; Moje, Collazo, Carrillo, & Marx, 2001).

The relationship between home and school literacies was perhaps most clearly illustrated in Shirley Brice Heath’s (1983) seminal ethnographic study of how literacy was embedded in the contexts of three rural North Carolina communities in the United States. Heath recorded how people in the three communities used reading and writing in their everyday lives, and identified how each community had different “ways with words”. However, it was only in one community—the mainstream middle-class residents of the town—where children’s home literacy practices were congruent with the school-based literacy practices. In the other communities, text served distinctly different purposes than those at school, which caused these students to be unsuccessful at school. Heath’s study reminds us not only of the local and situated nature of literacy, but also of the need for science educators to familiarize ourselves with students’ backgrounds and experiences with literacy outside school.

In the science classroom, students inevitably bring their own experiences with literacy and science to bear when negotiating scientific ways of using written language. It then becomes a question of whose literacies are valued, welcomed and supported in the classroom. In a study of the home and school resources that frame students’ literacy learning in science, Moje and colleagues (2004) showed how students used relevant representations from popular culture, such as television and news media, to frame their understandings of related science concepts outside the school context. In school, on the other hand, students were reluctant to contribute and rely on these resources. Given the amount of research indicating that many students experience school science as decontextualized content far removed from their everyday lives (e.g. Lyons, 2006), these findings are not surprising. However, such findings do emphasize the importance of actively constructing spaces in school where students’ everyday ways with language and text are drawn upon to learn the disciplinary literacy practices that are valued from a scientific perspective (Moje et al., 2004).

In the Budding Science and Literacy research project, we found evidence of multiple literacies, which attended to markedly different purposes, in the six primary school science classrooms that were studied (Sørvik, Blikstad-Balas, & Ødegaard, 2015). On the one hand, students engaged in literacy practices that were typically “schooled”, in the traditional sense, such as reading a definition from a concept wall or writing to document a task. On the other hand, students also incorporated informal elements from their everyday literacy practices as valuable resources in the dialogic process of inquiry. This was perhaps most prominent in a literacy event that took place around Google Images in a third-grade classroom. The students had watched a video of a humming bird to observe its characteristics, but did not agree on whether it was possible to observe that the humming bird had two or four limbs (“Look, it has no legs!” one student firmly insisted). One of the other students in the class then repeatedly asked if they could go online to find an image of a humming bird instead of watching the video over again ("Can't we just find a picture. It's so much easier"). Eventually, the teacher agreed and the class jointly used Google Images to find evidence of humming birds having four limbs. In the following lessons, searching for images online became a valued practice in this classroom and was used to collect data on the characteristics of different animals. What was especially interesting about this event was that it concerned a practice suggested by a student, which was then picked up by the teacher and reframed for a school scientific purpose. Across the six classrooms in the study, several other hybrid literacy practices emerged, as students incorporated their own experiences and textual resources into literacy practices that are central to science (e.g. using vivid colours and speech balloons when visually representing natural phenomena or using science fiction texts as prior knowledge). In this regard, it is interesting to note that scientists—as so clearly shown by the work of Latour and others (e.g. Latour & Woolgar, 1986)—also rely on text and talk in a number of informal ways during the process of scientific inquiry, not solely the formalized accounts that are eventually published in peer-reviewed journals and often bear little resemblance to the actual process.

Still, as Jewitt (2008) emphasizes, the ways in which everyday or informal literacies are incorporated into school science is nevertheless a matter of power: "it is about what is allowed to count, to whom, and for what purpose" (p. 253). This does not imply that everyday ways of reading (and writing and talking) should be prioritized over scientific ways of reading (and writing and talking). Rather, building on students' informal literacy practices involves acknowledging that there are multiple literacies at work in the classroom, sometimes even co-existing, which relate to different purposes, different social contexts, and different backgrounds and experiences (Gee, 2008).

3 Science reading and writing activities in school differ in their "authenticity"

The third element in the framework concerns the out-of-school applications and contexts for engaging with literacy in the science classroom. While we do not use a term like authenticity without reservation—as we believe that any situation involving text is in some sense authentic to the participant (i.e. the student)—we will use the term here to consider how literacy in school science relates to relevant contexts and social practices beyond the classroom (Gee, 2001). In educational settings, Purcell-Gates, Duke, and Martineau (2007, p. 14) further define authentic literacy activity as a) the reading and writing of texts that occur outside of a learning-to-read-and-write context and purpose, and b) reading and writing those texts for the purposes for which they are read or written outside of a learning-to-read-and-write context and purpose. In other words, the notion of "authenticity" differentiates between literacies that are confined to the context of school science and literacies that transcend "real-world" contexts, like professional science, the workplace, or home.

In line with related work on situated learning and cognition in science education (Sadler, 2009), a social view of literacy implies that reading and writing is something people do for particular purposes in particular sociocultural contexts. Thus, learning to read (or write) a certain text in a certain way requires "having access to, and ample experience in, social settings where texts of that type are read in those ways" (Gee, 2008, p. 48). The consequence for school science is that science education must be positioned as contexts for exploring actual uses of scientific information outside the confines of the classroom, most notably the contexts of science and daily life.

There is, however, an increasing body of research indicating that students often experience school science as the transmission of scientific facts from expert sources, such as the teacher or the textbook (Lyons, 2006). In this mode of science teaching and learning, reading and writing is mostly reduced to distinctly "schooled" literacy practices, such as copying information from the blackboard or the textbook (Danielsson, 2010; Lindahl, 2003; Osborne & Collins, 2001), memorizing information before a test (Knain, 2002), or answering textbook questions (Driscoll, Moallem, Dick, & Kirby, 1994). Rather than being connected to meaningful contexts in which scientific information is actually read or written, reading and writing in school science becomes embedded in a school science culture that emphasizes the memorization of "important" information (Goldman & Bisanz, 2002). In contrast, when students engage in authentic literacy activities in school science, research has shown that these activities are also impressively related to students' increased comprehension and production of informational and procedural science texts (Purcell-Gates et al., 2007).

The notion of authentic literacy activities in school becomes clearer when we look to other contexts in which scientific information is read or written on a daily basis. For example, while scientists often write to inform or persuade the reader about a particular argument or result (Yore, Hand, & Prain, 2002), these are dimensions of science writing (the purpose and audience of a text) that are rarely talked about in the classroom (Af Geijerstam, 2006).

Instead, when literacy is actively used in the service of scientific inquiry, students read and write to investigate phenomena, discuss interpretations and arguments based on data, and efficiently communicate these ideas to their peers or other audiences (Pearson et al., 2010; Sørvik et al., 2015; Ødegaard, Haug, Mork, & Sørvik, 2014). Similarly, when science is encountered in daily life, it is necessary to evaluate information across different media from not only a scientific perspective, but also in interaction with the specific social, political, economic, and value positions that affect the situation (Kolstø, 2001). In the classroom, this means that students can authentically communicate across several meaningful contexts when dealing with complex socio-scientific issues (i.e. from various social and economic perspectives, or from a purely scientific perspective) (Knain & Kolstø, 2011; Mork, 2005). For instance, they can compare how climate change research is presented in newspapers and research reports, and discuss these texts from the perspectives of a journalist, scientist, or consumer.

Nevertheless, it is important to emphasize that literacy practices often considered as traditional or "schooled" literacy practices are also a part of the literacies of school science—but they cannot be the only form of literacy that students encounter in the science classroom if the situated nature of literacy is to be taken into account. From our previously mentioned study of primary science classrooms, many of the daily routines and scaffolding practices were dependent on text (Sørvik et al., 2015). These were distinctly schooled practices, but they were also integrated with the students' inquiry activities to provide structure and guidance. Knain and Kolstø (2011) describe similar literacy practices for upper secondary students engaging with inquiry and socio-scientific issues in terms of specific "support structures". They identify, for example, the use of wikis as a planning tool, learning goals and evaluation criteria, suggested information sources, short lectures from the teacher on relevant topics, and writing templates. Purcell-Gates et al. (2007) also claim that "schooled" ways of using text and "authentic" reading and writing activities in school are not mutually exclusive. Rather, depending on teachers' choice of text and purposes for using these texts, school-only activities can also be experienced as meaningful for students in a school science context.

4 School science literacy is embedded in explicit instruction

The last element of the framework concerns explicit instruction, which has been particularly central in work on reading and writing strategies, and reading comprehension (Kolstø, 2009; Mork & Erlien, 2010; Wellington & Osborne, 2001). A social view of literacy involves just as much how we talk about texts as how we read and write those texts. Information is stored in science texts and genres of science as they incorporate the conventions, norms and values of science, and separate them from other types of texts. However, these genres are largely unfamiliar to students (Wellington & Osborne, 2001), which make it especially important to provide structures that support them in reading and writing such texts. To be enculturated into a particular discipline implies that students are gradually using the communication forms and language of that discipline, and that they develop an understanding of how communication forms and language conventions are related to the social practices and ways of thinking in the actual discipline (Gee, 2008).

It has long been debated how new language forms are best learned, particularly those that are not acquired in everyday discourse. Those asserting that language is best learned by explicit instruction seem to be at one end of a continuum, while those claiming that language can only be learnt through participating in situated use of particular language forms are at the other. Purcell-Gates et al. (2007) emphasize that most researchers (including the authors) and teachers hold a middle position that includes a combination of embedded experiences and explicit instruction.

Several studies have shown that explicit instruction on reading strategies and text structure can improve comprehension and composition of such structures (e.g. Anthony, Tippett, & Yore, 2010; Guthrie et al., 2004). Anthony et al. (2010) showed that students who had worked on the brochure genre and made their own brochures were better able to read and identify information in unknown brochures as compared to the control group. In contrast, in a longitudinal study of authentic literacy and explicit teaching in grades two and three, Purcell-Gates et al. (2007) reported that students' abilities to comprehend and write science informational and procedural texts were not enhanced by explicit instruction of relevant linguistic features. The authors suggested several possible explanations for the results: the age of the students, type of genre, that the teachers also focused on authentic literacy in all study groups, that explicit instruction of genre should be combined with explicit teaching of reading and writing strategies to be effective, or that explicit instruction and genre features were operationalized in a particular way. Purcell-Gates et al. (2007) concluded that explicit teaching of the features of science procedural text must be in the context of authentic use of that text type for greater growth in the ability to produce it.

In the Budding Science and Literacy research project, we studied examples of how lack of modelling and explicit instruction in a specific lesson influenced third-graders writing a log to summarize their investigation of making glue with different ingredients (Mork, 2012). The activity started out with a short whole-class summary at the smart board, before the students were told to write a log. The excerpt below illustrates the teacher's initial instructions and other instructions given during this lesson as the students continually asked about what they should write:

Excerpt 1: Teacher instructions during a scientific log writing session in third-grade (Mork, 2012).

Time	Speaker	Utterance
0 min.	Teacher:	*We are going to write a log about what we did yesterday and today. You should write in your own words. The sentences on the smart board are only for assistance.*
5 min.	Teacher:	*A log is that you write about the work we did.*
8 min.	Teacher:	*A log is to write about what we have done. A kind of report.*
20 min.	Teacher:	*Don't write everything you read about in the book yesterday. You should write more about what you did when you did the research. Write about the experiment, what you did, that is the part that is exciting to read about afterwards. You can use concepts from the concept wall.*
32 min.	Teacher:	*The text should be written in such a way that someone who was not here could understand what we have done when he reads the text.*

The excerpt shows that the initial instructions from the teacher were vague, and that she needed to specify the task five times during a 45-minute lesson. The class, who are normally rather quiet, became restless and continually asked about what they should write. Several students then started copying sentences from the science trade book that they had read the day before. As we see from the excerpt, even the teacher became insecure about the text she wanted her students to write; she started mixing features from several genres (logs and reports). When a sample of students were interviewed after the lesson and asked if they had used their imagination during the lessons, several students in this group said that they had used their imagination when writing the log—indicating that they had not understood the purpose of scientific log writing (Sørvik et al., 2015). In this case, explicit instruction about the purposes and conventions for writing a scientific log could have clearly supported the students in writing this particular text.

Discussion: A social view of literacy

In this article, we have argued that a social view of literacy provides science education with the theoretical perspectives to examine the role of literacy in a transcending science subject (cf. Wickman et al., 2012). Central to this view of literacy is the situated nature of reading and writing, which enables us to consider how literacy is a part of contexts that influence science education and are relevant to the long-term goal of scientific literacy. The most notable of these contexts, we argue, are students' daily lives as citizens in a democratic society, school science, and professional science. Literacy, then, cannot be viewed as an additional element to science education, but becomes a constitutive practice of school science that cannot be ignored if students are to truly become scientifically literate (Gee, 2008; Osborne, 2002). Relying on the idea that literacy is best understood as something people do with text in their everyday lives—not a set of skills that you either have or do not have—we have then presented a four-part framework, based on relevant research, which illustrates what a social view of literacy implies for science teachers and science educators in practice.

The logical entry point of the framework concerns the range of texts through which science is represented, communicated, and used by scientists, the general public, and students. The potential use of these types of text in the classroom, we claim, should build on students' own experiences and informal literacy practices, relate to authentic contexts beyond school science, and be combined with explicit instruction about the specialized language conventions of science.

For science education, a social view of literacy also implies that the literacy practices associated with school science are always in a state of constant change. They are at once shaped by social, historical, cultural and political factors, such as the local traditions of science teaching, curriculum reforms, the current foci of the science education community, and the changing nature of learners' lived lives in the digital information age—some of which change more quickly than others. In this regard, it is worth elaborating on how different views of scientific literacy will translate into differently valued literacy practices in local science classrooms. As Feinstein (2011, p. 172) clearly emphasizes:

> Educators do not promote the development of literacy practices with equal energy. Instead, we encourage particular practices that support socially valued ends. Although it may be true that literacy

practices contribute to any vision of useful science education, different descriptions of science literacy imply different literacy practices.

From our perspective on literacy, this means that there will always be multiple *school science literacies*—the sociocultural ways in which literacy occurs in science learning environments—related to different conceptualizations of science education and scientific literacy. Accordingly, adopting a social view of literacy does not represent a set of pre-determined literacy practices to promote in science classrooms, but it presents us with a means to reflect on how and why scientific information is used in various societal contexts that are important to our vision of scientific literacy. Unfortunately, when literacy is regarded as a social practice, it also becomes apparent that many of the prevalent literacy practices in science classrooms rarely provide students with opportunities to transcend the context of school science. This seems especially worrying when the online environments of new media and Web 2.0 are continually changing people's literacy practices and use of available information (Barton & Lee, 2013).

In this article, it should also be noted that science has largely been presented as a single, unified entity, which, of course, it is not. This is particularly evident in the work of Karin Knorr Cetina (1999) on two different laboratories (one in high-energy physics and one in molecular biology), where she shows how the sciences exhibit distinctly different practices and "machineries" for constructing and validating knowledge. Furthermore, the work of Tenopir and King (Tenopir & King, 2004; Tenopir, King, Edwards, & Wu, 2009) on scientists' journal article readings efficiently demonstrates the multiplicity of literacy in the sciences. Whereas astronomers and chemists were estimated to average 228 readings and 276 readings per year per faculty member, engineers (applied scientists) were estimated to average 98 readings per year per faculty member. Engineers did, on the other hand, spend a lot of time reading other types of scientific output in addition to scholarly journal articles, such as e-mails, internal and external reports, books, trade journals, and patents (Tenopir & King, 2004).

Finally, for researchers interested in exploring literacy across contexts, a social view of literacy implies that literacy must be investigated in the context in which it occurs (Blikstad-Balas & Sørvik, 2014). Along this line of research, studies that investigate young people's literacy practices and activities involving science beyond the classroom would not only greatly add to our understanding of how new and digital literacies influence students' relationships with socio-scientific issues and science texts in their daily lives, but also to how this relates to the social practices of school science. This, and similar research into various science literacies across different social contexts (in and out of school), might hopefully advance science educators in having learners read and write meaningful texts in contexts that are meaningful and relevant to their science education.

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ARTICLE IV

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Reality Lost? Re-Use of Qualitative Data in Classroom Video Studies

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Key words: re-use; archived data; video data; video studies; secondary analysis; classroom studies; Norway

Abstract: There has been debate on the re-use of qualitative data in the social sciences for more than a decade now. However, video data are rarely explicitly discussed in this regard, even though new media pose both new opportunities and new challenges when it comes to the archiving and secondary analysis of qualitative data. Two illustrative case studies from the educational sciences are presented here to document the processes of archiving and secondary analysis of video data. These cases are based on the two Norwegian classroom video studies *PISA+* and *Budding Science and Literacy*. In light of these two cases, we propose that establishing more common practices for video research and re-use of video data will help address the contextual issues often related to re-use of archived qualitative data, as well as the ethical and practical issues that may weigh more heavily with archived video data than with other types of qualitative data. For the video research communities, this would involve establishing ethical guidelines for re-use and sharing, standardized tools and procedures for generating data, agreed-upon analytical tools, and procedures for logging and archiving video data. By making this the focus of debate, research communities engaged in video research may, in turn, contribute to more cumulative research in the field, and in the educational sciences in general.

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1. Introduction

There has been more than a decade of debate on the use of archived qualitative data (BISHOP, 2007; COLTART, HENWOOD & SHIRANI, 2013; CORTI, FOSTER & THOMPSON, 1995; HAMMERSLEY, 1997, 2010; MAUTHNER, PARRY, BACKETT-MILBURN, 1998; PARRY & MAUTHNER 2004, 2005; THOMPSON 2000). Archived qualitative data are often portrayed as a rich and unique, albeit unexploited, source of research material (CORTI, 2007; CORTI & BISHOP, 2005; DALLAND, 2011), but certain methodological issues have been raised regarding the re-use, and on ethical and epistemological grounds in particular. As qualitative data are characterized by an authentic and intuitive or informal element (HAMMERSLEY, 1997, p.138), and bound by the conditions and context of their production (MAUTHNER et al., 1998), how is the secondary researcher to deal with what may get lost in the process of archiving? In the present article, we will use two Norwegian video studies from the educational sciences as illustrative cases—one from the perspective of the secondary analyst and one from the perspective of the archivists—to investigate ways to address the contextual issues that are often raised regarding re-use of qualitative data. As the archiving and re-use of video data present certain ethical and practical issues that weigh more heavily than with other types of qualitative data, we will also present and discuss how the two research projects have dealt with anonymity, informed consent, and procedures for archiving. [1]

Despite the methodological issues regarding the re-use of qualitative data that are currently being discussed (BISHOP, 2007; CORTI, 2007; FIELDING, 2004; HAMMERSLEY, 2010; MOORE, 2007; PARRY & MAUTHNER, 2004), little has been presented of actual research reporting on the re-use of archived data (BROOM, CHESHIRE & EMMISON, 2009). This has led to calls for research and examples of re-use that may inform the methodological discussion (e.g. SEALE, 2011). SEALE (p.353) also argues that a general methodological discussion (e.g. qualitative data as authentic and unique) should not be treated as an obstacle or a fixed ruling governing researchers' conduct. In addition, few articles discuss the role of archived video or observational data; instead, the discussion has largely revolved around interview data (CORTI & BACKHOUSE, 2005). This is evident in a series of special issues on re-use and archival of qualitative data in *FQS* (e.g. 2005, vol. 6, issues 1 [edited by CORTI, WITZEL & BISHOP] and 2 [edited by BERGMAN & EBERLE], and 2011, vol. 12, issue 3 [edited by VALLES, CORTI, TAMBOUKOU & BAER]), where none of the articles deal explicitly with video data. Thus, this article aims to explore the ways in which the two cases presented here have dealt with the processes of archiving and secondary analysis of video data, and how these accounts may inform the methodological discussion. The first case is based on the PhD project "Dialogue as an Instructional Tool During Whole-Class Teaching", a study in which data from the PISA+ video study (KLETTE, 2009) are used to investigate new research questions that are different from those of the initial study. The second case covers the process of archiving video data in the on-going "Budding Science and Literacy" research project (ØDEGAARD, 2010), a longitudinal classroom study that has built on the PISA+ video study in its methodological approach. We believe that establishing common and shared practices for the archiving and re-use of video data will help address the methodological issues of re-use and contribute to moving the field of video research forward. Like GROSSMAN and McDONALD (2008), we argue that common practices will enable researchers to build on each other's work and collect knowledge for a more expansive research. Common archiving procedures may also help support the long-term ambition of programmatic research in the educational sciences, for example by contributing to building a common language and a conceptual framework for investigating classroom practices. [2]

In the subsequent sections of this article, we first examine some of the proposed advantages with using video to analyze social interaction. We then put forward the main challenges associated with archived qualitative data, and re-use of video data in particular. After outlining some of the advantages and challenges of using archived video data, we present the two illustrative cases. Finally, we discuss the two video studies in light of common practices to prompt further discussion on how to fully benefit from the opportunities that new media provides for classroom researchers. [3]

2. Video Studies in Qualitative Research

2.1 The use of video to analyze social interaction

For many years, researchers have looked for innovative ways to improve research on the quality of teaching and learning in classrooms. Development and innovation within technology and the media industry have recently made video recording a more flexible and adaptive methodological design for investigating classroom practices (DERRY, HMELO-SILVER, NAGARAJAN, CHERNOBILSKY & BEITZEL, 2006; DERRY et al., 2010; KLETTE, 2009; KNOBLAUCH, BAER, LAURIER, PETSCHKE & SCHNETTLER, 2008; SEIDEL et al., 2009). Furthermore, the miniaturization of recording and storage devices has improved mobility and increased the range of contexts in which it may be used. It has also turned this technology into a less intrusive mediator between researchers and their research objects (KLETTE, 2009). The recent development of recording technology is clearly recognized within the design of educational video studies, where both high-tech solutions and portable black box solutions are now possible (BERGEM & KLETTE, 2010). In the educational sciences, the term *video study* refers to research of social or educational practices based on analysis of video recordings (JANÍK, SEIDEL & NAJVAR, 2009). JANÍK et al. (p.7) claim that the investigative potential of video studies lies in the fact that complex phenomena and events, when captured on video, are available for analysis that can focus *ex-post facto* on various aspects of the material under investigation. Furthermore, video studies represent complex methodological approaches, which enable the use of a number of perspectives, strategies, and methods or techniques for generating and analyzing video data (DERRY et al., 2010; JANÍK et al., 2009; KNOBLAUCH, SCHNETTLER & RAAB, 2006). Sharing and establishing such infrastructures for research represent what DERRY and colleagues (2010) refer to as *boundary objects*, which, they argue, may promote re-use in the video research communities. [4]

According to HEATH (2011), it has long been recognized that the moving image provides extraordinary opportunities for social science research. Video as a visual media seems to provide just the resources that ethnographical studies need: it gives the opportunity to catch activities as they arise in natural habitats, such as in the classroom, at home, or in the workplace (HEATH, 2011). Video data are therefore often characterized as natural data (KNOBLAUCH et al., 2006); recordings made in situations affected as little as possible by the researchers (SILVERMAN, 2005). These records can then be analyzed repeatedly, and they provide access to fine details of conduct and interaction. Moreover, they can be shared and shown to others, and they provide the opportunity to develop an archive of data that can be subject to a wide range of analytic interests. It also brings new opportunities for credibility and trustworthiness in qualitative research methodology: video recordings can, for example, be viewed multiple times by multiple people and in some cases even at different times or by different research groups. This makes it easier to subject claims or research findings to debate, or to check the researcher's interpretation against the captured event (DERRY et al., 2010). Still, it is important to emphasize that videos, nevertheless, are artifacts—a document of a certain situation or event (ERICKSON, 2006; SCHNETTLER & RAAB, 2008)—having been recorded for particular purposes and in certain contexts, as well as representing aspects of the recording activity itself (such as camera angles or focus) (KNOBLAUCH et al., 2006). Thus information derived from video recordings does not give unmediated access to "reality" (ERICKSON, 2006). As SCHNETTLER and RAAB (2008) further point out, to characterize video data as natural or naturalistic data means to recognize both the conservation of a wide range of aspects of a certain event *and* its construction by the researchers through the means of video technology. [5]

Last, but not least, sharing video data also means not having to go through the process of gathering new data in each and every research project. From a cost-efficiency perspective (cf. SZABO & STRANG, 1997), re-use of video data can be regarded as fruitful for the video research communities, as video studies require both video equipment and time. It is, however, still a time-consuming process in many ways for both the primary researchers (in terms of archiving) and secondary researchers (in terms of familiarizing with the data) (DALLAND, 2011). Furthermore, FIELDING (2004) emphasizes the potential of secondary analysis in avoiding the possibility of certain groups being over-researched. In our field of research, re-use of video data unburdens teachers and students by reducing the presence of researchers in schools and classrooms. These aspects of secondary analysis have also been argued with regard to re-use of quantitative data in the educational sciences (e.g. OLSEN, 2005). In the next section, we will draw attention to four main issues, or challenges, associated with the re-use of video data: the issue of context, the issue of fit, ethical guidelines, and data infrastructure. [6]

2.2 Archived video data and challenges associated with using them for secondary analysis

HAMMERSLEY (1997) considers the archiving of data to have two main functions. First, it provides the opportunity for other researchers to check findings from a study through *re-analysis*. Second, it enables other researchers to use existing data for *secondary analysis*; that is, to use archived data to find answers to research questions that differ from the ones asked in the original data analysis (HINDS, VOGEL & CLARKE-STEFFEN, 1997). Researchers can in the latter case use archived data to supplement their own primary data or to perform historical, comparative or meta-analysis on the archived data. A new angle or methods can also be employed that may not have been possible at the time of the original data analysis (CORTI & THOMPSON, 2004). Several challenges have, however, been debated in the literature on qualitative secondary analysis. We will now turn to some of these challenges, with particular focus on video data. For a longer discussion on challenges in re-using qualitative data in general, see CORTI (2011) and CORTI and THOMPSON (2004). [7]

The first challenge we would like to address is the issue of *context*, which has long been one of the main concerns when it comes to qualitative secondary analysis. MAUTHNER et al. (1998), for instance, argued that the conditions under which data are produced are inescapable, rendering re-use of qualitative data as problematic. MOORE (2007), on the other hand, claimed that that the labels of *re-use* and *use* create a false distinction between primary and secondary use of data, because all data are constituted, contextualized, and re-contextualized within any study or research process. HAMMERSLEY (2010, Section 4.9) contends that the "re-contextualization argument" fails to acknowledge that data, in some sense, exist prior to the research process, *as well as* being constituted and constructed within any study:

> "Data are, then, in an important sense given as well as constructed: they are not created out of nothing in the research process, nor should we construct whatever inferences we wish to on the basis of them. At the same time, it is important to recognise that they are also constructed or produced in the course of research, and to be aware of aspects of this process that could be relevant to what would and would not be legitimate inferences from them." [8]

According to HAMMERSLEY, the methodological issue of context can arise in any research project, but the risk is greater when using secondary data; it is more a matter of degree. There can certainly be important distinctions between what is available as data to the primary researcher, and what is accessible to a second researcher who re-works the data, whether for a similar or very different purpose. In the process of acquiring primary data, researchers generate not only the data itself, but also the implicit understandings and memories of what they have seen, heard, and felt during the data acquisition process (HAMMERSLEY, 2010). Despite this constraint, CORTI (2000, §30) claims that there is an advantage to using video if we wish to use the material for secondary analysis:

> "Of course, audio and video-tape recordings enhance the capacity to re-use data without having actually been there. For archives, documentation of the research process provides some degree of the context, and whilst it cannot compete with being there, field notes, letters and memos documenting the research can serve to help aid the original fieldwork experience." [9]

Video recordings undoubtedly provide the opportunity to catch activities as they arise in the natural habitat (HEATH, 2011), and at some levels, can provide secondary researchers with data that are not as dependent on what the primary researcher(s) have in terms of memories and procedures from the data collection. This is even more probable if the researcher is familiar with the research object that is being studied. Considering the example of video recordings from a classroom and a researcher who knows what is common in this type of environment, it would be easier to say that video data can enhance the capacity for re-use without having actually been there (CORTI, 2000). However, if the researcher conducting the secondary analysis is not familiar with the object of study, he or she faces further challenges in terms of interpreting the videotaped data. On the other hand, it might be argued that being familiar with the situation could bring a certain freshness and new perspective to the situation being studied (IRWIN & WINTERTON, 2011; LYNG, 2004). [10]

To address some of the contextual issues of re-using archived data, BISHOP (2006, 2007) argues that it is necessary to consider the interactional, situational, and cultural or institutional levels of context that apply to your data. Here, the interactional level of context refers to what the secondary researcher is likely to discover about the interaction or conversation in the data material, without having experienced the specific context it occurs in. The situational level refers to the setting, which is what is usually referred to as "context" in qualitative studies. For instance, this includes the persons present, their relation, the physical setting etc. The third level of context concerns the institutional or cultural factors influencing the research project at the time of data collection. In an educational research setting, this may include the national curriculum at the time of observation, the political situation, and leading reform initiatives. [11]

The importance of considering the levels of context that influence one's data has also been shown to be central in analyzing video and interactional data in general (DERRY et al., 2010; LEMKE, 2000; WORTHAM, 2005; ØDEGAARD & KLETTE, 2012). One example of this comes from two studies that re-used video material from the *PISA+* study. SVENNEVIG, TØNNESSON, SVENKERUD and KLETTE (2012) used the *PISA+* data to investigate students' use of rhetoric in oral presentations. They found that one of the boys in the material excelled at using both *logos* and *pathos* during the presentation, while a girl in the same group did not have the same proficiency in using these rhetoric steps. These results were found by analyzing the video recordings of the oral presentations in the data material alone. However, when DALLAND (2011) used the same data to analyze the recordings made before this particular oral presentation, she found that the girl was the one who held the group together and organized the presentation, while the boy, on the other hand, did not contribute to the layout of the presentation. The different interpretations in these two studies illustrate the importance of explicitly addressing the contextual issues of re-using data in terms of BISHOP's (2006) levels of context, and also that such considerations are dependent on the object of the study. [12]

Secondly, the issue of *fit* is an important challenge that must be considered when re-using data. According to HAMMERSLEY (2010), this issue can arise in any research project, as it is not always possible to obtain all the data needed for a research project. The issue of fit is, however, obviously more apparent when a researcher only possesses the amount of data that is already available to address the research questions. Thus, HAMMERSLEY argues, it is extremely important to have a research question that is likely to be answered with the available data. In this regard, an important advantage of video data is that they can be open to many different perspectives and approaches. [13]

The third challenge we would like to address concerns the *ethical issues* related to the re-use of qualitative data. Because video recordings are more sensitive to exposing the informants' identities, there are certain important issues, which weigh more heavily than with other types of data in this regard (CORTI, 2000). A common option to enable re-use and protect confidentiality with qualitative data is anonymization, usually by removing identifying information or camouflaging real names. The key issue here is to agree on an appropriate level of anonymization, so that the data are not distorted, or their potential for re-use reduced (CORTI, DAY & BACKHOUSE, 2000). Video data, however, are not easily anonymized, nor is it always appropriate to do so if they are to be subjected to new analytic perspectives or procedures. For example, if the participants' faces need to be filtered out or masked on a video recording, then the video data may lose most of its value for the secondary researcher. DERRY et al. (2010) propose that confidentiality to the research participants can still be protected in several ways, even with the non-anonymous nature of video data. Filtering and masking the identities of the participants is a possibility, albeit an expensive one, which in turn could compromise the data. They also propose restrictions of access to video data and confidential information. Access can for example be restricted to the research group or researchers officially involved in the original research project if a host controls a digital repository of the data, or it may be restricted by the depositor, as described by CORTI et al. (2000) for Qualidata. As informants usually consent to being part of a study under the promise of confidentiality with respect to the research project and its members, there is also the question of informed consent for the secondary researcher to consider (HEATON 1998); e.g. how was consent originally obtained? CORTI et al. (2000) emphasize the importance of issues concerning confidentiality and informed consent being resolved prior to data acquisition, which implies that the ethical challenges of re-using qualitative data applies to primary researchers as much as it does to secondary researchers. DERRY and colleagues (2010) conclude that these are important issues to address to enable sharing and re-use of video data, for example, by developing and sharing practices for obtaining informed consent that protect the research participants and support the future sharing of video data. [14]

Finally, issues related to *archiving procedures and storage* have to be carefully addressed when it comes to archiving qualitative data for later use, preferably already at the beginning of a research project (HUMPHREY, ESTABROOKS, NORRIS, SMITH & HESKETH, 2000). Archiving data for video studies requires vast amounts of storage space and a well-organized data infrastructure. This is because virtual repositories from such studies often include digital files of student work, digitalized field notes, various metadata, and other digital resources, in addition to video data (DERRY et al., 2010). PEA and HAY (2003), for instance, claim that developing effective metadata coding schemes is a central issue for the video research communities—if we wish to exploit the usefulness of video research tools. Associating some type of metadata to the video, or segments of the video, is a central step in the analysis of video data (PEA & HAY, 2003), and also in giving structure to a virtual repository. This is particularly important in archiving data for re-use, as it enables the secondary researchers to navigate and build on the archived data and metadata available to them. [15]

These perspectives will be used as a background for discussing the two different projects, as well as how we are working with generating, archiving, and re-using qualitative data, and video data in particular. [16]

3. Data and Evidence

In the following, we present two cases to highlight some of the issues considered in the preceding sections regarding the processes of archiving and conducting secondary analyses on video data. [17]

The first case draws on a PhD project using archived video data from science and language arts classrooms from the PISA+ video study (KLETTE et al., 2008), which was conducted in 2005-2006. The study was an in-depth study of six ninth-grade classrooms, which were video recorded for three weeks, intended to explain the Norwegian results from the international comparative studies PISA and TIMSS, and come up with suggestions for improvement. The archived data material contains 152 videotaped lessons from science, mathematics, and language arts classrooms (ordinary classroom lessons and laboratory work, field work out of classrooms, excursions etc.), 13 teacher interviews, and 77 video-recorded interviews with students. The research design included a three-camera solution: one camera focusing on the whole class, one focusing on the teacher, and one on a pair or group of students. In addition, field notes were written during the same lessons. Several theses, articles, and book chapters have been written based on to the primary PISA+ video data. Since then, however, new researchers linked to the study have analyzed the PISA+ video data for new purposes and perspectives (DALLAND, 2011; DALLAND & KLETTE, 2012; SVENKERUD, KLETTE & HERTZBERG, 2012; SVENNEVIG et al., 2012). [18]

The second case takes its data from an on-going research project, the "Budding Science and Literacy" project. This study is a longitudinal, design-based classroom video study that focuses on integrated approaches to inquiry-based science and literacy in six Norwegian elementary school classrooms

(ØDEGAARD, 2010). The overarching goal of the research project is to develop a teaching model for science-literacy integration with the support of the participating teachers through design-based research (cf. COLLINS, JOSEPH & BIELACZYC, 2004). The "Budding Science and Literacy" project is connected with the PISA+ study through researchers who have worked on both projects. The research design was also modeled around the PISA+ study. The first round of data collection was conducted in 2011, and the current number of video observations in the project comprises 53 science lessons (approx. 200 hours of video data), interviews with 33 students, and pre- and post-interviews with six teachers. [19]

For this article, it is also important to consider the Norwegian context for the archiving and re-use of personally identifiable data. In Norway, all social science research projects that require the processing of personal identifiable data are under obligation to report to The Norwegian Social Science Data Service (NSD) a minimum of 30 days prior to data collection, which are then evaluated against the Personal Data Act and the Personal Health Data Filing System Act. Re-use of personally identifiable data is to be restricted, and usually requires renewed consent. Data that has been anonymized, on the other hand, are not subject to the same conditions. For video data, this would imply blurring out the faces of the persons caught on the recordings and muting the sound track. For more detailed information on the ethical research guidelines for Norway, see The National Committee for Research Ethics in Norway's (2006) Guidelines for Research Ethics in the Social Sciences, Law and the Humanities. [20]

In what follows, we report on these two classroom studies: one in which secondary analysis is being performed on archived video material, and one in which the primary video researchers are collecting and archiving data for future re-use. [21]

3.1 Two illustrative cases: PISA+ and "Budding Science and Literacy"

3.1.1 Case 1: Re-use of the PISA+ video material

The first case considers the conduct of secondary analysis of archived qualitative data from the classroom video study PISA+. Today, both the original researchers and a number of new researchers attached to the research project share an extensive virtual data archive, which comprises audio and video data, contextual information, and metadata. The strength of having access to data from a larger project, such as the PISA+ video study, is that there are several researchers who know the material well, and who took part in the original data collection. There are also researchers who are almost finished with their projects and researchers who have recently started working with the material. [22]

3.1.1.1 Navigating the video data archives of PISA+

Navigating the data archives of a classroom video study can prove to be a daunting task to which clear logging procedures offer valuable assistance. The PISA+ study logged every video recording with data and time/sequence of the school day, subject, and teacher(s) involved. This logging system makes it possible for the new generations of researchers to get an overview of the entire data material, access requested segments and sequences, search for related sequences or contrary sequences, and use parts of the data material for their priority research focus. We will argue that clear procedures for logging and archiving the data are crucial for secondary analyses. [23]

All field notes from the videotaped lessons are transcribed, digitalized, and archived. The field notes also provide contextual information on how schools, classes, students, and teachers were selected for participation in the research (DALLAND, 2011), including procedures for informed consent from the participants. HEATON (1998) argues that a researcher who uses qualitative data for secondary analysis must be aware of how consent was obtained in the original study. It is usually not feasible to seek additional consent, she argues, and the researchers have to make a decision about whether re-use of the data violates the original contract between the participants and the primary researchers. [24]

Manuals and coding procedures used in the primary analyses were also archived together with the original data sources. The data are currently stored in a local database, which is restricted to the researchers (both primary and secondary) attached to the research project. Coding manuals from the original research project are the only data stored on this database that are published and fully accessible for a wider audience. The publication and sharing of such coding manuals is considered important for cumulative and coherent research in the field of educational sciences (KLETTE, 2009). It also provides transparency in the analytical process. [25]

Access to initial analytical approaches, such as coding manuals, have served at least two functions when re-using the PISA+ data. They have given access to the primary analytical tools, and thus, revealed possible weaknesses, problems, and strengths linked to the initial analyses. In addition, access to primary analytical tools has made it possible to build on these tools (e.g. coding categories), and thus, contribute to developing a shared language for studying classroom practices. In the PISA+ study, for example, a set of codes covering a wide range of different features of classroom interaction was developed. Some of these codes covered dialogic and monologic teacher moves in the classroom, which are critical features for our analyses of the archived PISA+ data. These codes represent coding approaches that future researchers can build on, or as we have used it, as an analytical device to further investigate features of teachers' talk during entire class sessions (ANDERSSON & KLETTE, forthcoming). In this case, having access to these original coding procedures has facilitated a more targeted use of the data material, as the sequences that were coded for dialogic talk could be elaborated on and further analyzed. [26]

One of the main arguments for secondary analysis is that it is less consuming of both time and money (SZABO & STRANG, 1997). In terms of time- and cost-efficiency, a researcher would not be able to gather such rich data material as the PISA+ single-handedly; however, it should be emphasized that time also is an issue when working with archived data. As a secondary researcher, one has to spend a lot of time getting to know the contextual information and the video data that one aims to analyze. One might argue that the researchers involved in the original data collection will know the data better before starting the analysis, but as DALLAND (2011) and others have pointed out, the PISA+ video material gives a good description of the context—with the exception of information about socioeconomic background (due to ethical limitations of the study). In addition to rich classroom descriptions, the data source material also covers information about the students' gender, age, and ethnicity. [27]

3.1.1.2 The question of fit

A related, but slightly different argument is the question of fit: how well does the data available fit with your research questions—is it likely they may be answered with the help of the available data? In re-using data from the PISA+ video study, the question of fit has been addressed through close contact with the primary researchers, both during the design of the new research project and during the project period (i.e. as PhD student and supervisor). It is our experience that if one approaches archived material without prior knowledge of what the material contains, the issue of fit becomes extremely relevant. However, when the secondary analyst is in contact with the primary researchers, this difficulty can be limited. This is mainly due to the knowledge of the primary researchers; they know content of the data, and whether the secondary researchers' research questions can be answered with the help of these data. In Norway, there are also strict ethical guidelines for re-use of personally identifiable data—such as video data—that requires the approval of both the original researchers and the Norwegian Social Science Data Services to do so. This is, of course, a factor in enabling a close cooperation between primary and secondary researchers in the re-use of video data. [28]

Having contact with the original researchers, however, is not a requirement for re-using the material. It can be an advantage to have persons who know the material well, but it can also be inhibitory if the original researchers are too attached to the material and their original perspectives and analyses. [29]

3.1.1.3 Video data as contextual data and re-contextual data

The PISA+ material is used for both its original purposes (see KLETTE et al., 2008) and re-use by new researchers. Thus, all researchers working with the PISA+ data material have access to the original data material. For the secondary researcher who did not take part in the primary data collection, it is particularly important that the material is well organized. Although issues about the context of videotaping are crucial, this can be compensated for with access to all original data, clear procedures for logging and storage procedures, and access through indexing and logging systems. The more explicit and clear these procedures are, the more they support the secondary researchers in re-contextualizing the data, we will argue. Indeed, experiences from conducting secondary analyses on the PISA+ material show that having access to the original data material helps the researcher to retrieve contextual information and to obtain information about the context of the study. This may also reduce the need for direct access to the primary researchers. [30]

BISHOP's (2006) three levels of context (the interactional, the situational, the institutional/cultural) have served as a valuable frame of reference for conducting secondary analyses on the archived PISA+ material. Research questions from the original study and those in the current study need to be taken into consideration as well. When studying a construct such as dialogue, it is necessary to consider not only the single utterances made by the teacher or the students, but also the exchange of utterances and the segment as a whole (LEMKE, 2000). A huge challenge, therefore, is to determine the length of the segments that should be taken into consideration. This depends on the purpose of the study (WORTHAM, 2005). In this case, entire lessons were selected to analyze dialogues and instruction from this large video material, and the object of analysis was accordingly concerned with the social action on an *interactional level*. If the aim of the study was to investigate changes in dialogue over the course of a school year, it would be necessary to pay equal attention to the *situational level* of context in order to take account of the social relationship between teachers and students, changes in seating arrangements and the social roles in the classroom over time. When it comes to the *cultural or institutional level* of context, however, there are certain important considerations that have to be made in re-using the PISA+ video data. The PISA+ data were collected in 2005, a year prior to the implementation of the current national curriculum in Norway. What was new to the national curriculum was a focus on *basic skills* across all subjects in primary and secondary education, which is taken to include reading, writing, arithmetic, digital, and oral skills. This implies that the research questions posed in the original study may no longer be as relevant today as they were at the time of data collection, but also that re-use of the PISA+ data needs to consider these changes in formulating new research questions. [31]

3.1.1.4 Secondary analysis—an illustrative example

With access to such a large body of data, it is necessary to select a manageable sample of the material. The sample used in this case was derived from an interest in the segments that contained entire class teaching sequences in the PISA+ data. To reduce the sample to entire class sessions in science and language arts (L1) classrooms, we randomly chose lessons from those classrooms. [32]

A coding scheme—developed by FURTAK and SHAVELSON (2009)—was then used to code for dialogic and authoritative teacher moves during classroom discourse in these classrooms: the primary researchers on the PISA+ video study had previously coded entire lessons with a coding scheme describing different features in the classrooms. A preexisting coding scheme was then used to apply tested and reliable video coding categories to the PISA+ video data, in this case on the topic of how teachers use dialogue in classroom discourse. It can be mentioned that there is now large body of research on classroom discourse in the educational sciences, but the steady emergence of new video coding categories often makes it difficult to compare findings. According to KLETTE (2009), building on previous coding schemes prevents the researchers in the field from "reinventing the wheel" over and over again. Some of these codes included teacher-student dialogue and teacher monologues in these classrooms. However, these codes only showed when the teacher interacted with the students or not; they did not separate between different teaching moves within these two categories. By applying FURTAK and SHAVELSON's coding scheme, it was possible to investigate dialogic and authoritative teaching moves on a more detailed level. In this case, the secondary analysis illustrated how language teachers used dialogues when talking about different types of texts and how the teachers in language arts and science asked questions and gave responses to the students—results that were new to the original analysis of the same data. [33]

3.1.2 Case 2: Archiving video data—"Budding Science and Literacy"

The second case considers the "Budding Science and Literacy" classroom study (ØDEGAARD, 2010), and approaches the re-use of video data from the perspective of the archivists (and primary researchers). The "Budding Science and Literacy" study has used the design of the PISA+ video study as a starting point, along with the experiences of the primary and secondary researchers from that study, to address some of the issues often raised regarding re-use of qualitative data in video studies. In the "Budding Science and Literacy" research project, it has been an objective from the start to archive video data, artifacts, and contextual information for the length of the project period, and to facilitate secondary analysis of the data. Here, the main factor influencing re-use of data lies in the duration of the research project. As "Budding Science and Literacy" is a longitudinal research project, all data will be archived until the end of the research project (currently the year 2030). Due to the personally identifiable nature of video data, the data material generated from the study is also bound to the primary research project and its ethical considerations, in accordance with the national ethics research guidelines and the Personal Data Act. This implies that re-use of the "Budding Science and Literacy" data is restricted to researchers formally involved in the research project. The primary research group will therefore need to apply the Norwegian Social Science Data Service for inclusion of new researchers to the research group. The new researchers will then have to follow the ethical guidelines that were established when the data was collected. In this manner, the ethical issue of anonymity for future re-use is resolved by restricting access to the data (DERRY et al., 2010). [34]

3.1.2.1 Archiving "the context"

Well-documented data and contextual information are central to the archiving and re-use of any qualitative data. In order to provide future researchers with the contextual information needed for re-use of the "Budding Science and Literacy" data, emphasis was first put on capturing the "whole" of the classroom through the cameras that were to be used in the study. Accordingly, a camera set-up was designed to capture the events of the entire classroom: a whole-class camera to provide an overview of the classroom (including all students and the teacher), a camera that follows the teacher continuously, and a head-mounted camera on a student in each of the two focus groups in the class. In this way, a researcher who wishes to focus on student conversation in groups, and who is primarily going to use data from the head-mounted student cameras, will still have access to what goes on outside of the group in question, e.g. by time-coordinating several videos. If a gaze is averted (obviously not by the student wearing a head-mounted camera), or if one of the students makes a comment about something not captured by the camera in the group, the researcher has the opportunity to use different video sources to understand what is distracting the student with the averted gaze, or what is being referenced by the other. Hence, important contextual information on an interactional level is not lost in the process (cf. BISHOP, 2006). [35]

In addition to the video data generated in the classroom from the four-camera solution, all student work, curriculum materials, and other teaching materials have also been archived. Field notes and research protocols were written during and subsequent to each video observation, and they were archived to provide contextual information. Thus, procedures for log keeping have been an important aspect of the video observations. The log keeping covers background information on teachers and students (in particular, the students in the two focus groups), dates and times of observations, time-logged field notes, and technical aspects of the video observation. The latter includes information about the research tools used in a given video observation; that is, camera specifics, the number of additional sound recordings, whether or not the video recording equipment functioned properly, or if any unforeseen interruptions or technical failures occurred that may have caused gaps in the video data. Together with the four-camera set-up, these measures all work to provide a sense of context to the material, in particular on the interactional and situational levels. Within a relatively large research project such as the "Budding Science and Literacy" project, it is also clear that all the primary researchers cannot be present for all of the video observations and data collection. Thus, contextual data seems to be equally important for the primary researchers working as a part of a research group as well as for the research community. [36]

Another step that has been taken to ensure the availability of a wider context for future researchers is to collect video recordings and surveys from the in-service professional development course. During this course, the teachers engaged in testing and adapting science lessons together with their students. On two different occasions during the two semesters that the course ran, the teachers also had to present their experiences to the other teachers in the group as a part of the course. Among other things, the teachers were then asked to connect their lessons to the national curriculum and to relevant theories from the course, as well as to include possible improvements or teaching challenges. These presentations and the following discussions were video-recorded and subsequently archived. The teachers also took part in a survey before and after the course, in which they were asked about their educational background and years of teaching, as well as more open-ended questions about their teaching practices. From the start of the professional development course, the teachers were informed of the design-based nature of the research project and of the value of their feedback in this regard. The data generated from these video recordings and surveys provide additional and important information on the situational and institutional levels of context, relative to the period of data collection in the research project. In order to support the participating teachers with findings and implications from the research project after the course ended, voluntary seminars have also been arranged each semester, where the latest findings from the "Budding Science and Literacy" project have been presented and where the teachers can share ideas and experiences from their own teaching. [37]

3.1.2.2 Facilitating for secondary use of data by way of data infrastructure

Because there are challenges for secondary researchers in navigating the vast amounts of data that are generated in a classroom study, we have also developed and archived metadata-coding schemes for all the data that were generated in the study, as well as metadata from video analyses. The coding schemes range from practical codes for logging video files, such as project name, school, date, time, and source of data (e.g. whole-class camera, teacher camera, etc.) to video coding categories. In the coding schemes for logging video files, and the subsequent metadata, the names of the participating schools, teachers and students are anonymized and stored in accordance with the Norwegian "Guidelines for Research Ethics in the Social Sciences, Law and the Humanities" and the Personal Data Act. The video coding categories cover both generic classroom activities, such as reading, writing, talking, and practical activities, and subject-specific categories, such as the central processes of scientific inquiry (ØDEGAARD, MORK, HAUG & SØRVIK, 2012). These coding categories have then been applied to all of the video data in the study, and the resulting coded material have been archived together with the coding schemes and the video recordings. The video analyses have been performed with Mangold Interact coding software—a tool for the systematic logging of observational events with onset and offset times for each coded event. The coding categories for video analysis have also expanded on prior coding schemes from the PISA+ study (KLETTE et al., 2005) and the EXPLORA[1] project (ØDEGAARD et al., 2011) to enhance the reliability of the coding categories. The creation of such metadata-coding schemes has been central to the research project group in creating a secured virtual repository to which all members of the research project have access and know how to "read," as well as in establishing a system that can be expanded upon and used by new researchers. As PEA and HAY (2003) emphasize, metadata coding is one of the most important lessons to be learned when it comes to the usefulness of video sharing. [38]

1 EXPLORA was a Nordic collaboration between science educators at the universities of Linköping (Sweden), Aarhus (Denmark) and Oslo (Norway) to develop a coding manual for video analysis of science lessons with the aim of investigating if there are any common teaching patterns between the countries. The resulting coding manual was published by ØDEGAARD and colleagues from the participating institutions (2011).

Creating a well-organized infrastructure for qualitative data and metadata, however, is a time-consuming effort. Although new media is made readily available to researchers, the effort needed to handle and organize the data that is generated is rarely acknowledged. In order to develop a data infrastructure that can handle the amounts of data generated in the "Budding Science and Literacy" video study and facilitate future re-use, it has been necessary to invest time and effort far beyond what the primary research questions required. [39]

3.1.2.3 Gaining consent in a design-based study

A central aspect of design research is *progressive refinement*, where formative research is carried out to test and refine educational designs based on principles from prior research and theory (COLLINS et al., 2004). In the case of the "Budding Science and Literacy" project, the participating teachers tested out and helped refine a model for the teaching of science and literacy through inquiry. The professional development course provided a meeting ground between researchers and participants, in which the researchers could emphasize the value of video observations from classrooms, as well as the teachers' feedback for further refinement of the teaching model. Throughout the professional development course, the teachers also had the chance to ask questions openly regarding the research project and what they would be consenting to. It also provided us, as researchers, with the opportunity to explain our reasons for wishing to archive the data for a longer period of time, and to be able to do so with the support of the teachers in the study. [40]

To deal with the ethical issues regarding the archiving of video data, both students and teachers were fully informed about the purposes of the research project prior to data collection, and they were asked to participate voluntarily by signing informed consent forms. All participating teachers were similarly informed of the aims of the research project in general, the duration and longitudinal design of the research project, their rights to confidentiality, and that all personally identifiable information will be deleted by the end of the project period unless otherwise specified. This means that some of the ethical issues regarding informed consent for re-use were addressed prior to the original data collection (cf. CORTI et al., 2000), as the participants were informed that new researchers may eventually join the research project group within the time span the project period. After the teachers consented to participate in the study, their school administrations were formally asked. The students were then asked, with parental consent, to participate in the study. The researchers involved in the project made themselves available for school visits and information meetings about the project, although none of the parents or students took up on this offer prior to the commencement of data collection. Interested parents did however ask for updates subsequent to the data collection. Therefore, members of the research group attended parent-teacher conferences to describe the research process. One student did not wish to participate in the study, and special arrangements were made for her by the researchers and her teacher to avoid her being video recorded (i.e. changing seating and adjusting camera angles). [41]

4. Discussion

When archived qualitative data are used for secondary analysis, there should be little doubt that the context that informs the data can never be fully disclosed. Thus, "reality" is in some ways lost for a secondary researcher. There is however a paradox in such a phrasing. Using archived qualitative data under the assumption that the contextual information provided "completes" the data material implies that a "naively realist" position is adopted—seeing the data as "real" entities that are freed from the conditions of their production (MAUTHNER et al., 1998, p.743). As HAMMERSLEY (1997) points out, it will never be possible to gather *all* the data on which a study was originally based on. In actuality, the issues of context and fit do arise in any research study, whether primary or secondary (HAMMERSLEY, 2010). This is also apparent from the experiences with the "Budding Science and Literacy" project, in that it was not possible for all the researchers in the research group to be a part of, and present during the video classroom observations. This shows that these issues are also highly relevant for primary researchers working within a large research group. With secondary use of data, however, such issues are more likely to arise, and they need to be addressed carefully. In this regard, HAMMERSLEY draws the conclusion that it is possible, and desirable, to use material that other researchers have generated, and that the labels of "re-use" and "secondary analysis" to such work are of value to the research communities (cf. MOORE's [2007] challenge to the use of the term "re-use"). In light of our two cases, it also seems purposeful with such terminology, as the data in the two research projects seem inextricably bound to the conditions of their production. The label of re-use thus provides important background information for "reading" the data, and subsequently, the presented evidence. [42]

The PISA+ data serve as an example of this. The data were collected in 2005, prior to the implementation of the current national curriculum for Norway, which creates certain implications for the inferences that might be drawn from the data. For instance, an exchange between teacher and student in the PISA+ data material occurs at an interactional level in the classroom, but it also occurs at levels defined by the cultural and institutional conditions at the time (BISHOP, 2006). In the first case presented here, interactional and situational issues were addressed through a rich background material, from the original data collection and a close collaboration between the primary researchers and the secondary analyst. Similar issues can also be expected with the "Budding Science and Literacy" data material, in which the teachers attended a professional development course during the data collection period. In this project, archived data from the professional development course, in the form of surveys and videos of teacher presentations, help to complement the video data and the contextual information for each video observation. Although these issues apply to all video data and need to be addressed—as video segments represent certain events that are removed from their larger context (DERRY et al., 2010)—it becomes especially important to address in the re-use of video data. In light of the two cases presented here, addressing the different levels of context is clearly not an issue that only concerns the secondary researchers; it necessarily involves the primary researchers as well. In order to provide credible and transparent accounts of the research, in addition to moving the video research communities towards a long-term goal of programmatic research, it seems that both primary and secondary video researchers should engage in developing standardized ways of generating and archiving video data in classroom studies. [43]

The issue of fit arises in the re-use of data, as the secondary researcher has a fixed set of data available to answer his or her research questions. Both cases presented here have tried to address this issue by making it an objective to archive data for further use, from the start of the original research project—for example, by having camera set-ups that aim to capture the "whole" of the classroom and explicit logging and storage procedures. Collaboration between primary and secondary researchers in the PISA+ study has also been shown here as a way to address the issue of fit. On the other hand, if we are to share video or build on data across research groups, then the importance of standardized tools (e.g. camera set-ups and logging and archiving procedures) for conducting video research in classroom studies needs to be emphasized. [44]

As both cases presented here deal largely with video data, the issues of confidentiality and anonymity are of special concern. With other forms of qualitative data, the most common option to protect confidentiality is to remove key information, such as the names of the participants and the names of the locations and places where the research was conducted. With video data, however, the participants can never be fully anonymous. One example of issues that can arise if video data are to be shared or re-used is the desire of the Norwegian Social Science Data Service to remove the sound or blur the faces in the videos in the PISA+ study if they were to be re-used, thereby compromising the data. Experience from the "Budding Science and Literacy" study, however, indicates that close cooperation between teachers and researchers—through the professional development course and the design-based nature of the research project—may be, in fact, a positive influence on teachers in consenting to long-term archival and re-use from the start. Still, it is apparent that ethical issues remain highly debatable if video research communities are to benefit fully from the sharing of video data. A case in point is how the data in both of the cases presented here are bound to the specific research project, thereby disabling sharing of data outside of the research group in question. We concur with DERRY and colleagues (2010) that negotiating such guidelines is part of the work that needs to be done by the video research communities to benefit from the increasing opportunities for sharing video data. For example, what should the ethical guidelines be for gaining consent in video studies, when the specificity of research questions is not known in advance (cf. BISHOP, 2005, 2007; PARRY & MAUTHNER, 2004)? [45]

To benefit fully from the amounts of data generated in a classroom study, there is also a need to implement explicit archiving and logging procedures. The two cases presented here suggest that such procedures should be implemented from the start of the original research project. In this manner, the secondary researcher can address contextual issues more easily, and possibly build on what has previously been done with the data. These findings are in line with the findings of HUMPHREY and colleagues' (2000) study, in which an archivist was connected to the research project from the beginning, in order to preserve the textual data that was generated. The practice of archiving qualitative data also brings attention to the area of data infrastructure. Developing a well-organized data infrastructure is time-consuming, and it should be recognized as an important area for the video research communities to develop further in collaboration. HUMPHREY et al. (§17) claimed that there was a "need to raise awareness about data preservation among the academic and funding communities," and, in the case of video data and new media, it appears to be equally important for researchers involved in classroom studies today. [46]

GROSSMAN and McDONALD (2008) argue that in order to move the field of research on teaching and teacher education forward, there is a need to develop common, or shared, practices further. This is similar to what DERRY and colleagues (2010) envision for video researchers in the educational sciences by focusing on boundary objects, the common factors that enable us to share research and research tools in a way that accumulates knowledge in the field. One such tool is the coding categories we use in analyzing video data. In the first of our two cases, the coding schemes and original video analysis from the PISA+ study were investigated on a more detailed level; here, the experiences with having access to the original video analysis, as well as the coding categories, resulted in a more targeted use of the data material. In the second case, the PISA+ coding categories were elaborated on for higher reliability, and all metadata has been continuously archived together with the archived video data. Lately, there has been a tendency to collect and share such analytical tools across video-based research projects in the educational sciences, e.g. the EXPLORA project (ØDEGAARD et al., 2011). This tendency is also apparent in recent work with the Timescapes Qualitative Longitudinal study as well, in which COLTART et al. (2013) describe how the Timescapes study has encouraged data re-users to build on the published works of the originating project teams. [47]

Another shared practice that can be identified within the two illustrative cases that have been presented here is the methodological approach applied in the two studies. Both classroom studies have tried to facilitate for re-use from the start of the original research projects, for instance by capturing the ‘whole' of the classroom with their camera set-ups, and by extensive archiving of contextual information as well as the video data. With the large amounts of data that new media offer to the video research communities, there is a need to develop and agree on such common practices and tools for conducting video research. This includes agreed-upon methods of archiving and re-using video data and metadata, but also the ways in which we follow the ethical standards that guide our research. As GROSSMAN and McDONALD (2008, p.198) state:

> "To move forward, the fields of research on teaching and teacher education need to develop more programmatic research that addresses a set of critical questions over time as well as develop a range of common tools and approaches for making progress in answering those questions. [...] We also need to invest in the

> development of common research instruments for generating knowledge about teaching and teacher education. We need to develop common instruments for investigating teaching [...]. Such common tools for research would help researchers make progress in aggregating knowledge about the impact of teaching approaches." [48]

Further, they argue that by literally speaking the same language, researchers can build on prior work and communicate their findings more powerfully, both to each other and to other practitioners (GROSSMAN & McDONALD, 2008). In video research, this would involve establishing ethical guidelines for re-use and sharing, standardized tools and procedures for generating data, agreed-upon analytical tools, and procedures for logging and archiving video data. By building on prior research and sharing research and research tools, video research in the educational sciences can move forward and benefit from the amount of complex data that new technology provides. [49]

5. Concluding Remarks

It is clear that archived video studies offer information that is open to different perspectives, and methods and strategies for generating and analyzing data (JANÍK et al., 2009), but their potential is rarely made use of. In light of the two cases that have been presented here, we believe that it is necessary for both primary and secondary video researchers to engage in shared or common practices (GROSSMAN & McDONALD, 2008) for archiving and using archived video data if we are to benefit fully from the potential of new media. This will also be necessary if we are to produce credible, transparent, and programmatic research in the field. Common practices for conducting classroom studies and re-using video data will not only help researchers address the contextual issues commonly related to archived qualitative data, but also enable researchers and research communities to pool resources for more expansive research. The re-use of video data also poses new questions in the debate on re-use of qualitative data that may be more easily addressed with other types of data. For instance, the personally identifiable nature of video data requires different approaches for sharing, and there are clearly new practical demands for archiving procedures and data infrastructure that need to be recognized. There is accordingly a need for more research that furthers the establishment of such common practices and standardized tools for doing video research (primary and secondary), which, in turn, may help advance the field of classroom video studies not to mention enable a more cumulative research effort in the field, and in the educational sciences in general. [50]

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