Søknad om prosjektmidler – Utdanning 2020

Budding Science and Literacy – ("Forskerføtter og Lserøtter")
A longitudinal study of using inquiry-based science and literacy in comprehensive schooling

1. Aim, rationale/intension and relevance

The "*Budding Science and Literacy*" project aims to study how the interplay of indoor and outdoor inquiry-based science activities and literacy activities can improve teachers' instructional competence and students' learning outcome in science.

The present project is an intervention and development study that seeks to combine teachers' unique competence from the classroom with the competence of science education scholars (researchers). Teachers, with the guidance of researchers, will develop and adapt curriculum material in science education that concurrently will be tried out in the science classroom and improved. The material will be based on using inquiry-based science activities (forskerspire-aktiviteter) and basic skills (grunnleggende ferdigheter) in particular reading and writing in the service of learning science.

The study's starting point will be a professional development course (10 ECTS credits) for teachers at the University of Oslo. The course is developed and will be implemented by science educators at the Norwegian Centre of Science Education together with reading educators at Institute of Teacher Education and School Development. We define the project as an intervention study, as the teachers will try out and develop the teaching methods in the context of their own practice. We will map teachers' interaction with students over time by following a selection of teachers from the professional development course in their own classrooms. The selected teachers and their students will be our cohort of informants for the longitudinal study as well. This study includes teachers and students in primary education, and higher education. Norwegian science education research has mainly had focus on secondary education (Kjærnsli et al.2007, Klette et al. 2007) and it is imperative to understand more about what is happening in the early years of science in school. We find it important to understand the connections and interplay between teachers' upgrading of competence and students' learning outcomes. (Rowan et al., 2007)

This study will increase our knowledge base regarding:

- Implementation of instructional strategies – how teachers implement new teaching strategies in science education. In this case how they combine literacy skills and scientific inquiry to increase students' learning outcomes.
- Learning processes and learning outcome in science – how literacy skills may enhance learning in science. And in a longer term; how the context of science may enhance literacy skills. How outdoor fieldwork may enhance science learning.
- Evaluating a professional development program – how teachers can contribute to and prolong their own professional development by researching their own teaching practice in science. (Being "budding scientists" on their own practice.)
- Developing curriculum material – how to develop good curriculum material to support the interdisciplinary nature of this way of teaching and learning.
  Good and effective curriculum material will be accessible on www.naturfag.no.

"*Budding science and literacy*" will increase both teachers and researchers competence in educating students in science and literacy. The combination of working close to teachers in practice and using material adapted from international studies will enhance Norwegian research in science education.

We apply for funding of a moderate research project that will serve as a starting point and foundation for a longitudinal study in science education. This means that we request funds for one Phd-student and a 50% research position in addition to project resources. We will apply for supplementary funding elsewhere for an additional Phd-student. However, many researchers are partly involved and thus contribute with their own time resources. The project covers mainly the thematic area A; educational objectives, content, and teaching and working methods, but also thematic area B; assessment forms, learning processes and learning outcomes in education. Main focus will be on the relationship between the teaching and working methods in science on which the "*Budding Science and Literacy*" project is based, as well as the learning processes and learning outcomes they promote.

2.1. Background and status of knowledge

The National curriculum (LK06) has introduced a new topic in science; "the budding scientist" (forskerspiren) and stress importance of basic skills (reading, writing, orals, arithmetic, digital competence) in all subjects. Due to a decrease in recruitment to science related studies (Schreiner, 2008) and low performance on international knowledge tests in science and reading (Kjærnsli et al., 2007; Grønmo et al., 2009), the Government has increased the emphasis on sciences and mathematics education. Even societal organizations as Tekna (The Norwegian Society of Graduate Technical and Scientific Professionals), LO (The Norwegian Confederation of Trade Unions) and NHO (Confederation of Norwegian Enterprise) have through a joint initiative; "Kunnskapsdugnaden", expressed concern for the lack of interest in science education. In addition, classroom studies like Klette et al. (2003) and PISA+ (Ødegaard and Arnesen, 2009) show a limited use of teaching instructions in science. In the light of these challenges, schools, school authorities and society express needs for:

- Well functioning explicit teaching and learning strategies.
- In-service courses for science teachers in primary and secondary school.
- Early innovations in primary schools as well as further up.
- Teaching material that integrates science and basic skills (especially reading and writing)

The Norwegian Centre of Science Education emphasizes the topic area "good teaching and working methods in science" (GLA' i naturfag; "*G*ode *L*æringsaktiviteter og *A*rbeidsmåter i naturfag"), where the "*Budding Science and Literacy*" project will be a central component.

2.1.1. *Budding Science and Literacy* – theoretical framework

Budding Science and Literacy is based on some central educational principles partly inspired by the Seeds of Science/Roots of Reading project developed at University of California, Berkeley and Lawrence Hall of Science (Barber, Pearson et al., 2007).

1. Engage students in first-hand and second-hand investigations
2. Multimodal learning activities
3. Synergy effects of inquiry-based science and literacy
4. Explicit teaching

Based on these educational principles the teachers at the professional development course will be asked to develop a teaching program including inquiry-based science (indoors and outdoors) and literacy focusing on the diversity in nature.

First principle: It is important to engage students in both first-hand and second-hand investigations to make meaning of the world surrounding them. First-hand investigations are practical "hands-on" investigations, and second-hand investigations are text-based investigations involving texts written about scientific studies accomplished by others (Palinscar and Magnusson, 2001). We will integrate text-based inquiries as a natural part of indoor and outdoor science inquiries like they are in academic science and show how texts can enhance and support "hands-on" inquiries. The continuous shift between first-hand and second-hand inquiries is therefore a crucial element in the project. The students practice searching for evidence and arguments in both experience-based information and text, and this supports the development of scientific language. (Barber et. al., 2007, Mork, 2005, 2006) It also supports understanding about the dynamics between data and text in authentic science (Norris and Phillips, 2008; Knain, 2005; Kolstø, 2009)

The second principle: Because of the shift between "hands-on" activities indoors and outdoors, and text-based activities there will be a natural variation in work methods. The students are introduced to a greater diversity of working modes than usual for traditional science inquiries. Examples of shifting between such activities in the Norwegian context are described in Erlien and Mork (2009). We draw on educational projects like "Seeds/Roots" and their multimodal learning activities: "Do it. Talk it. Read it. Write it." (Cervetti et al. , 2006), as well as tools, language and different ways of reflecting in relation to inquiry-based science, from studies like Driver, Asoko, Leach, Mortimer and Scott (1994) and Mortimer and Scott (2003). Underlying the multimodal learning activities are Gardner's multiple intelligences and his entry points, such as narrational, logical, quantitative, foundational, aesthetic, experimental and collaborative methods in approaching the topic (Gardner, 2006).

The third principle: The strategies students use to understand a text, are the same as they use when doing inquiries in science. Norris and Phillips (2008) describe reading as interpretation of text, where the reader makes meaning from the text by integrating information from the text with the reader's relevant background knowledge. Even though the "doing" activities in reading and science are different, the cognitive meaning-making process is very similar. (Cervetti et al, 2005; Norris and Phillips, 2008). Another synergy is that words *are* concepts. The most advanced form for knowledge of words is concept knowledge. To learn scientific words is to learn scientific concepts, where new words must be integrated with known word knowledge. To learn science is to create and master rich networks of scientific concepts. Science is an academic language that is constructed to communicate about the natural world. It is organized in claims, evidence and reasons, so argumentation is important for the social construction of scientific knowledge. Hence it is crucial for science teachers to find good arenas for students to communicate about natural phenomenon.

The fourth principle: The teacher should give reasons for his or her pedagogical choices and in this way make the teaching methods visible, so the students understand why they are doing what they do. This integrated model; not only teaching *what* the students should learn but *how* they should do it, (Weinstein, Bråten, Andreassen, 2006) is also used successfully in projects like "Communities of Learners" (Brown, 1997) and "CORI" (Guthrie et al, 2004). Research from Norwegian lower secondary reading and science classrooms indicate that explicit teaching strategies are not used systematically (Ødegaard and Arnesen, 2009, Anmarkrud 2009). The objective is that the students gain a meta-cognitive understanding and insight in their own learning strategies. Lave and Wenger (1991) describes this as transparency in the learning process; that use of tools (here: learning strategies) and understanding the use is integrated. In concrete situations "transparency" will make knowledge and understanding more available for students. In a "Teaching for understanding" project Wiske (1998) found that students acquired deepest understanding when they had meta-cognitive insight in their own learning and that their teachers possessed a deep understanding of the instructional framework. Another area we want to make more explicit and visible for students is the nature of science.

2.1.2. Inquiry-based science education

Practical work in science classrooms has been emphasized (Anderson, 2007; Jenkins, 1999), because it is important that student get insight in the process dimension of science (Isnes 2005; KD2006; Sjøberg 2004), and because it enriches students learning about scientific phenomenon and systems (Scott, Asoko and Leach, 2007).

The idea of inquiry-based science teaching has been prevailing in the anglo-american science education environment. Inquiry science is considered to be suitable for guiding students to understand scientific processes and scientific concepts (Keys and Bryan, 2001). However, the Norwegian PISA+ study (Ødegaard and Arnesen, 2009) rapported few observations of science lessons that included inquiry elements. There is no unified definition or method description of what inquiry-based science education is in the international research community. The formulation will necessarily depend on teachers' interpretation of what inquiry is, and other local factors. Crawford (2007) asserts that one of the critical factors influencing a prospective teacher's intentions and abilities to teach science as inquiry, is the teacher's complex set of personal beliefs about teaching and of science. The Norwegian "budding scientist" curriculum involves elements of these features, but lacks the description of pedagogical tools to implement them. Klette (2007) underscores the scarcity of pedagogical tools in many subjects in Norwegian classrooms. This is an essential point, where our "*Budding Science and Literacy*" project will contribute.

Our objective is to help teachers help their students to find good, interesting and motivating inquiries in science that facilitates their understanding of scientific facts and the nature of science. Findings in several central studies are important for us to consider. Wiske's study (1998) points out the importance of having progression in activities in order to obtain deep understanding. Students start with "*messing about"* activities, followed up by with *"guided inquiry",* and then ending with *"culminating performance"*, where students work autonomously and demonstrate their understanding. Engle and Conant (2002) suggested four criteria for promoting productive disciplinary engagement: 1) students should problematize the disciplinary content, 2) give students authority, 3) make students accountable towards other students and towards disciplinary standards, 4) supply relevant and sufficient learning resources. Berland and Reiser (2008) identify three goals of engaging in these related scientific practices: (1) sensemaking, (2) articulating, and (3) persuading. However, they found persuading others of an understanding requires social interactions that are often inhibited by traditional classroom interactions. Arranging learning situations where students are given authority and are accountable for their findings are found to be crucial elements for engaging students in meaningful learning. One of the strategies we will use to meet these specific points is to use drama methods in order to engage students in for instance role-play where science is contextualized in real life situations (Ødegaard, 2001; 2003) Another important strategy is fieldwork inquiry (see 2.1.4.).

2.1.3. Science and literacy

In their book on language and literacy in science education, Wellington and Osborne (2001) draw together and synthesize current good practice, thinking and research in this field. They assert that learning the language of science is a major part of science education. Every science lesson is a language lesson. They claim that language is a major barrier to most pupils in learning science and show many practical strategies that can help to overcome these barriers. Mortimer and Scott (2003) have analyzed spoken interactions in the science classroom, as they also see language as a fundamental learning tool. They focus on the distinction between everyday language and scientific language, and show how these sometimes are in conflict. They describe three central features of the scientific language; description, explanation and generalization. Ødegaard and Arnesen (2009) show that in some Norwegian lower secondary science classrooms, the science talk has an excess of descriptions. As indicated above the role of language is central to this project.

Several studies show success in combining inquiry science and literacy. An evaluation of the "Seeds of Science Roots of Reading" project (Wang, 2005), report that students in the program outperformed students in the control group in both science and literacy. Teachers were also highly motivated to use the material. Fang et al. (2008) describes a study where university-based reading educators work together with science teachers during a school year,organizing reading strategy lessons and science lesson plans. Pre- and post-tests showed that students who received reading infusion significantly outperformed those who did not. In a study in Norway involving reading comprehension and social science, Rune Andreassen (2008) found that students outperformed the control group with respect to reading strategies, but did not perform significantly better on measures of reading comprehension or reading motivation. Andreassen (2008) concludes that teachers may need extensive preparation, support, and time to implement new approaches for instruction. Both implementation and process data are needed in intervention studies to explain their outcomes. These studies show that the area of science and literacy is complex and that interventions may be difficult to implement. The difficulties may be due to the background of the involved teachers, the quality and quantity of the professional development or the way the outcome is measured.

2.1.4. Outdoor fieldwork in science

According to the Norwegian national curriculum (Kunnskapsløftet, KUF 2006) teachers should arrange for the local environment to be integrated in the students' education. This means that teachers should bring students out of the classroom and in this way expand the classroom. Educators (e.g. Dillon, 2006; Frøyland, 2002; Jorde, 2007; Orion, 1993) state that the expanded classroom will give students other experiences and an other understanding than the traditional classroom. Fjær (2005) defines fieldwork as teaching activities that actively engages students, as apposed to the traditional teacher lead excursion. Orion and Hofstein (1991) demonstrate the importance of accomplishing preparations before a fieldtrip. Thus, the students should engage in cognitive, geographic and psychological preparation. In a study of the quality of teaching outside the classroom Bamberger and Tal (2006) show that students' learning outcome increases if students are given specific tasks to solve in smaller groups.

Based on several studies (Bamberger and Tal 2006; Dillon et al., 2006; Orion and Hofstein 1994; Orion, 1993) the following points are necessary for effective and meaningful fieldwork: 1) Students should be afforded specific activities that can only be implemented in field. 2) Students should solve the activities together with others. 3) The fieldwork should be carefully planned, prepared and followed up at school. Our project encourages teachers to include fieldwork as firsthand experiences in the scientific inquiry cycles they develop with their students, and we will study how this influences the students learning outcomes. There is a shortage of empirical studies in this field.

2.2.1. Research Questions

Based on the discussions above, we put forward the following research questions:

- How does an intervention with inquiry-based learning strategies influence/change teacher practice in science and reading?
- How can literacy be used as a tool to support inquiry-based science education indoors and outdoors?
- What are the synergies found between literacy and inquiry-based science education?
- How does early intervention with inquiry-based learning strategies influence students' learning outcomes in science and reading?

2.2.2. Methods

This project is a longitudinal intervention study (Rothman and Thomas, 1994). The intervention is the special "*Budding Science and Literacy*" teaching methods (Barber et. al, 2007). The longitudinal perspective is divided in two phases (for description of the two phases, see 2.3. below). In this application we apply for Phase 1 with a duration of three years(see also table 1 below). The "*Budding Science and Literacy*" " phase one, will combine and draw on different sources of data;

observation data, interview data, teacher logs plus achievements scores (test data) in science and literacy. Together and separately the different data sets will contribute to answer the proposed research questions and overall aim of our study. The research design will be organized as a classroom video study covering observations and interviews of students and teachers, similar to the PISA+ design (See Klette et al. 2008). The classroom observation data will focus on offered learning activities (actions) and experienced learning activities (meaning) within the observed science classrooms. In addition we will collect prestructured teachers logs' covering three phases of each school year (covering six weeks each time). Several scholars has documented the benefits of combining different sources of data in the purpose of estimating how professional development programs make impact on teachers' classroom practice and student outcomes (Rowan et .al. 2007).

Students' learning outcomes will be measured in science and reading by a repeated measures design using standardized tests. For science we will use excerpts of National tests in science (see St.m. 31) developed at the Centre for Science Education, and for reading we will use reading comprehension tests(e.g. Setningsleseprøven, Kartlegging av leseferdighet) (see Andreassen, 2008). For linking process and product data we will further cooperate with the proposed LIMM (Linking Macro and Micro data) project (see application from Roe et al. 2009 in this call for proposals).

Several studies that overviews effects of professional development programs has aggregated knowledge in the field of effective strategies. (Borko, 2004; Penuel et al., 2007) Successful factors are: program features that involve active learning; duration of the program in terms of both time span and total contact hours; the collective participation of teachers from the same school or district. Enhanced knowledge and skills and changes in teaching practice are further linking to pd programs that emphasize content knowledge and focus on students' learning. The proposed "*Budding Science and Literacy*" project draws on this insight and translates it into a Norwegian context.

A possible spin-off of this intervention study is a more formal evaluation where we use expertise from the research group CAMP (Classroom Analyses from Multiple Perspectives) at our neighboring Faculty (Education) to evaluate the "*Budding Science and Literacy* course" as a model for professional development.

2.3.1. Project plan

This present project is an intervention study where the main groups are primary teachers that participate in a "*Budding Science and Literacy*" professional development course and their students. Phase 1 starts by studying teachers and their students for a period of two-three years. However, the present project represents Phase 1 (See Table 1) of a longitudinal study over 7 years. We are not guaranteed that teachers follow the same class over two years, so subsequently we will follow students and teachers independently. We will monitor students, from grades 3-5 up to grades 10-12, to map whether an early intervention in students' learning strategies have impact on their science (and literacy) learning later. However, the grade of students is also dependent of the teachers we select from the cohort taking part in our professional development course. Our criteria of selecting teachers to participate in the proposed study are variety in subject background, experience and motivation.

Phase 1 – providing a foundation for good practice, motivated students and a longitudinal study. The project will officially start in spring 2010, but the professional development course will start fall 2009. 5-10 teachers and a small group of their students will be selected as informants and followed, if possible, during both Phase1 and 2. Through this we will obtain insight in both teachers' and students' learning and development processes as described in 2.2.2. The teachers'

exam projects, where they must reflect and document their own practice, will also be used as means for documentation and information.
The second year, 2011, we will continue to analyze and gather data and follow the same teachers and students for a limited period of time, for instance 2-3 weeks during a project period. The teachers will be offered to follow up their development work in learning study groups. The "*Budding Science and Literacy*" professional development course will also be arranged in 2011. Hence, if needed, we can supplement our cohort of informant teachers from here.
The third year, 2012, we will analyze and prepare our data for publication. We will present our findings through international research journals, research conferences, teacher journals and websites and teacher conferences.

Table 1. Project plan for Phase 1 of the Budding Science and Literacy project.

Time schedule	**Research activities /** ***Milestones***	**Responsible**
Aug2009-May2010	Professional development course 1 Project preparations	Project group
Year 1 (2010)	*Kick-off conference*	Project group
	Classroom observations, interviews, logs : of teachers 1 and students 1 (+ school leaders)	Project group with Phd-students
	Pre- and posttests in science and literacy of students 1 and comparing groups	Guttersrud and Andreassen
	Meta study of course 1	CAMP
Year 2 (2011)	Professional development course 2	Project group
	Progress seminar : evaluation of year 1	Project group
	Classroom observations, interviews, logs : of teachers 1+2 and students 1+2 (+ school leaders)	Project group with Phd-students
	Pre- and posttests in science and literacy of students 2 and comparing groups, Posttests of students 1	Guttersrud and Andreassen
	Meta study of course 2	CAMP
	Starting data analyses	Project group
Year 3 (2012)	*Progress seminar : evaluation of year 2*	
	Data analyses, Presenting findings, Writing publications	Project group
	Analysing and presenting; meta study of course 1 and 2	CAMP
	Concluding conference	Project group

Phase 2 – Following up; good practice, knowledgeable and motivated students.
For the next 4 years the project will follow up as many of our teachers and students as possible with focus on the same research questions. This will be important in order to revise and improve professional development initiatives and science education curriculum material. It is possible to scale up the project to include supplementary areas of research., e.g. science and second language students, science and students with learning disabilities, more in-depth about reading factual texts, and role of educational leadership.

2.3.2. Project management and organization

The project is led from the Norwegian Centre of Science Education, a defined research unit closely connected to both the Faculty of Mathematics and Natural Sciences and the Faculty of Education, especially ILS (Institute of teacher education and school development) and the research group CAMP (Classroom Analysis from Multiple Perspectives). Our centre has broad research expertise in science education. The Centre's head of research, associate professor Marianne Ødegaard will act as project leader, and will together with associate professor Merethe Frøyland and associate professor Sonja Mork, both employed at the Centre, constitute the project group. In addition the project group will include two Phd-students. (One funded by this application, and one funded by the *Geo-program* (see below). Both will follow one of University of Oslo's doctoral programs.

Other involved colleagues at the Centre are associate professor Øystein Guttersrud, responsible for testing students for achievment in scientific literacy. (see 2.2.2) Guttersrud is an expert in developing and implementing quanitative tests for measuring of knowledge, attitudes and other factors in science. Associate professor Anne Lea will contribute with an interview study of how school leaders support teachers' professional development. University lecturer Anne Kristine Byhring is responsible for the practical administration of course and project matters. Cand.philol. Eva Narvhus, scholar in reading education at ILS, is responsible for the professional development course together with Ødegaard.
Associate professor Rune Andreassen at Østfold University College has a Phd on explicit reading comprehension teaching. (see 2.1.3 and 2.2.2) In the applying project he will measure students learning outcomes in literacy and contribute in literacy and scientific literacy issues. From Telemark University College, associate professor Erik Halvorsen, a scholar in geology and with long experience in teacher education, will especially focus on teachers working with earth science. Faculty of Education, University of Oslo, will have two visiting Fulbright Scholars that we will collaborate with as much as possible. Doctoral candidate Diana J. Arya works with language, literacy, society and culture at The University of California, Berkeley; and Fulbright Scholar Tom Hatch (Colombia University/ New York) has expertise on teachers professional development , and the use of videos in professional development.

The Geo-program, involving earth science education is a project funded by StatoilHydro in order to develop teaching methods, material and do research on the new subject earth science. The Geo-program and Budding Science will have extensive collaboration. One Phd-student and Frøyland, the Geo-program project leader, are partly funded over the Geo-program and are both part of the project group. Their special focus is outdoor science inquiries. (Geotopen)
The Budding Science project will also cooperate with the EXPLORA project at the science centre. Ødegaard and Mork is involved in this Nordic research project on video studies of explorative work in the science classroom. It is funded by The Councils for research in the Humanities and Social Sciences in the Nordic countries (NOS-HS).
CAMP (Classroom Analyses from Multiple Perspectives) is a cross disciplinary collaborative research group located at the Faculty of Education, University of Oslo. The main thematic focus of the research group is knowledge cultures and learning processes in classrooms and schools. Members of Camp will cooperate and do a meta-study of this applying project's professional development intervention. "Mind the Gap" is a EU network project linked to the CAMP group. Their main focus is inquiry-based science education, and they will be a valuable partner in discussing analysis and findings.

Internationally, we have contact with the researchers behind the "Seeds of Science. Roots of Reading" project at Lawrence Hall of Science, University of California, Berkeley; especially co-principle investigator Jacqueline Barber is interested in discussing findings on implementing science and literacy. In July 2009 Frøyland and Ødegaard will have a study tour to Lawrence Hall of Science. We also have contact with researcher Tina Blyth at Harvard Graduate School of Education at Harvard University i Boston.

2.4. Budget

We apply for funding of the "*Budding Science and Literacy*" project with 6 mill. NOK over three years. (2 mill. a year). This includes one Phd-student, one 50% researcher over three years and project operating expenses. (See electronic budget)

3. Perspectives and strategic foundation

3.1. Strategic foundation

The research questions and the project as a whole are very well rooted in The Norwegian Centre for Science Education's mandate and strategic plans. The centre's main objective is to enable pupils and teachers to consolidate competence and motivate interest in natural science. The centre assists in actions to develop in-service training and further education for teachers of natural science in primary and secondary education and teacher training. In order to accomplish this properly there is a need to explore and understand more about the processes of implementing science inquiry activities.

3.2. Relevance to society, environmental perspectives and aspects of gender and equity

As mentioned in 2.1., there is a general concern in society about the lack of interest, motivation and achievement in science education. This applying project meets important demands (see 2.1). The main topic of the professional development course will be diversity in nature. (see 2.1.1) The involved teachers in the project are encouraged to also include fieldwork in their teaching projects. This will influence the students' awareness of diversity and the environment. There will be an emphasis on inclusive teacher methods and on science activities in environmental and societal contexts (Frøyland, 2002; Mork, 2006; Ødegaard, 2001).

3.4. Ethical aspects

All datainnsamling, lagring og gjengivelse av data vil skje i tråd med god forskningsetikk og datatilsynets retningslinjer, especially important for longitudinal studies. Forskerføtter og leserøtter er basert på gjensidig samarbeid om kunnskapsutvikling, med en ambisjon om at resultatene kommer alle parter som er direkte involvert til gode; elever, lærere, og forskere i akademia.

4. Communication and mediation

We start the project with a kick-off conference where all involved parties can communicate with each other and other researchers. Every year the project will have a progress seminar where we invite external reserachers to comment on our work. In year two and three our aim is to present our work on international conferences like ESERA, NARST and AERA in addtition to the Nordic Science education conference. We will publish our results in international and Nordic educational research journals (e.g. JRST, IJSE, NorDiNa). The Norwegian Centre for Science Education has well established channels for communicating with teachers: an annual teachers' conference; a popular science education journal (Naturfag); and a teachers' resourse website (www.naturfag.no) that we will use frequently to mediate the project's research findings and tested teaching materials. We will end phase one of the project with a concluding conference, inviting researchers, govermental officials and teachers.

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