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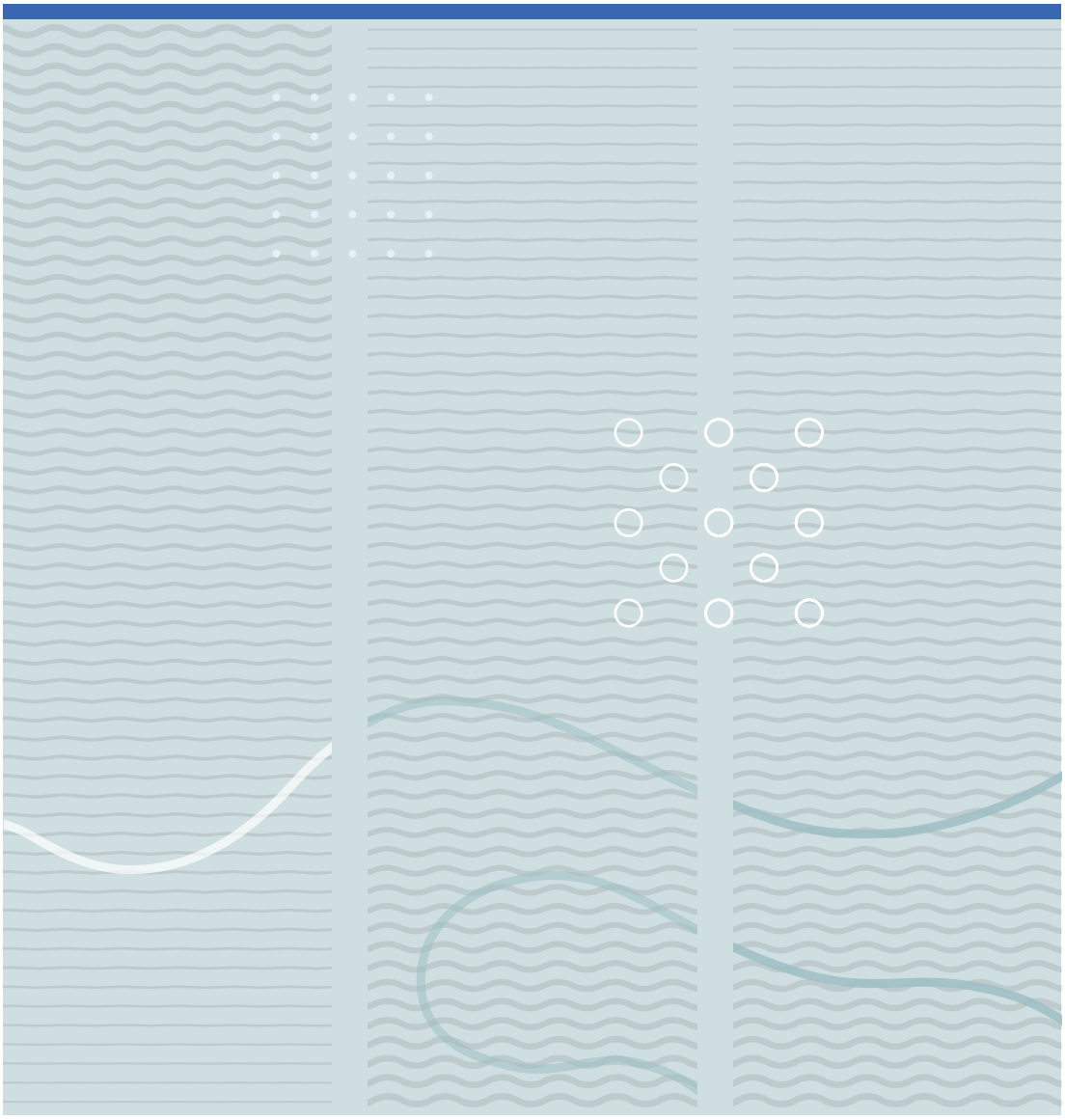
Maren Skjelstad Fredagsvik

Supporting students' creativity in primary science education

Classroom practices and teacher conceptions



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A PhD dissertation in
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Maren Skjelstad Fredagsvik

Abstract

The objective of the thesis is to examine how creativity can be facilitated in primary science education by exploring essential aspects of creativity and different aspects that contribute to the development and strengthening of students' creativity. The thesis comprises three articles that present results from three different studies that focus on and shed light on various aspects of the objective of the thesis, in addition to a meta-text. The research is conducted in a Norwegian primary school and considers three central perspectives: the student-teacher interaction perspective through video-observation (Article I); the student perspective through video-observation (Article II); and the teacher perspective through interviews (Article III). The overarching research problem is: *How can creativity be facilitated in primary science education?* The overarching research problem is concretised by five research questions, corresponding to the three articles of the thesis.

The thesis considers creativity theory and literature on how to support creativity within an educational context, embedded in social cognitive theory. Social cognitive theory highlights students' and teachers' creative self-efficacy and observational learning by social modelling. A social cognitive view of facilitating students' creativity is based on the perspective that humans exercise agency through a system of triadic reciprocal causation among external factors, internal factors, and behaviour. It recognises the joint involvement of teachers, students, and the learning environment, and acknowledges the important role of the teacher in facilitating the environment and functioning as a role model for the students.

Data are collected during a teacher-practitioner collaboration influenced by the principles of design-based research (DBR). By collaborating with two teachers, the researcher developed a design for learning and creativity, called 'Mission Mars', which aimed to support students' creativity. The two teachers implemented the design in three primary science classes (one fifth grade and two sixth grade classes) over the course of 1,5 years. Data consist of video observation of students working on 'Mission Mars' (23 groups á 3-5 students) and interviews with two teachers before developing

the design, after the first implementation and after the third and final implementation of the design (two individual interviews per teacher and one group interview). Through a qualitatively driven multimethod concurrent design, the data are analysed with the use of three different analysis methods to develop a comprehensive understanding of the research problem. Interpretative Phenomenological Analysis (IPA) is used to gain insight into the teachers' beliefs about creativity, Conversation Analysis (CA) is used to gain insight into what teachers do when interacting with students by focusing on their words and deeds, and constructivist Grounded Theory (GT) is used to gain insight into the students' creative process.

Through a synthesis of the findings in the three articles, three conditions for facilitating creativity in primary science education are identified: (1) capitalising on the students' creative thinking abilities; (2) a shift in thinking towards a more collaborative student-teacher interaction; and (3) increasing teachers' creative self-efficacy.

First, capitalising on the students' creative thinking abilities, highlights that students have creative skills that may be squandered in the classroom. It is important that teachers and researchers acknowledge and capitalise on the students' creative competence when teaching for creativity and developing strategies and methods for creative learning. The findings related to Article II show that the students can come up with several ideas, combine and synthesise different ideas and concepts to make new ideas, and elaborate on their creative ideas in collaboration with their peers. In this process, the students use several higher-level thinking skills related to creative thinking and prove that they can conduct both divergent thinking and convergent thinking. They are also able to include science content knowledge in the process. By explicitly focus on making the creative process visible through dialogue and by allowing the students to explain how their ideas are developed, the teacher can use a skill focused approach rather than an evaluative approach. Yet, the findings in Article I show that the teachers encourage students to present their ideas and then evaluate the ideas by displaying preference or dis-preference without exploring how the ideas are developed or could be further developed.

Second, a shift in thinking towards a more collaborative student-teacher interaction represents a need to fundamentally change the way teachers interact with students during creative processes. Literature on how teachers can support students' creativity implies that teachers should act as collaborators that follow up on the students' ideas together with the students, provide sufficient feedback with the use of open-ended questions and cue the students within the domain and task restraints. The results from Article I and Article III suggest, however, that guiding the students in such context is challenging for the teachers due to a product-oriented focus, the wish to maintain control over the class, and a wish to help and follow up on all groups. This results in minimal time used on each group.

Third, increasing teachers' creative self-efficacy is needed if they are to facilitate and support students' creativity in the classroom. Teachers' creative self-efficacy is important as it serves as a mediator to their behaviour in the classroom. The results from Article III show that, even if the teachers value creativity as an important aspect of the science education, the teachers have doubt in their own creative abilities and in their own competence in supporting students' creativity. The wish to support creativity and facilitate creativity in the classroom are also seen to compromise with the need to cover all the standards. They are also hesitant to allow the students sufficient freedom and time to make their own choices and think creatively, because they fear this will cause chaos in class. The teachers present a narrow view of creativity by focusing mainly on the novelty aspect of creativity, while minimising the importance of appropriateness. This misconception of creativity leads the teachers to believe that creativity can only flourish when students are given complete freedom, undermining the importance of structure and constraints in creative processes. This also impacts their creative self-efficacy in a negative manner as their self-efficacy is determined by a need for control and structure in their teaching. The observational data support these findings as the teachers' creative self-efficacy impact their behaviour in the classroom.

The knowledge contributed by this thesis is of importance for teachers in primary school that want to facilitate students' creativity. Embedding creative learning in a social

cognitive theory framework also highlights how creativity can be facilitated in a way that builds on the students' competences and creative thinking skills, and where teacher and students collaborate in developing little-c creative ideas from the students personally meaningful mini-c ideas through dialogue, modelling and cuing. It also highlights how teacher agency is based on their creative self-efficacy and understanding of creativity in the context of science education.

Keywords: Creativity, Primary school, Science education, Creative self-efficacy, Teachers

List of papers

Article I

Fredagsvik, M. S. (2021). The challenge of supporting creativity in problem-solving projects in science: A study of teachers' conversational practices with students. *Research in Science & Technological Education*, 1-17. doi: 10.1080/02635143.2021.1898359

Article II

Fredagsvik, M. S. (2021). Student approaches to creative processes in an open-ended project in Science. *International Journal of Science Education* (Revised and under second review)

Article III

Fredagsvik, M. S. (2021). Teachers' self-efficacy and the freedom paradox: Teachers in primary schools' beliefs of creativity in science education. *NorDiNa* (Submitted)

Unpublished articles are omitted from online edition

List of tables, lists and figures

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Abbreviations

BCC	Big-C creativity
CA	Conversation Analysis
DBR	Design-Based Research
GT	Grounded Theory
ICT	Information and communications technology
IPA	Interpretative Phenomenological Analysis
LCC	Little-c creativity
LISSI	Linking Instruction in Science & Student Impact
NACCCE	National Advisory Committee on Creative and Cultural Education
NESH	The National Committee for Research Ethics in the School Sciences and the Humanities
NOS	Nature of science
NSD	Norwegian Centre for Research Data
NTNU	Norwegian University of Science and Technology
QUAL	Qualitative
SCT	Social Cognitive Theory
STEM	Science, technology, engineering, and mathematics
STS	Science and technology studies
UNESCO	The United Nations Educational, scientific and Cultural Organization

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1 Introduction

1.1 Background and objectives

Creativity is described as an essential 21st-century competence, alongside critical thinking, collaboration, and communication (UNESCO, 2013). This means that creative competence is an important part of the knowledge, skills, and attitudes citizens need in the future society. Our society has become highly complex and is characterised by rapid change, new and easily accessible information, and innovative technology. In order to meet the multidimensional challenges emerging in the society, it seems that our future depends on creative vision and innovations (Hadzigeorgiou et al., 2012; Mukhopadhyay & Sen, 2013). Hence, creativity is widely valued for utility reasons, and creative learners are seen as essential to a nations' future economy and global innovation (Beghetto, 2007a; Beghetto & Kaufman, 2007; Craft & Hall, 2015; Newton & Newton, 2010a). Corresponding with these global trends, we witness an escalating interest in the importance of creativity and innovation in the educational system. Carlos Moedas (the European commissioner of research, science, and innovation) says in the report *Science Education for Responsible Citizenship* (European Commission, 2015) that:

> [a]s the world becomes more inter-connected and globally competitive, new economic opportunities often come hand in hand with complex societal challenges. Therefore, we must engage all of society in research and innovation processes. We must provide the space for open, inclusive and informed discussions on the research and technology decisions that will impact citizens' lives. (p. 5)

This means that in order for all people to be able to participate in science-informed decision-making and in knowledge-based innovation people need to have a better understanding of science and technology, alongside a strengthening of our capacity of innovation and creativity (European Commission, 2015).

As education plays an important part in helping students to meet the unpredictable demands of the future (NACCCE, 1999), schools play an important role in developing students' creativity. Research and literature on creativity present several arguments to

why we need to develop students' creativity. In a society in which humans need to adjust constantly to new problems and find original solutions, developing students' creative thinking may enable them to solve problems in both educational and personal context (Barbot et al., 2011; Kettler et al., 2018; Plucker et al., 2004). By developing their creativity, students may be able to offer new perspectives, generate novel and meaningful ideas, raise new questions and come up with solutions to ill-defined problems (Sternberg & Lubart, 1999). Hence, students may be better equipped to generate new knowledge, new social and technological innovations and to utilise and adapt to technological and societal change. Students may also become more flexible and able to handle changes in their working lives (Kind & Kind, 2007). On a more personal level, research has suggested that fostering students' creativity may impact their personal and intellectual development (Hui et al., 2015). For example, creativity-oriented learning has shown to promote student motivation (Beghetto, 2006; Cropley & Cropley, 2008; Newton & Newton, 2010a) and creative self-efficacy (Beghetto, 2006). It has also been proved positive related to students' learning and long-term knowledge retention (Elaldi & Batdi, 2016; Gajda et al., 2017; Kaufman & Beghetto, 2009; Plucker et al., 2004). Developing students' creativity in school seems, therefore, important related to students' personal well-being, learning and intellectual development, and future possibilities.

There are discussions among creativity researchers regarding whether creativity is domain-general or domain-specific. This has implications for how creativity is developed in school. Earlier researchers mostly agreed that creative performance depends on both general creativity skills and domain-specific knowledge and skills (Sawyer, 2015). However, in recent years researchers argue that, although creativity has some common attributes, its form is highly dependent on the discipline and the context (Diakidoy & Constantinou, 2001; Lubart & Guignard, 2004; Newton & Newton, 2014). Several researchers claim that creativity is situated, and therefore dependent on, the nature of the context or the domain (Alexander, 1992; Amabile, 1996; Baer & Kaufman, 2005; Blamires & Peterson, 2014; Han, 2003; Mukhopadhyay, 2013). This indicates that fostering creative thinking in relation to learning relies on specific domain or discipline-

based knowledge and skills Therefore, in the context of school education, domain-specific creativity has received more and more attention. The thesis builds on this view and see this as an argument to why research on creativity should be conducted within specific subject areas.

The view of creativity as domain-specific is further supported by Kind and Kind (2007), who state that each school subject should emphasise creativity within an agenda reflecting the characteristics of each. Looking past the debates on whether creativity is domain-general or domain-specific, Science is without doubt a creative domain and creativity is an essential aspect of the nature of science (NOS) (Osborne et al., 2003). One fundamental aspect of the nature of science is that scientific knowledge is a product of human creativity and imagination (Aydeniz & Bilican, 2014; Hadzigeorgiou et al., 2012; Kind & Kind, 2007; Meyer & Lederman, 2013; Urhahne et al., 2011). Hence, scientific creativity plays an important role in many scientific processes. Scientific ideas are the result of scientists being able to define the problems around them, coming up with new ideas to explain a phenomenon or solving problems in innovative ways by applying their knowledge, imagination, and reasoning skills (Aktamış & Ergin, 2008; Liang et al., 2009; Liu & Lin, 2014). This aspect of Science should, as much as possible, be reflected in school science (Hadzigeorgiou et al., 2012). When we provide opportunities for engaging in creative thinking in science education through scientific processes and problem-solving activities, we reflect this very important aspect of professional Science. It may also make school science more meaningful for the learners in the sense that is perceived as more authentic and this way increase students' engagement with the subject (e.g., Meyer & Lederman, 2013).

Despite the high level of interest in creativity and innovation skills, concerns remain about the extent to which students' creativity is being developed in schools. Research show that science teachers usually see science as a creative subject, but that they also believe art offers more opportunities for creative thinking (Newton & Newton, 2009). According to research conducted by Newton and Newton, science teachers see subjects that are perceived as more open-ended, less theoretical, more open to self-expression,

provide room for imagination, provide less writing tasks and more independent activity with own ideas as more creative (Newton & Newton, 2009; Newton & Newton, 2010a). Creativity is, therefore, not seen as something that naturally occurs in a science education context, but something that is "additional, something segregated from the usual curricula" (Beghetto, 2007b, p. 30). One reason why creativity is seen as something additional may be that teachers do not identify knowledge as an important factor for creativity, as identified by e.g., Diakidoy and Kanari (1999). Research also show that teachers often see opportunities for scientific creativity in practical work, rather than in for example discussions (Newton & Newton, 2010b), and associate creativity with the ability to create something physical (Kaufman & Beghetto, 2009).

Research also show that many students perceive and experience that scientific investigation is an unproblematic method for fair testing with little room for the students' own ideas, creativity, and innovation skills (Askew, 2013; Duschl & Bybee, 2014; Hume & Coll, 2010; Wong & Hodson, 2009). This is also supported by the Norwegian LISSI-project (Ødegaard et al., 2020) that explores characteristics of Norwegian classroom practice in science. Analysis of video-observations from 20 classrooms (Grade 4-5 and Grade 8-9), student tests, questioners and interviews with teachers, shows that scientific investigations are conducted with the purpose of improving the students' conceptual understanding, rather than developing inquiry abilities and scientific ways of thinking. The project also shows that students are rarely involved in developing questions, hypotheses, and methods, and although the students gather different types of data, these data are seldom linked to theory and implications (Ødegaard et al., 2020). This way of learning science does not leave much room for creativity in the sense that students need to come up with questions, solutions, and investigation designs, and they do not need to demonstrate their knowledge in new and different settings. Acquiring key competence rather than just learning facts and learning science as a process of observing and gathering of information about the way nature works, is believed to provide more room for creativity (e.g., Aktamış & Ergin, 2008; Meador, 2003; Mukhopadhyay, 2013). A science education that focuses on outcomes that are easy to assess, such as recalling of facts and application of standardised

procedures, is probably a product of assessment practices. Assessment that values such outcomes will naturally impact what is being the valued and preferred in the lessons, side-lining possibly more valuable learning outcomes such as creativity (Askew, 2013). This implies that for creativity to be valued as an important part of science education, a shift is needed, both in how the curricula presents creativity as a valued outcome of science education and how schools and teachers place value on- and focus on creativity in the education. However, this poses several questions. These questions include, but are not limited to, how creativity can be defined, what features of creativity are valued and measured, and how we can achieve some consistency in the assessment, bearing in mind that creativity is often recognised as having a subjective nature (Blamires & Peterson, 2014). The teacher is, therefore, presented as one important factor when it comes to developing students' creativity.

The teacher's job is to prepare the students for a life in an uncertain future, and teachers, therefore, play an important role in developing students' creativity (Barbot et al., 2015). Research show that teachers can foster students' creative abilities and creative thinking by providing learning opportunities for creativity in the classrooms (Cole et al., 1999), and by acting as role models and mentors for the students (Kampylis et al., 2009). Some of this research present concrete advice about how teachers can encourage creativity in school by creating an open and supportive classroom environment that rewards and supports creativity, and by motivating and helping the students to be confident and to trust in their own creative abilities (e.g., Beghetto & Kaufman, 2014; Craft, 2005; Cropley, 1997; de Souza Fleith, 2000; Gregory et al., 2013; James, 2015; Rejskind, 2000; Sternberg & Williams, 1996). However, a comprehensive amount of research indicates that teachers' perceptions of creativity and its nature are often limited and different from the theories that guide creativity research (Andiliou & Murphy, 2010; Bereczki & Kárpáti, 2018; Davies et al., 2013; Dawson et al., 1999; Skiba et al., 2010; Westby & Dawson, 1995). Several researchers claim that teachers' understanding, or limited understanding of creativity, makes them less equipped to nurture students' creativity (e.g., Barbot et al., 2015; Bereczki & Kárpáti, 2018; Patston et al., 2018; Plucker & Beghetto, 2004). Plucker et al. (2004) blame this on the lack of a

widely agreed-upon and coherent definition of creativity and see this as one of the limiting factors for educational implementation of creativity. For example, even if teachers agree that creative products require the notion of originality and novelty (Mullet et al., 2016), they often fail to acknowledge originality and appropriateness as joint requirements for creative outcomes (Aljughaiman & Mowrer-Reynolds, 2005; Andiliou & Murphy, 2010; Bereczki & Kárpáti, 2018; Diakidoy & Kanari, 1999; Kettler et al., 2018; Liu & Lin, 2014). However, research on teachers' belief about creativity also shows that teachers generally value creativity and believe that it can be nurtured in every student and across many subjects (Aljughaiman & Mowrer-Reynolds, 2005; Bereczki & Kárpáti, 2018; Sak, 2004). Despite of teachers' positive beliefs about creativity, research also show that these are rarely translated into creativity-fostering practices (Bereczki & Kárpáti, 2018). This indicates that there is a distance between research on creativity and practice in school.

Research on school practice has long been criticised for separating research from the reality in classrooms and the lived experience of teachers and students (Levine, 2007). This is also evident within research on creativity. Despite the increasing number of studies on how to develop students' creativity and why it is important to support students' creativity, it seems to have had little impact on school practice (Sawyer, 2015). The minimal impact in schools may not be due to the lack of desire in teachers to promote creativity, but a reflection of little and unavailable information, support and professional development from policy makers and education system (Patston et al., 2018). More in-depth research on teachers' perceptions about supporting creativity in the context of science education and how teachers' beliefs impact their classroom behaviour is needed (Bereczki & Kárpáti, 2018; Mullet et al., 2016). There is also a need for research that informs educational decisions, in classrooms, schools, and beyond (Richardson & Mishra, 2018).

Researchers also report cultural differences as well as similarities in the teachers' beliefs about creativity, indicating that implicit theories reflect cultural differences (e.g., Choe, 2006). There are, for example, differences regarding how creativity is being

implemented into schools in different countries (e.g., Hong & Kang, 2010). In their review of research on teachers' beliefs about creativity and its nurture, Bereczki and Kárpáti (2018) show that there is little research about how teachers in many cultures conceptualise creativity. Since creativity is perceived and implemented differently in different countries and cultures, and because there seems to be a lack of such research within a Norwegian context, there is a need for research investigating teaching practices in a Norwegian context.

The thesis explores the essential aspects of creativity in science education and the different aspects that contribute to the development and strengthening of students' creativity. It explores two teachers' perceptions of creativity and how this impact their classroom behaviour and problematises aspects that might be negative or inhibiting towards supporting students' creative potential. The thesis contributes to increase the empirical research-based knowledge about teaching and learning processes related to creativity in a Norwegian educational context. The empirical data are collected during a project in a Norwegian primary school, where the researcher collaborates with two teachers on developing a design for learning and creativity, called 'Mission Mars'. The design is implemented in three primary classes (5th and 6th grade) by the two teachers, and video-observations from the three implementations serve as empirical data in the study, in addition to several interviews with the two teachers during the project. The result of the thesis has practical implications for conditions that need to be present to develop students' creativity in science education, alongside reasons to include creativity as part of the teacher education and teacher training courses.

1.2 Research problem and research question

The overall research problem for the thesis is:

How can creativity be facilitated in primary science education?

The overall question is answered by five sub-questions, covered in the three articles of the thesis as follows:

i. How do teachers respond to students' creative ideas during the phase of identifying problems and generating ideas in a creative science project? (Article I)
ii. How do teachers' responses to students' creative ideas impact the students creative process? (Article I)
iii. How do students in fifth- and sixth grade display creative thinking while working on an open-ended project in science? (Article II)
iv. How do students include science knowledge during the creative process? (Article II)
v. What are primary teachers' beliefs about creativity and how to support students' creativity when developing and implementing a creativity-supporting, open-ended science project? (Article III)

The five above-stated research questions examine the thesis research aim from three central perspectives: (1) the student-teacher interaction perspective through video-observation, (2) the student perspective through video-observation, and (3) the teacher perspective through interviews. The different perspectives create the opportunity for exploring different methodologies best suited to answer the different research objectives. The three different perspectives are, therefore, followed by three different methods for analysing the data: conversation analysis (perspective 1 - Article I), constructivist grounded theory (perspective 2 - Article II), and interpretative phenomenological analysis (perspective 3 - Article III).

1.3 The Norwegian context

How schools and teachers approach creativity can be influenced by the curriculum and the standards of science education. The current section explains how creativity is emphasised in the Norwegian curricula in general and in the science curricula in specific.

It also provides a short explanation of the Norwegian educational system for international readers.

1.3.1 The Norwegian school system

The Norwegian school system is divided into primary school (grade 1-7, ages 6-12), lower secondary school (grade 8-10, ages 13-15), and upper secondary school (grade 11-13, ages 16-18). Grades 1 through 10 are compulsory, and the students have one shared curriculum. Upper secondary school brings greater freedom of choice and students can choose between general study program that qualify for university admission and vocational programs that prepare them for a vocation but not necessarily university studies.

Science is taught as a compulsory subject in Norway in Grades 1-10 (The Norwegian Directorate for Education and Training, 2021a), and the students receive, on average, approximately 61 hours of science lessons a year (The Norwegian Directorate for Education and Training, 2021f). If students choose to attend upper secondary school, science is also a compulsory subject in Grade 11 at the general study programs. The science subject in Norway includes various disciplines such as biology, chemistry, physics, geo-science, and technology. However, the subject is treated as a holistic subject, both theoretically and practically, with teachers who teach the whole subject (The Norwegian Directorate for Education and Training, 2021g). In Grade 12 and 13, the science disciplines are taught in a more subject-oriented way, primarily as physics, biology, and chemistry.

1.3.2 Creativity in the context of the Norwegian curriculum

We have recently witnessed an escalation of interest in creativity as an important concept and aim within the Norwegian education system. This interest has occurred simultaneously to, and is related to, concerns for developing students' creativity

internationally, made evident through policy-documents, school curricula and by several researchers (e.g., Craft, 2005, 2006; Davies et al., 2018; Davies, 2006; Demir & Şahin, 2014; Hadzigeorgiou et al., 2012; Heilmann & Korte, 2010; Shaheen, 2010). At the time of writing this thesis, the school curriculum in Norway has gone through a process of renewal. The renewal was first implemented in primary- and lower secondary school in the fall of 2020, and the implementation will proceed throughout 2023. The renewal aims to meet the needs of the future society by emphasising knowledge and competencies that are relevant and future-oriented (The Norwegian Directorate for Education and Training, 2021c). In the curriculum, development of creativity is, both explicitly and implicitly, an important aspect of compulsory education, not only because politicians say it is important, but because it connects the various disciplines to new thinking, innovation, and creation. The core curriculum states that creative learning processes are a necessary part of students' development as human beings and in their development of their identity, as students who learn about and through creative activities develop the ability to express themselves in different ways, solve problems, and ask new questions (Ministry of Education and Research, 2021). Hence, in the core curriculum, creativity is treated explicitly as an essential human quality to be developed in future citizens. Science education is considered as one of the tools for such educational endeavour.

The science curriculum emphasises creativity related to the subject's aim of developing students' "sense of wonder, curiosity, inventiveness, engagement and innovation by opening up for them to work in the subject in a practical and exploratory manner" (The Norwegian Directorate for Education Training, 2021e). Hence, creativity is explicitly emphasised in the curriculum through the importance of being able to develop students' ability to be innovative and by making use of technology and create new technology (The Norwegian Directorate for Education and Training, 2021d). More implicitly, the curriculum connects education for creativity to the students' understanding of the nature of science. The curriculum states that "[t]rough practical work and making their own models to solve challenges in this field, the [students] can develop their ability to be inventive and innovative, and develop their understanding of natural-science theory"

(The Norwegian Directorate for Education and Training, 2021d). Emphasising the role of creativity in inquiry and technological design makes creativity a legitimate goal for science teaching and a means of science education. However, this connection is not explicitly emphasised in the Norwegian curriculum, at least not on a micro level, through the subject's competence aims.

1.4 The research journey – motivation and development

Scientific research aims to fill gaps in a specific field of knowledge, but research is also highly based on personal interests and motivation. In this section, I will describe my research journey and motivation for this study. In qualitative research it is important that the researchers "disclose all relevant research processes via an honest detailing of every aspect of the data collection process and the rules used to analyse data" (Tuval-Mashiach, 2017, p. 128). Describing the researcher's personal journey, motivation and development will contribute further to the transparency of the research.

I have always been fascinated by Science and the complexity of nature and wildlife. As a teacher student, I therefore chose to focus on science subjects, where I learned about the concepts of Science and how to practice Science through laboratory work and field excursions. I then decided to pursue a master's degree in science education at the Norwegian University of Science and Technology (NTNU). Here, I was able to immerse myself and learn more about the scientific practices and styles of reasoning that result in scientific knowledge. I became aware of the importance of inquiry, curiosity and creativity in science, and the importance of including this in the science education as well.

After completing the master thesis, I started working at the NTNU's Resource Centre for STEM-Education, where I among other things, worked on teaching in-service teachers about inquiry-based science education and how to include inquiry and creativity in their professional development and in specific technology and design-projects. Research and policy documents have for a long time communicated the importance of enhancing

students' creative potential in school, often in the contexts of inquiry-based methods and technology and design projects. Working with teachers, I have experienced that it can be challenging to include creativity in schools. This tells me that we need to focus more on how to include creativity within the school's frames, rather than simply telling schools to do so. Pursuing my PhD, I therefore, wanted to include the development of methods and strategies where creativity was the defining element in the thesis.

I started my PhD journey by optimistically planning and starting a Design-based research-project (DBR) in collaboration with the two teachers in this study. Already during the first cycle, I realised that the amount of work related to such a design was not possibly for a single PhD-student within the given timeframe. The amount of data from the implementation was overwhelming, and it became clear that I was not able to analyse it all before the second cycle. I, therefore, decided that the DBR-project was treated as the thesis' empirical context (further explained in chapter 3). I then decided to focus my study on trying to understand the different aspects that may impact the way teachers implement and support creativity in their teaching, rather than develop certain teaching methods and teaching strategies which was the general aim of the planned DBR-project. Reading previous research literature on how to support students' creative potential made me realise that few studies focused on observing and understanding how the teachers' self-efficacy towards supporting creativity and their perceptions of creativity impact their behaviour in the classroom. I, therefore, decided to explore this more thoroughly by extensive observation and conversations with the teachers. I also wanted to see how the students managed to approach the creative process, and how the teachers affect the students' creativity during the creative process.

1.5 Thesis outline

The thesis consists of six chapters. Chapter 1 has introduced the background, objectives, context, and research questions. Chapter 2 elaborates on the theoretical background for understanding creativity in a classroom context. Chapter 3 introduces the

methodology and research design of the thesis. Research participants, data collections, analytical approaches, research credibility and ethical considerations are considered and discussed. Chapter 4 presents the results by briefly describing the purpose and main findings in the three articles of the thesis. Chapter 5 discusses the results with respect to the overall research question. Chapter 6 discusses the theoretical and practical implications, in addition to presenting methodological reflections and conclusion.

2 Theoretical background

The theoretical background for the thesis is creativity theory and literature on how to support creativity within an educational context, embedded in social cognitive theory. Embedding creativity in a social cognitive framework, makes the fusion between creativity and learning more evident. Modelling and self-efficacy are considered as essential components for teachers in supporting students' creativity in an educational context and are, therefore, further elaborated.

2.1 Social cognitive theory

Social cognitive theory (SCT) is theoretically relevant for the discussion about how creativity can be supported within an educational context. SCT sees human functioning as a reciprocal relationship and interaction between personal characteristics, behaviours, and environment (Bandura, 1986). At the same time, SCT recognises the agentic, active role of individuals (Bandura, 2001). Educational research is set within a complex environment that influences students' learning, and this is reflected in SCT's model of triadic reciprocal causation. The model of triadic reciprocal causation (Figure 1) illustrates human functioning as a three-way reciprocal, causational relationship among external factors (e.g., environment), internal factors (e.g., person, biology and thinking) and our behaviour (e.g., actions). The figure signifies causation as all three elements influence on another and signifies reciprocity as the relationship between the elements are two-directional.

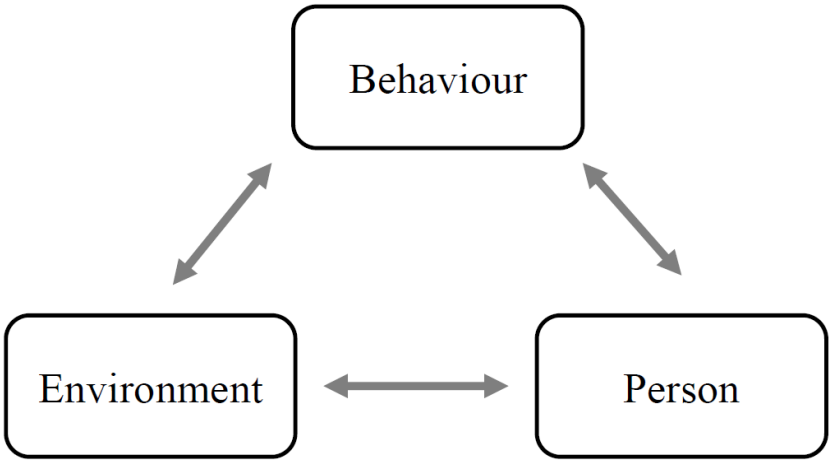

Figure 1: Triadic reciprocal causation model of human functioning (adapted model) based on theory by Bandura (1989) and illustration by Schunk (1989).

The model shows for example that a person's behaviour influences both the person itself and the environment, and that the environment and person, at the same time, influences the person's behaviour. The person factor in the model comprises a person's cognition, affective state and motivation, the behaviour factor comprises people's actions and decisions, and environmental factors are external elements to people. In the context of the thesis, personal factors include students' perceptions of their own preferences, beliefs, and motivation towards conducting creative tasks as well as teachers' perceptions, beliefs, and motivation towards supporting students' creativity. For the teachers, behaviour reflects how the creative processes are modelled for the students and how they respond to the students' creative ideas. For the students, behaviour is their actions during the creative process. Environment consists of the social context that emphasises support or constraints on the teachers' and students' creative process, e.g., the school, classroom, available resources etc.

In social cognitive theory, learning is related to observing others (models) through social interactions (Bandura, 1977). Learning may not always occur from direct experience but may also occur by vicariously observing others. From observing peers and significant others performing actions, a concept of how new behaviour patterns are performed

forms, which later will serve as a guide to action (Bandura, 1971 cited in Bandura, 1977). The process of observing is important for students to develop understanding and self-efficacy (Bandura, 1986) and for teachers to develop understanding of the concept and strategies for supporting students' creativity and develop self-efficacy in doing so.

Within the system of triadic reciprocal causation (Figure 1), human agency is a central factor, together with the interacting personal, behavioural, and environmental influences. The agentic perspective in SCT propose that people take an intentional and active role when conducting actions and, hence, make causal contribution to their own motivation and action through own efforts (Bandura, 1989). People motivate themselves, guide and regulate their actions by use of forethought (Bandura, 1993). People plan and anticipate the consequences of future events before executing own actions, and people's personal agency is, according to Bandura (1993), posited in people's beliefs in their own self-efficacy. In the context of the thesis, it is, therefore, relevant to discuss how teachers' agency influence, and are influenced by how creativity is perceived, their self-efficacy, and the contextual factors in educational contexts. It is also relevant to discuss how teachers' agency influences how students engage in creative tasks.

2.2 Creativity

Creativity "may be found in any domain of human activity" (Clegg, 2008, p. 220), and is an important part of education. Creativity is a term that is widely used in several aspects of society, thus it can be difficult to know the meaning of the term. Coming up with a unified definition of creativity is difficult because the different definitions in the literature represent such a wide range of activities and personal styles (NACCCE, 1999), and depends on how the authors view the creative function. In the 1960's, reviewers identified over 40 different definitions of creativity in the literature (see e.g., Rhodes, 1961), and in the comprehensive meta-analysis of the creativity literature in 2001, Treffinger et al. (2002) found 120 different definitions of creativity. Plucker et al. (2004)

highlighted the definitional issue in their review of 90 articles, where they found that only 38% of them provided explicit definitions, and that the definitions presented varied wildly. However, most definitions include the notion of novelty and usefulness, but they also include other concepts of creativity. To unify and represent the multiple perspectives represented in their synthesis, Plucker et al. (2004) propose the following definition of creativity: "the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context" (p.90). The definition includes the dynamic interaction with the process, not only focusing on the creative product, but at the same time includes the importance of social context of creativity. Within the field of science education, Hu and Adey (2002) propose a similar definition for scientific creativity: "a kind of intellectual trait or ability producing or potentially producing a certain product that is original and has social or personal value, designed with a certain purpose in mind, using given information" (p.392). This definition adds to the comprehension of creativity by including the importance of subject knowledge and that a creative outcome may be seen as creative if the outcome is new to a person and holds personal value, and not only if the outcome is new and useful to the whole world.

To anchor the work presented in the thesis, while at the same time acknowledging the varied perspectives represented in the literature, the following definition of creativity represents the thesis' conception of creativity, based on the definitions of Hu and Adey (2002) and Plucker et al. (2004):

Creativity is the interaction among person, process, and environment by which an individual or group produces a product that is both novel and has personal or social value, designed with a certain purpose in mind, using given information.

The definition closely aligns with social cognitive theory, that emphasises the triadic reciprocal relationship between personal characteristics, behaviours and environment (Bandura, 1986), and at the same time values the agentic work of individuals (Bandura, 2001). The agentic perspective of SCT, for example that individuals hold an intentionally and active role in their actions of producing outcomes (Bandura, 2001), also challenges

the conception that creativity is reserved for the eminent few and cannot be taught or developed (Aljughaiman & Mowrer-Reynolds, 2005; Mullet et al., 2016; Plucker et al., 2004). As creativity can be developed, the teacher's active and agentic role of influencing students' creativity in the classroom, is increasingly important. The approach to creativity in educational context also includes the relationship between creativity and knowledge, curriculum, and pedagogical strategies that foster and support creativity in the classroom (see Lin, 2011).

2.2.1 The 4 P's framework of creativity

Creativity is a multifaceted phenomenon that has been described by different people in different ways. However, since Rhodes (1961) proposed the 4 P's framework of creativity, the notion of creativity has been described within the four dimensions: the creative product, person, process and press (e.g., pressure, environment and situation). The 4 P's framework is also widely used in updated and new research on creativity, making it a relevant framework for the thesis (e.g., Beghetto & Kaufman, 2014; Glaveanu, 2011; Jordanous, 2016; Lin et al., 2003). Rhodes (1961) sees creativity as a phenomenon where an individual develops new products with the use of implicit cognitive thinking, and where the environment potentiates the creation. Using this framework allow us to pay attention to four important features of creativity: the creative product, the person who creates the creative product, the process that occurs when producing the creative product, and the environment that influences the creative development (Jordanous, 2016).

The framework is built on an individualistic approach to creativity, and the four concepts have usually been studied separately (Isaksen, 1995). This individualistic approach is being problematised in creativity literature (Glaveanu, 2011; Jordanous, 2016), because it aims to make universal assumptions about how creativity "works" without considering the social and cultural nature of the phenomenon. Studying the concepts separately, for example, if we restrict creativity to products, we are bound to miss out on the full aspect

of creativity as the process, person and environment is interconnected in every creative activity. By building on the four aspects of creativity as an interconnected approach to creativity, we are better equipped to acknowledge the creative potential and personal creative efforts of individuals who produce creative products that are not novel and appropriate to the world (Runco, 2005), and better acknowledge the dynamic process of creativity-in-the-making (Moran & John-Steiner, 2003). This makes the framework especially useful when exploring creativity in the scope of teaching and learning.

2.2.2 Creative thinking

According to the 4 P's framework, individuals develop creative products with the use of cognitive thinking within a supportive environment (Rhodes, 1961). Hence, students need to use creative thinking when coming up with creative ideas. A decade before Rhodes presented the 4 P's framework, Guilford (1950) presented his seminal paper which is said to have sparked the interest of creativity research within the educational context. Following and based on this paper, creativity was mostly regarded as being primarily a matter of divergent thinking (Cropley & Cropley, 2008; Mukhopadhyay & Sen, 2013). Divergent thinking is defined as the production of multiple or alternative answers from available information (Cropley, 2006). It requires producing a great number (fluency) of various (flexibility) ideas that are unusual and unique (originality) and richly detailed (elaboration) (e.g., Aktamış et al., 2005; Diakidoy & Constantinou, 2001; Mukhopadhyay & Sen, 2013). These four components (fluency, flexibility, originality and elaboration) are not seen as isolated acts, but as working together during the idea generative process (Sarnat, 2011, cited in Talens, 2016). However, for a considerable time, many authors have argued that a creative act is not a singular event but is seen as a multicomponent process, mediated through social interaction (see DeHaan, 2009), and that creativity also requires convergent thinking (e.g., Brophy, 1998; Sternberg, 2006). Weisberg (1986), for example, argues that the ability to produce numerous ideas does not necessarily ensure that any of them qualify as creative. Convergent thinking is oriented toward combining and joining the ideas produced by

divergent thinking and narrowing them down into the best (or correct) solution to a problem that is both novel and appropriate (Cropley, 2006; Liu & Lin, 2014), and involves abilities such as redefinition and sensitivity to problems (Guilford, 1967, cited in Mukhopadhyay & Sen, 2013).

Following the view of divergent thinking and convergent thinking as stages in the creative process, Finke et al. (1992) suggest that the creative process comprises two phases, a generative phase and an evaluative phase. The generative phase relates to divergent thinking, and the evaluative phase to convergent thinking. Identifying the creative process in two phases is also consistent with results from cognition research, which identifies two distinct modes of thought, associative and analytical (Neisser, 1963; Sloman, 1996). Associative thinking relates to divergent thinking as it is defocused, suggestive and intuitive, and aims at revealing remote or subtle connections between ideas or concepts that may or may not be causally related, while analytical thinking relates to convergent thinking as it is focused and evaluating, and aims at analysing relationships of cause and effect (DeHaan, 2009).

Bloom's taxonomy classifies different levels of thinking, from recalling knowledge and procedures to the most complex act of creating new and original work (Bloom et al., 1956). The taxonomy separates between six levels of students' cognitive abilities; (1) knowledge – recall or recognition of facts, (2) comprehension or understanding – interpretation and classification of ideas, (3) application – using learning material in new situations, (4) analysis – the ability to separate material into component parts and show the relationships between those parts, (5) synthesis – the ability to put ideas together in new ways, and (6) evaluation – the ability to judge the worth of ideas against stated criteria (Forrester, 2008). Higher-level thinking skills are defined as the cognitive abilities of students at a level of analysis, evaluation, and synthesis (Krathwohl, 2002) – which is now replaced by three terms from Anderson and Krathwohl (2001): analyse, evaluate and create. Creative thinking belongs to the higher cognitive levels in Bloom's taxonomy (Anderson & Krathwohl, 2001), which indicates that creativity can be taught in schools, also on primary level.

Being able to use higher-level thinking skills is often what separates novices from more able learners. This means that the distinction between novice creators and more able creators is not the amount of content knowledge, but the ability to use and organise this knowledge related to the complex cognitive schemata and to retrieve and apply the knowledge when confronted with problems (see Schmidt, 2011). According to Newton and Newton (2014) these are abilities all learners can be encouraged to practice. They emphasise that teachers, therefore, need to provide opportunities for the students to develop and use creative thinking (e.g., adapting ideas, suggesting alternatives, using analogies), problem solving (e.g., raising questions, searching for solutions, generating ideas), and critical thinking (e.g., weighing evidence, justifying choices, challenging assumptions). Hence, critical thinking relates to convergent and analytical thinking and is an important aspect of creative thinking.

2.2.3 Levels of creative magnitude

Much of the literature on creativity in the context of education approach creativity in two different ways. The first approach is that creativity can be fostered in education (Lin, 2011; Newton & Newton, 2009), and the second is that all students have the potential to become creative (Hong & Kang, 2010; Lin, 2011; National Advisory Committee on Creative and Cultural Education, 1999). This thesis builds its understanding of creativity on the belief that creativity is a process that can be developed and enhanced in education, and that every student has the potential to be creative given the opportunity and chance to do so through activities in a creativity supporting environment.

Craft (2001) distinguishes between two different levels of creativity. The first refers to extraordinary creativity displayed by geniuses with special gifts, often called 'high' or 'Big-C creativity' (BCC) and the second refers to the more ordinary, everyday creativity, called 'little-c creativity' (LCC). Little-c creativity recognises that everyone has the potential to be creative in terms of everyday problem-solving, by exhibiting personal agency and self-direction (Chander, 2012; Csikszentmihalyi, 1997; Lin, 2011).

Beghetto and Kaufman (2007) note that a distinction between little-c- and Big-C creativity is not sufficient for capturing the full range of variations in levels of creativity. Therefore, they propose a model - the Four C model of creativity - that distinguishes between four levels of creative magnitude: (1) Big-C – creativity of eminent creative persons whose work or thinking impacts a field of expertise (e.g., Einstein), (2) Pro-C – creativity of individual experts in their profession (e.g., a scientist), (3) little-c – creativity of everyday life considered as creative by their peers (e.g., projects students creative to demonstrate knowledge), and (4) mini-c – creativity experienced by learners as they interact with new information and experience (Beghetto & Kaufman, 2014). Big-C and Pro-C also distinguish from little-c and mini-c as the former are valued as creative in a broader social context, and the latter two occur in a more narrow social context (e.g., Richards, 2001). The framework acknowledges that most people are not able to make substantial creative contributions on an expert- or professional level. However, most people may obtain certain 'aha'-moments of discoveries on the level of little-c and mini-c.

What separates the different levels of creative magnitude is the role of deliberate practice and expertise (Kaufman & Beghetto, 2009). Young students' creativity is more personal and tied to their own experiences, but according to the Four C model, their creative expressions can be valued as creative if their ideas or problem solutions are novel and appropriate to the students themselves (Runco, 1995, 2003). As students make learning meaningful to themselves and interpret new knowledge and information, they are experiencing mini-c creativity (Kaufman & Beghetto, 2009). The process where students construct knowledge and ultimately learn may, therefore, be seen as a creative process (Beghetto, 2007b). As young students show mostly mini-c or little-c creativity (Beghetto & Kaufman, 2014), defining creativity according to Big-C or Pro-C levels of creative magnitude is not suitable related to child development and educational realities (Skiba et al., 2010).

According to Beghetto and Kaufman, everyone has the potential to be creative and most creative potential starts in mini-c (Beghetto & Kaufman, 2007; Kaufman & Beghetto,

2009). This means that mini-c creativity is not just for children but represents the initial creative interpretations to all creators (Kaufman & Beghetto, 2009). However, they argue that if nurtured right, mini-c can become little-c, and in extraordinarily cases, little-c creativity can turn into Pro-C and Big-C. According to Beghetto and Kaufman, in their framework called ideational code-switching, there are three kinds of teacher support strategies that are necessary for supporting the development from mini-c to little-c: (1) taking the time to listen to and attempt to understand students' mini-c ideas, (2) cuing students when their contributions do not make sense within the given domain and task constraints, and (3) giving the students multiple opportunities to translate their ideas into products (Beghetto, 2007b; Beghetto & Kaufman, 2007). The framework highlights the importance for skilled others (e.g., teachers) to recognise the value of mini-c creativity and at the same time introduce the novice (e.g., students) to the conventions and knowledge of the domain (Beghetto & Kaufman, 2007). In this way,

> [t]he Four C model can help teachers understand the levels of creative expression most germane to the classroom environment (i.e. mini-c and little-c) and identify key factors necessary for supporting the development of creativity from one level to the next (Beghetto & Kaufman, 2014, p. 55).

The model also highlights the importance of recognising creativity inherent in students' unique and personally meaningful insights and interpretations during learning, while emphasising students' creative potential rather than creative outcomes (Kaufman & Beghetto, 2009, 2013). Teachers' awareness of the various levels of creative magnitude will make them more aware of the importance of constraints in creativity and, therefore, make them better equipped for considering what constraints are most appropriate in their classroom (Beghetto, 2007b). As Big-C constraints are clearly inappropriate for evaluating creative expressions in the classroom, teachers are advised to focus their efforts on supporting students little-c creativity (Beghetto, 2007b).

Research on creativity has come up with several strategies and methods for supporting creativity in an educational context. Building on the 4 P's framework, which claims that the development of a creative product is impacted by the person, the process and the

environment, and the idea that creativity can be developed in everyone, the next chapter presents factors for supporting creativity in an educational context.

2.3 Supporting creativity in an educational context

There are several factors that may influence the development of students' creativity, and several researchers point out that creativity involves a combination of cognitive, conative, and emotional factors, and that these are interacting dynamically with the environment (e.g., Ahmadi & Besançon, 2017; Besançon & Lubart, 2008). Hence, when it comes to nurturing creativity in the classroom, the environment (classroom context) is believed to play an important part (Amabile, 1983; Beghetto & Kaufman, 2014; Bereczki & Kárpáti, 2018; Csikszentmihalyi, 1997; Sternberg & O'Hara, 1999).

Davies et al. (2014) define 'creative learning environments' as learning environments designed to promote 'creative learning' and include both the physical environment and pedagogical environment. In their literature review, Davies et al. (2013) identifies several features of the learning environment that are conducive to the development of students' creativity. With respect to the physical environment, they emphasise the need for flexible use of space, and availability and incorporation of a wide range of materials and tools, including the use of ICT. With respect to the pedagogical environment, the authors note that the use of play-based learning and relationship between teachers and learners can impact learners' creativity. Barbot et al. (2015), in their review, present two aspects of the school environment that seem to influence students' creativity: "(1) the structure, atmosphere, and operation of the classroom, and (2) the attitude of the teacher towards creativity" (p. 377). Hence, both reviews highlight that students can potentially achieve their full creative potential if they are being supported through various means in the classroom, and that the teachers have a key role in structuring and maintaining the environment.

2.3.1 The teacher's role in facilitating creativity

Several researchers emphasise that the teacher is crucial for supporting students' creativity in school and that any effort to facilitate creativity in education must include the teacher (Barbot et al., 2015; Chan & Chan, 1999; Csikszentmihalyi, 1997; Diakidoy & Kanari, 1999; Henriksen et al., 2016). Teachers are important in students' development and learning as they act as role models, mentors and spend a considerable amount of time with students (Kampylis et al., 2009), alongside being the one who are called to realise the goals specified by the national curricula and educational programmes (Diakidoy & Kanari, 1999).

To support students' creativity, teachers need to understand the nature of creativity, be able to identify opportunities for creativity, and have knowledge about how to foster it in different contexts (e.g., Beghetto & Kaufman, 2010; Blamires & Peterson, 2014; Newton & Newton, 2014). This means, according to Aljughaiman and Mowrer-Reynolds (2005, p. 17), that "teachers need to identify characteristics of the creative personality, recogni[s]e creative production, understand the cognitive processes used by creative students, and ultimately establish an environment that promotes the child's interests". That is, being able to recognise the full aspect of creativity related to the 4 P's framework (see Rhodes, 1961). This is grounded in a wealth of research which claim that teachers' belief are important indicators of their behaviour in the classroom (Bryan, 2012; Hofer & Pintrich, 1997; Pajares, 1992; Skiba et al., 2010; Waters-Adams, 2006). On the one hand, teachers' belief towards creativity or students' abilities may affect the development of students' creative potential (Barbot et al., 2015; Beghetto, 2006; Beghetto & Kaufman, 2014; Liu & Lin, 2014; Skiba et al., 2010). On the other hand, teachers who misperceive creativity may unwittingly supress creative expression in the classroom and fail to recognise opportunities for supporting creative potential in students (Beghetto, 2009).

Several authors also emphasise the necessity for teachers to adopt a positive attitude towards fostering students' creativity (Rubenstein et al., 2013), including the need to

recognise the importance of creativity (Akcanca & Cerrah Ozsevgec, 2018; Aljughaiman & Mowrer-Reynolds, 2005; Sak, 2004). In their review, Davies et al. (2013) state that:

> 'creative' teachers adopt a positive stance towards learner engagement, creativity and creative learning; that they take a 'long-term view' of a learner's potential; and that they continue to develop the skill and the professional knowledge to facilitate the development of pupils' creative responses". (p. 87-88)

This indicates that teachers who are creative are better equipped to nurture students' creativity.

2.3.2 Teaching creatively vs. teaching for creativity

When characterising creative teaching in the classroom, literature on creativity distinguishes between 'teaching creatively' and 'teaching for creativity'. 'Teaching creatively' refers to the ability of the teacher to use creative approaches with the aim of making learning more interesting, exiting, and effective (Jeffrey & Craft, 2004; National Advisory Committee on Creative and Cultural Education, 1999). Teaching creatively is also characterised as merely 'good practice' as the teacher creates and develops materials and approaches that motivate and interest students (Rutland & Barlex, 2008). 'Teaching for creativity' refers to teaching methods with the purpose of developing students' creative thinking and behaviour (Jeffrey & Craft, 2004). As 'teaching for creativity' is more focused on developing learning that employs creative thinking, Jeffrey and Craft (2004) suggest the term 'creative learning' as more appropriate.

The authors of the British NACCCE report - *All Our Futures: Creativity, Culture and Education*, claim that there is a close relationship between 'teaching creatively' and 'teaching for creativity. They claim that teachers' creative abilities are engaged when they teach for creativity, and that young students' "creative abilities are most likely to be developed in an atmosphere in which the teacher's creative abilities are properly engaged" (NACCCE, 1999, p. 90). This means that nurturing creativity is found in both practices. Teachers who teach creatively may encourage learners' creativity by passing

on their enthusiasm, imagination, and other creative talents (Lucas, 2001). 'Teaching for creativity' may create a learning context for problem solving and an environment that appreciate students' creative expressions (Fryer, 1996). This relationship between the two practices supports the importance of the teacher as one of the main components of a creative pedagogical environment that support students' creative development and engagement. Teachers who focus more on developing creative learning strategies and strategies that promote creative thinking may lead to several positive outcomes for the learners, as stated by Jeffrey and Craft (2004, p. 84): "Learners [may] model themselves on their teachers' approach, find themselves in situations where they are able to take ownership and control and are more likely to be innovative, even if the teacher was not overtly planning to teach for creativity".

2.3.3 Environmental conditions for converting mini-c creative ideas into little-c creative ideas

Over the years, numerous researchers and scientists have proposed several aspects of the school environment that may enable teaching for creativity. A look at relevant literature on how to support and develop students' creative potential in science results in diverse advices for practice. The advices relate to three overall aspects of the classroom environment: (1) a social/psychological learning environment that enable students' creativity, (2) a physical environment that enable students' creativity, and (3) methods and strategies for enabling students' creativity within the science domain. The advices presented below also provided the foundation for developing the design for learning and creativity, called 'Mission Mars'. The process of the literature review is described in chapter 3.3.2.1 - *Developing principles for supporting creativity through literature review*.

2.3.3.1 Social/psychological learning environment that enable students' creativity

Teachers play an important role in shaping students' perception of whether creativity is tolerated in the learning process (Beghetto, 2005). Hence, an important aspect of a creativity supportive pedagogical environment is a teacher that values creativity and welcomes students' creative expressions in the classroom (Beghetto, 2007b). This is based on evidence that suggests that students who perceive teachers as accepting and interested, are more likely to express their creativity (Tighe et al., 2003, cited in Beghetto, 2005). This is further supported by Fasko (2001) who claims that teachers who explicitly show students that they value creativity, affect students' creativity in a positive manner. The openness towards creative ideas, is also important among students themselves (Al-Abdali & Al-Balushi, 2016), alongside a general atmosphere of mutual respect and trust among students and teachers (Beghetto & Kaufman, 2014; Davies et al., 2013; Sawyer, 2015). An important feature of such pedagogic environment also includes teachers that hold high expectations towards the students (Davies et al., 2013; Sawyer, 2015).

A way that shows that teachers value creativity in the classroom is that they take students' suggestions and questions seriously (Cropley, 1997; Hadzigeorgiou et al., 2012), including showing respect towards unusual questions and unusual ideas (Sawyer, 2015). This is supported by Sak (2004) that claims that "[c]reativity flourishes in an atmosphere that is constructively responsive to unusual ideas" (p. 216). To support ideational code-switching in the classroom and to reward students for taking the intellectual risk of sharing their ideas, teachers must listen to all students' ideas, even ideas that are unexpected and unusual, and seriously and respectfully consider these ideas further (Beghetto & Kaufman, 2014). One way to do this is by taking the time to hear and explore students' unique ideas and follow up with questions (Beghetto & Kaufman, 2014; Fasko, 2001; Soh, 2017). In this way teachers show that they reward creative ideas, an important aspect of a creative environment highlighted by several researchers (de Souza Fleith, 2000; Fasko, 2001; Sak, 2004). Questions whether this is possible within todays' educational system can, however, be raised.

An environment where students are motivated to generate multiple creative ideas are considered one of the most important aspects of creativity (Gregory et al., 2013). Teachers can encourage such idea generation by asking open-ended questions and by posing questions and problems that have more than one correct answer (Gregory et al., 2013). Asking students questions and following up on their ideas are also seen as a useful scaffold for students when solving open-ended problems and tasks (Hathcock et al., 2015), making this a useful strategy in science education. In addition, teachers should encourage students to think about implications and implementations of each idea to promote the notion of appropriateness of the idea (Ahmadi & Besançon, 2017; Beghetto, 2007b; Gregory et al., 2013). Open-ended questions are an important part of the inquiry process in science, and teachers should, therefore, encourage students to think, analyse, and offer evidence for their ideas (Hathcock et al., 2015). Hence, asking open-ended questions and providing students with open-ended problems may be used to develop students' scientific creativity in science education (Aktamış & Ergin, 2006, cited in Demir & Şahin, 2014).

Further, teachers are advised to take an inclusive approach to teaching, meaning that students and teachers collaborate to identify problems and issues, that later are discussed together (Sawyer, 2015). The teacher should, therefore, act like a fellow collaborator who joins the students in their knowledge building (Sawyer, 2004; Scardamalia & Bereiter, 2006). Following up on the students' creative expressions together with the students have several positive results. One of them is that the teacher delays judging the students' ideas until they have been thoroughly worked out and clearly formulated (Cropley, 1997). Researchers also provide arguments for an assessment practice that focuses on mastery goals, which provide students with useful information and feedback on how they are progressing relative to their own prior achievement. A mastery goal structured classroom seems to foster creative expressions better than those that represent a performance goal structure (Amabile, 1996; Tighe et al., 2003). Students in mastery goal structured classrooms are also more likely to adopt more positive attitudes towards learning, high levels of academic engagement,

perseverance in the face of challenges, more risk-taking and ask for assistance when needed (Pintrich & Schunk, 2002).

Secondly, by following up and delaying judgement, teachers provide opportunities for students to reflect and become more autonomous in the learning process (Soh, 2017). This may encourage students to employ self-evaluation of their thoughts and actions by elaborating, formulate and adjust their ideas, a quality highlighted as essential for creativity to develop (Ahmadi & Besançon, 2017; Cropley, 1997). Self-evaluation of creative ideas may lead to students appreciating own creativity, instead of waiting for the teacher assessing their creative expressions (Soh, 2017).

Third, joining the students in the creative process is especially important when students face difficulties and failed attempts. Teachers that take the time to listen, understand, and support the students during such phases may encourage the students to be resilient and regain confidence to continue the creative process (Cropley, 1997; Soh, 2017). This also sends a message to the students that mistakes are allowed in the classroom, further encouraging the students to take intellectual risks (Sternberg & Williams, 1996).

Fourth, joining the students in the creative process also allows students to express themselves in a social context, where the teacher guides the students rather than dictates (Soh, 2017). When collaborating with the teacher, as well as their peers, students are exposed to other people's ideas and information, which has been proven positive related to creative problem solving (e.g., Friedrich & Mumford, 2009). In this way, students are given the opportunity to imagine other people's viewpoints, to adopt different perspectives (Sawyer, 2015), and build their ideas on varied experience and knowledge (Gregory et al., 2013).

In their review, Davies et al. (2013) present evidence to students' creativity being closely related to opportunities for working collaborative with their peers, which also can extend to peer- and self-assessment. This may make students understand how their mini-c thinking can develop into new ways of seeing things by moving from what currently is to what could or should be (Beghetto & Kaufman, 2014). Collaborative work

also reflects an important aspect of the nature of science, as creative discoveries in the real world are influenced or stimulated by social interaction among experts (DeHaan, 2009; Hadzigeorgiou et al., 2012).

Teachers can also provide students with opportunities for choice and discovery in the classroom (Beghetto & Kaufman, 2014). Freedom to choose may provide students with a sense of ownership, which in turn increase their intrinsic motivation and engagement (Amabile, 1998, 2011; Amabile et al., 1996). This is also supported by research that shows that students' creativity develops in schools where they have the opportunity to take own decisions and act freely (Cremin et al., 2006; Erez, 2004). Teachers can provide such opportunities by encouraging self-initiated projects and activities, free thinking (Cole et al., 1999; Péter-Szarka, 2012), and to make own decisions (Puccio & Cabra, 2010) and ways to solve problems (Beghetto & Kaufman, 2014).

At the same time, teachers must help students recognise that there are constraints and conventions to be considered when communicating their personally meaningful ideas (Beghetto & Kaufman, 2014). This is based on the belief that creativity involves a combination of both originality and appropriateness. The relationship is explained further by Plucker and Beghetto (2004): "That which is novel but has no use, merit, or significance is simply novel, not creative. Likewise, that which is useful but is not novel, unique, or original is simply useful, not creative" (p. 157). Teachers need to recognise that creativity and constraints are in fact complementary, and that teachers can support creativity while also take the constraints of the classroom and the subject under consideration (Beghetto, 2007b). Balancing freedom with the constraints of the classroom is further supported by Davies et al. (2013) who in their review present evidence from several studies which claim that teachers need to provide a proper balance between structure and freedom to support creativity in school. However, constraint should also be determined by the level of creative magnitude displayed by the students, as explained in chapter 2.2.3 - *Levels of creative magnitude*.

Teachers also need to support students to develop the ability to generate original ideas in addition to the ability to evaluate whether or not their ideas are appropriate for the

given situation, problem or task (Beghetto, 2007b). Therefore, teachers need to cue students when their responses are not seemingly appropriate given the constraints of the task (Beghetto, 2007b; Beghetto & Kaufman, 2014). Beghetto (2007b) argues that teachers have the responsibility for helping students become aware of such constraints, as students may have not yet developed sufficient experience and expertise with the constraints of the domain or task. Therefore, teachers should provide sufficient feedback on how the students meet the constraints of the task. Doing so, students are given the opportunity to move from their personal meaningful and novel expressions (mini-c) to expressions of creativity that are perceived as meaningful and novel to others (little-c), through the process of ideational code-switching (Beghetto, 2007b). Recognising that creativity and constraints are in a complementary relationship, may also lead to teachers aligning their value of creativity with a pedagogy that supports it (Beghetto, 2007b).

2.3.3.2 Physical environment that enables students' creativity

The physical environment is important to consider when aiming to support students' creativity. Three aspects are emphasised in creativity literature as especially important related to the physical environment; (1) allowing time for creative thinking (Cremin et al., 2006; Davies et al., 2013; Sternberg & Williams, 1996), (2) providing students with sufficient resources (Amabile, 1998; Amabile et al., 1996; Beghetto & Kaufman, 2014; Cropley, 1997; Davies et al., 2013), and (3) flexible use of inside and outside spaces (Davies et al., 2013). Hence, the physical environment relates to the non-human resources needed to establish an environment where creativity can flourish. The teacher is able to create such environments by creating physical structures that allow for creative learning inside and outside the classroom walls (Beghetto & Kaufman, 2014). However, Davies et al. (2014) claim that "this can be difficult for teachers that encounter barriers such as a school culture that hinders creativity, perceptions of a 'performativity culture', constraints of time and resources for enhancing creativity, or lack of peer support" (p. 39). Teachers, as well as students, need support and encouragement for

creativity. Therefore, school administrators play a key role in establishing a school environment for teachers to teach for and with creativity (Beghetto & Kaufman, 2014). In their review, Rubenstein et al. (2018) present evidence from research showing that providing students with sufficient time for creative thinking is at risk in school environments designed for standardisation as teachers feel they cannot provide time to creative tasks because they need to dedicate time to cover all the standards. Hence, curriculum guidelines and school climate are reported as factors that make it difficult to facilitate students' creativity in schools (Aljughaiman & Mowrer-Reynolds, 2005; Andiliou & Murphy, 2010; de Souza Fleith, 2000; Rubenstein et al., 2013). This indicates that teachers who are to facilitate creativity in schools, should be supported by the school's administration and colleagues, as well as the school curricula and national standards.

2.3.3.3 Methods and strategies for enabling students' creativity within the science domain

Literature on creativity emphasises several approaches relevant to fostering creativity in science education (Hadzigeorgiou et al., 2012; Kind & Kind, 2007). Approaches most provided in these sources include open-inquiry, creative problem solving, problem solving in the STS context, creative writing, creating metaphors and analogies to understand phenomena and ideas, challenging students to find connections among apparently unrelated facts and ideas, mystery solving, including elements of creative expressions from other domains like art and ICT. These approaches are more likely to provide opportunities for imaginative and divergent thinking, thinking about future events and possibilities, and applying a sense of wonder (Hadzigeorgiou et al., 2012), all important aspects of creativity. In addition, several researchers emphasise the need to take a more student-centred to learning. Such approach may stimulate enjoyment, participation in classroom activities, self-concept, and student talents (Toh, 2003), alongside a promotion of teacher and student behaviour, such as diligence,

perseverance, curiosity, love of challenges, determination, and courage to take high risks (Cropley, 1997).

As previously mentioned in this thesis, domain-specific creativity such as scientific creativity is dependent on students mastering sufficient content knowledge. Teachers need to motivate their students to master content knowledge, so they have a solid base for divergent thinking (Cropley, 1997; Hadzigeorgiou et al., 2012; Scott et al., 2004). This is further explained by Soh (2017) who points out that:

> [i]t is a common misconception that to be creative is to be able to come up with something from nothing. It is a truism that many if not all great work, in the arts as well as sciences, have solid knowledge (and skills) as their base. Creativity comes in the form of adding just that critical element that was not there before. There may be serendipity in creativity but this is for the prepared mind. (p. 61)

When students master sufficient and essential knowledge, they can use this knowledge for creating. The teacher can then encourage flexible thinking by providing opportunities for the students to use this knowledge divergently and from diverse perspectives (Soh, 2017). Hence, content knowledge by itself is not enough to support creative thinking, as creativity also requires the ability to apply knowledge in flexible ways and in various contexts (Gregory et al., 2013). In this way, students can take the opportunity to apply new knowledge and see the value of such processes beyond school boundaries and outside the reach of traditional assessment (Kettler et al., 2018).

2.3.3.4 Supporting creativity in a supportive social environment based on Amabile's KEYS

Amabile (1997, 1998, 2011; Amabile et al., 2004) and her theory of KEYS sums up the advice described in the previous chapters in one theory, and it is, therefore, an important theory underpinning this thesis and the development of the design for learning and creativity, 'Mission Mars'. Amabile is one of the first researchers to argue in favour of a supportive social environment (the classroom in an educational context)

as being a key factor in ensuring that a person's creative potential is realised (Rutland & Barlex, 2008). The theory of KEYS is set within the context of a work environment, where she suggests that managers exert a decisive influence on the work environment and on workers creativity (Amabile, 1998; Amabile et al., 2004). This suggests that the environment is a factor that can be influenced by the manager through the organisation and strategies used. Amabile (1997) claims that managers can positively impact workers' creativity when they are provided with the KEYS of "freedom, positive challenge, supervisory encouragement, work group supports, sufficient resources and organizational support" (p. 8). The KEYS may increase their intrinsic motivation and create workers who attain high levels of creativity and achievement (Amabile, 2011).

James (2015) suggests implementing Amabile's KEYS into the classroom context, where the teachers are the classroom managers. By including the KEYS in the classroom, James (2015) asserts that we can create

> a positive learning environment of respect and collaboration, where students are valued and enabled to achieve academically and creatively. (…) [and] a learning environment that encourages students to be personally motivated to explore, think deeply and work hard at academic tasks, while at the same time exercise and growing their creativity. (p. 1034)

Building on Amabile's work (e.g., Amabile, 1998; Amabile, 2011; Amabile et al., 1996), James (2015, pp. 1034-1035) adapts the six KEYS to the classroom context: (1) Freedom – teachers provide students with freedom to choose, hopefully resulting in students feeling a sense of ownership, intrinsic motivation and engagement, (2) Positive challenge – teachers provide students with tasks that match their talents, knowledge, and interest, (3) Supervisory encouragement – teachers work to mitigate stress and provide a learning environment that is free from fear, with clear goals and feedback rather than criticism, display that they value students' work, and encourages inquiry and exploration both individual and together with the teacher, (4) Work group support – teachers create work groups thoughtfully and strive to ensure the students experience the work group as challenging but safe by helping students appreciate each other's expertise and mindset, (5) Sufficient resources – teachers give their students easy access

to quality resources, and by doing so communicate the inherent value of the work and help students succeed in their task, and (6) Organisational support – teachers promote and sustain a shared vision of creativity and productivity for all students, suggests problem-solving strategies and encourage risk taking and idea generation, establishes classroom norms of collaboration and communication, and create and maintain an infrastructure that enables and empowers students to successfully adhere to these norms.

2.4 Modelling and teachers' creative self-efficacy

"Creative leaders inspire creativity by demonstrating creativity themselves" (Beghetto & Kaufman, 2014, p. 65). Beghetto and Kaufman (2014) refer to research claiming that creative leaders in the business world inspire employee creativity and claim this is equally true within a classroom context. They claim that teachers who view themselves and their teaching as a creative act are better positioned to model, encourage, and support their students' creative expressions. There is consensus in the creativity literature that teachers should act as role models for the students by displaying and engaging in creative behaviour (Beghetto & Kaufman, 2014; Davies et al., 2013; Sawyer, 2015). Sak (2004) explains this by saying that "[t]he behavio[u]rs that the teacher displays shape the behavio[u]rs students develop" (p. 216). This means that students may learn to be creative by imitating the behaviours of their teacher. When teachers behave creatively, the student are likely to imitate them and behave the same. The idea of social modelling, or observational learning, originates from Albert Bandura (1986). He says that "most human behavio[u]r is learned by observation through model[l]ing. […] Much social learning is fostered by observing the actual performances of others and the consequences for them" (p. 47). This implies that teachers need to function as behavioural models when interacting with students and demonstrate creative behaviour themselves. This is further supported by intervention studies that suggest that explicit modelling and teaching of the creative process may inspire creative

development (Ma, 2006; Scott et al., 2004). But, as Rubenstein et al. (2018) points out, this has not been examined within teachers' practices in their natural environment.

Soh (2017) presents two limitations for fostering creativity via social modelling in the classroom. First, creative teachers are, by definition, rare to come by. This is explained by the contextual factors of education, as teachers who are creative are somewhat bound to the imposed boundaries of the curriculum. Hence, teachers often aim at convergence more than divergence in their teaching (Soh, 2017). The second limitation builds on the premise that social modelling has an emotional element, meaning that "students, especially the young ones, model on people they have positive emotional ties with, or simply, people they like and admire" (Soh, 2017, p. 59). Usually, there is a positive social-emotional relationship between a teacher and the students in the classroom, but as Soh (2017) problematises, this is not the case for all students. He says:

> [S]ome creative teachers may foster student creativity through social modelling and some students may develop creativity as a consequence of modelling on the creative teachers they like, but definitely this does not apply to all creative teachers and their students. (Soh, 2017, p. 59)

This underlines the importance of the teacher-students relation in the learning process and in the process of developing students' creativity. It also underlines the importance of teachers to have sufficient knowledge about what creativity behaviours are, and the environmental factors that support such behaviour, in order to display and model such behaviour to the students and demonstrate that it is a valuable aspect of education.

To support and model creative behaviour for the students, teachers need to have a positive attitude towards creativity, but also feel confident about their own skill base (Davies et al., 2014). This is further supported by Rubenstein et al. (2013) who argue that teachers must believe that creativity is valuable and worth facilitating and that this must be followed with a belief about their ability to facilitate creative growth in their students. Self-efficacy is a useful construct to discuss teachers' confidence to develop students' creativity and teachers' belief in their own creativity. Self-efficacy is a key aspect to social cognitive theory, where it is seen as a mechanism that may determine

how individuals self-regulate personal, behavioural, and environmental influences (Bandura, 1986, 1991). Self-efficacy also influences humans' motivation. People's self-efficacy beliefs to conduct an action are influenced by their belief of achieving success or failure, which also affect their motivation to go through with the action (Bandura et al., 1999). People who have strong beliefs in their capabilities exert greater effort to master a task than people who are beset by self-doubts about their capabilities (Bandura & Cervone, 1983). Teachers with low creative self-efficacy may, therefore, avoid such tasks, fail to persist, or select ineffective strategies in their teaching (see Schunk et al., 2014). Hence, self-efficacy is the most central mechanism of personal agency (Bandura, 1991). Self-efficacy assumes a sense of agency (Bandura, 1989), meaning that the individual is able to perceive a sense of control or the ability to influence personal behaviour, actions and processes (e.g., Bandura, 2001). "Among the mechanisms of personal agency, none is more central or pervasive than people's beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives" (Bandura, 1991, p. 257). Perceived self-efficacy is important related to students' efficacy-beliefs to be creative and master creative tasks as well as to teachers' beliefs in their efficacy to develop a classroom environment that facilitate creativity and in their ability to support students' creativity within the environment (Bandura, 1993; Rubenstein et al., 2018). Consequently, students' and teachers' view of own efficacy is more important than the actual efficacy.

According to Bandura (1977) there are four sources to self-efficacy: (1) performance accomplishments, (2) vicarious experience, (3) verbal persuasion, and (4) emotional arousal. Performance accomplishments affect self-efficacy as it is based on personal mastery experience. "Success [in mastering a task] raises mastery expectations; repeated failures lower them" (Bandura, 1977, p. 195). Bandura (1977) further claims that, in addition to strengthen personal efficacy by experiencing mastery on your own, mastery expectations can also be strengthen by observing others with similar competence mastering a task (through modelling), called vicarious experience. Self-efficacy may also be strengthened through verbal persuasion, as positive feedback from other people may strengthen one's mastery belief (Bandura, 1977). Finally, self-efficacy

can be affected by emotional arousal. "Stressful and taxing situations generally elicit emotional arousal that, depending on the circumstances, might have informative value concerning personal competency" (Bandura, 1977, p. 198). Experiencing a situation as especially stressful or scary may affect a person's expectations of similar situations in the future. According to Skaalvik and Skaalvik (2018), stressful experiences can lead to persons trying to avoid situations and problems that create such feelings.

In the Norwegian Education Act, section 1-1 (Ministry of Education and Research, 2020) students' self-efficacy is highlighted as students must develop knowledge, skills, and attitudes so they can master their lives and take part in working life and society. To fulfil this, schools and teachers need to facilitate for learning situations in which students can develop beliefs about their own capacity for knowledge and skills. Students' self-efficacy beliefs are found to be an important mediator for performance in school. For example, a study of 240 lower secondary students in Norway shows that a student's perceived self-efficacy determines the student's basic need for support in the education (e.g., autonomy, relatedness, competence) and performance (Diseth et al., 2012). Research also show that there is a positive relationship between teachers' creativity fostering behaviours and their self-efficacy beliefs (Ozkal, 2014). Teachers with high self-efficacy are more likely to support students' autonomy (Guvenc, 2011), are more open to new experiences and ideas, display better understanding of students' mistakes, and are more likely to consider a more student-centred teaching approach (Gorozidis & Papaioannou, 2011). On the contrary, teachers with low self-efficacy tend to establish more strict rules in the classroom and depend more on external reward and punishment in order to maintain classroom control (Tschannen-Moran et al., 1998), in addition to being more inclined to discourage creative responses and questions from students (Beghetto, 2009). This implies that if teachers hold higher creative self-efficacy beliefs, they will employ more creativity supporting teaching practices in the classroom. This thesis, therefore, focuses on self-efficacy as fundamental for supporting and facilitating creativity in the classroom and highlights the importance of teachers stimulating students' beliefs in their personal abilities and skills.

3 Methodology

The methodological approach for the thesis is a qualitative multimethod research design with pragmatic grounding. The thesis aims to explore how creativity can be facilitated in primary science education by providing further knowledge of the conditions that facilitate creativity and the challenges related to facilitating creativity in an educational context. This includes exploration of human processes in educational practices, an attempt to highlight the research participants' perspectives and contribute to a more overall picture of creativity in an educational context. It is, therefore, appropriate to place the project within a qualitative research tradition.

In this chapter, the philosophical background of the methodology of the thesis is presented before introducing the research design. The empirical background and research participants are then presented, before presenting the data collection, analytical approaches, and data analysis. Aspects of research credibility and ethical considerations are discussed towards the end of this chapter.

3.1 Pragmatism as a philosophical background to multimethod research

All research is based on an underlying philosophical framework which points to what is seen as valid results and, in turn, established knowledge. The philosophical framework can be based on one or several paradigms depending on the question to be answered and the work that needs to be done. A paradigm is seen as "an accepted model or pattern" (Kuhn, 1962, p. 23). The term holds many interpretations, but in the thesis paradigm is related to research as a set of attitudes which control the researcher's actions, based on the researcher's ontological, epistemological and methodological stance (Denzin & Lincoln, 2005). A paradigm is, therefore, seen as the philosophical motivation or purpose for conducting the research.

The philosophical framework of the methodological orientation of the thesis is based in a pragmatic paradigm. The thesis' ontological assumption is that "[r]eality is continually created through experience in interaction and transaction with the 'world'" (Mertens & Tarsilla, 2015, p. 437). Hence, reality is not seen as objective but something that is continually constructed through interactions and interpretations. Pragmatism is related to the epistemological level in that "ideas and knowledge are evaluated according to their consequences" (Mertens & Tarsilla, 2015, p. 437). To determine the value and meaning of our ideas, theories, presumptions etc., they need to be tested in practice (see Dewey, 1948). Knowledge is hence seen as something that is generated and constructed through interactions among actors in the research field.

The pragmatic paradigm highlights the relevance of context, as knowledge is seen as both situated and tentative (Johnson & Onwuegbuzie, 2004). This means that a theory or an idea which has value or is seen as meaningful in one context, no longer needs to hold the same value in a different context or at a different time. Classroom practices in one context may, therefore, not necessarily translate to another. The pragmatic paradigm is not occupied in finding "the truth" but sees that different knowledge assumptions may arise from different ways of engaging with the social world (Mertens & Tarsilla, 2015). Pragmatism is focused on solving practical problems "in the real world" (Dewey, 1958), and prefers, therefore, to talk about "warranted assertability" rather than truth (Carr, 2003). "Knowledge is [then] viewed as being both constructed and based on the reality of the world we experience and live in" (Johnson & Onwuegbuzie, 2004, p. 18). Hence, knowledge in pragmatically oriented multimethod research is constructed in the reflexive and rational interpretations of researchers employing different tools (methods, theories, etc.) to answer specific research questions (Harrits, 2011).

The pragmatic paradigm is not concerned with the strict methodological dictomies of the scientific traditions, but sees value in choosing the methodological approach that works for the particular research question, and that different methods can produce different understandings of the phenomenon because of the way the different methods

position the researcher to transact with the world (Johnson & Onwuegbuzie, 2004; Teddlie & Tashakkori, 2010). The pragmatic paradigm is the philosophical background for the thesis based on the flexibility regarding methodological choice. Methods are chosen based on the researcher's judgement regarding which methods will lead to warranted assertability of knowledge to the area of research, based on the research question and the research purpose (Biddle & Schafft, 2015). The pragmatic paradigm, therefore, justify the use of a multimethod research approach (Maarouf, 2019), which is the thesis' research design.

3.2 Research design

To gain insight into the multiple layers of creativity in an educational context and to be able to answer the overall research problem of the thesis, I chose a multimethod research design. Multimethod research is defined as the practice of employing different research methods within the same study or research program, instead of confining to the use of one single method (Brewer & Hunter, 1989, 2005; Hunter & Brewer, 2015). Multimethod research is often compared with mixed method research. However, unlike mixed method research, which is often restricted to combining qualitative and quantitative methods within the same study (Hunter & Brewer, 2015; Johnson et al., 2007), multimethod research open up to include the full variety of possible methodological combinations (Creswell & Plano Clark, 2007, 2011; Fetters & Molina-Azorin, 2017; Hesse-Biber, 2015; Hunter & Brewer, 2015). In this study, the research questions determined the research methods. To have the best possible chance to obtain a useful answer to the overall research problem, and to obtain useful answers to the sub-questions that correspond with the three articles of the thesis, a multimethod approach was best suited (see Johnson & Onwuegbuzie, 2004).

The research design applied in the thesis was a qualitatively driven multimethod concurrent design, in which the phases occurred more or less at the same time and supplemented each other in order to provide an answer to the overall research problem

(Hesse-Biber et al., 2015). The overall purpose of a concurrent design is to have the different data and data analysis provide different perspectives to the phenomena under study (Hesse-Biber et al., 2015). Figure 2 displays the qualitatively driven multimethod concurrent design of the thesis.

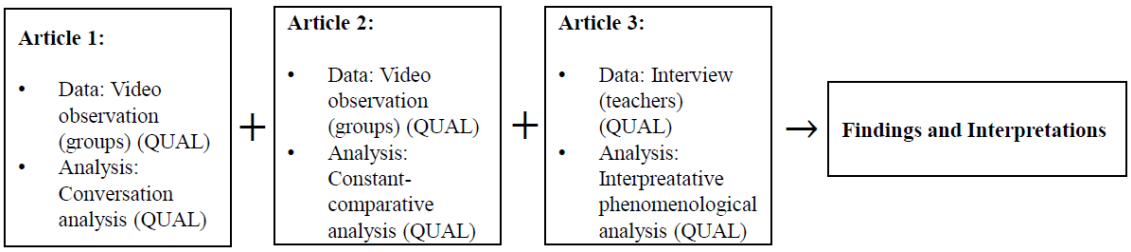

Figure 2: A qualitative driven multimethod concurrent design

The different research methods played equal parts in the development of a comprehensive understanding of the research problem, by providing valuable insight into different aspects of the phenomena. The interviews with the teachers and the Interpretative Phenomenological Analysis (IPA) granted access into the teachers' implicit beliefs about creativity, focusing on which aspects of creativity they valued and how we can build on these beliefs with the aim of facilitating students' creativity (Article III). The interviews also provided a context for the data collection and Conversation Analysis (CA) described in Article I, focusing on what teachers do when interacting with students. In that way, the different methods reflected both the teachers "words and deeds". "Words" is what the teachers say and reflect their thinking accessed through interviews, and "deeds" are what the teachers do accessed through video observations. According to Hunter and Brewer (2015) "words" reflect the teachers' attitudes and "deeds" reflect their behaviour, and by combining the research on attitudes and behaviour I was able to gain a larger picture of the degree of agreement or divergence between the two.

The video observations of groups of students also granted access to how students related to the creative process (Article II), as such being able to highlight another important aspect of the complex educational context, the students' behaviour. Related to the complexity of the phenomena under study, the research design opened up for a divergent result that spoke to different aspects of reality that the different methods were tapping into (see Hunter & Brewer, 2015).

3.3 Empirical context

This section describes the empirical context of the thesis which was based on a researcher-practitioner collaboration influenced by a design-based research (DBR) framework. The initial plan of this PhD-study was to conduct a DBR-project in three cycles of development, testing, and refinement of a design for learning and creativity in close collaboration with the two teachers in the study. The data collected during the implementations were supposed to help refine the design before the next cycle. Already during the first cycle, I discovered that the amount of data was overwhelming for me as the sole researcher on the project. I was not able to analyse all the data before the next cycle of the project, on my own. The research design was, therefore, changed after the first implementation and I decided to use the DBR-project as the empirical background, where the aim no longer was to develop a final design for learning and creativity, but where the cycles were used as context for collecting data for answering the current research question of the thesis. Data collection was done by video-observations of three primary classes working on the design for learning and creativity, and by interviews and conversations with the two teachers before the first cycle, between the first and second cycle and after the third cycle of the project. The study was conducted in one Norwegian primary school and data were collected over a period of 1,5 years.

3.3.1 Researcher – practitioner collaboration

The project was influenced by the principles of design-based research as it studied creativity in educational context through "systematic design and study of instructional strategies and tools" (Design-Based Research Collective, 2003, p. 5). The project provided research data, both during the implementations in the classrooms and from collaboration with the two teachers.

The idea behind the project was that the I could learn from practitioners' (e.g., teachers') implementation of the design for learning and creativity. Working with this project was, therefore, a learning process where the researcher enhanced her understanding of the phenomenon under study and the developed design through implementation in practice. The learning process reached another dimension when the practitioners tested the design, and the reflections about these implementations contributed to further development of the design and further knowledge about how we could facilitate and support creativity in primary science education. Knowledge developed through the study was, therefore, partly manifested in the developed design.

In the beginning of the researcher – practitioner collaboration, I lead a two-hour workshop about creativity, where relevant literature and research about creativity in school was presented and discussed. The literature and research presented and discussed with the two teachers was derived from a comprehensive literature review, further described in chapter 3.3.2.1 – *Developing principles for supporting creativity through literature review*. The literature and research on creativity are referred to as '*principles for creativity*' in the coming chapters.

3.3.2 The design for learning and creativity

The project contained three cycles of design, implementation, and evaluation. The design was built on *principles for creativity* drawn from the literature review conducted by the researcher (see chapter 3.3.2.1 for description about the literature review). The researcher and the two teachers collaborated in developing the design for learning and

creativity, which was later implemented in the teachers' science classes (three different classes – one class per cycle) by the teachers. The two teachers were both present during all three implementations. Observations and experiences from the implementation were later used in an evaluation of the design, which in turn provided suggestions for improvements in the next cycle.

The project took place within the complex environment of education, which meant that many factors influenced the developed design. I, therefore, used Sandoval's (2014) *Conjecture Mapping* (figure 3) to display how conjectures might influence the educational design in order to achieve the intended outcome of the design, which in the initial DBR-project was a design for learning and creativity that supported students' creativity. Sandoval (2014) "describe[d] a technique for mapping conjectures through a learning environment design, distinguishing conjectures about how the design should function from theoretical conjectures that explain how that produces intended outcomes" (p. 18).

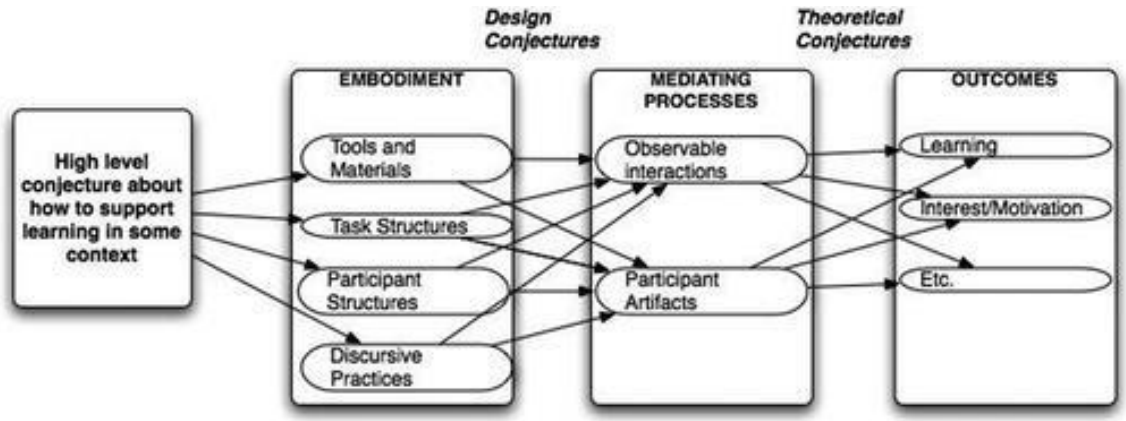

Figure 3: Generalised conjecture map (Sandoval, 2014, p. 21)

The *principles for creativity* drawn from the literature review were the theoretical supported high-level conjecture about how we can facilitate and support creativity in science education. The researcher and teachers used the principles in developing the

embodiment of the design for learning and creativity. The embodiment of the design contained descriptions of what students and teachers were supposed to do (task structures), how the students were supposed to work with each other and what the teachers' role was in the project (participant structures), how the involved participants were supposed to relate to each other (discursive structures), and which tools and materials should be available during the work with the design (tools and materials). The embodiment was expected to generate certain mediating processes, like the observable interactions between the participants during the process or the products from the activity (see Sandoval, 2014). To make claim to how the design facilitated and supported students' creativity, the mediating processes were observed and evaluated after the implementation. This evaluation provided suggestions for changing elements of the design in the next cycle.

3.3.2.1 Developing principles for supporting creativity through literature review

The building of the principles for supporting creativity in the context of primary science education was based on a comprehensive literature review of relevant research literature. Adding to the transparency of the research, I will now present relevant aspects of the literature review. The literature review was an ongoing process throughout the project. As my understanding of creativity developed and the research questions were further developed, the literature was revised, and new literature was added.

The initial literature review started with the researcher determining what to search for, where to search, and which aspects to include and exclude in the search. The inclusion and exclusion criteria are presented in table 1.

Table 1: Inclusion and exclusion criteria in the initial literature review

	Included	**Excluded**
Databases	Google Scholar, ERIC	
Time frame	1990 -2018	Articles published before 1990 (with some exceptions)
Publication type	Online peer-reviewed articles	Books and book chapters, conference proceedings, short papers, grey literature (e.g., reports), editorials
Focus	Theoretical and empirical studies with primary focus on defining the phenomenon creativity and creativity in science, focus on how to strengthen and support creativity in school and in science education. Articles that focus on students' creativity in primary and secondary years.	Articles focusing on other aspects like creativity in the workplace and at a university level, and articles that discuss the relation between creativity and intelligence, and creativity and personality.
Language	English, Norwegian, Swedish, and Danish	Other languages

Creativity is a complex term with different definitions, connections to many subject areas, and is an important part of all humans' aspects of life. Because the process of developing principles for supporting creativity happened on such an early stage in the research process, it was important not to limit the search too much but open for a wider grasp on the phenomenon of creativity.

The literature search resulted in millions of results in the databases. This was an impossible amount, and I chose to limit the search to peer-reviewed articles. I also limited the search to research that was no older than twenty years but included some highly relevant research before that time as well. Research on creativity in educational contexts arose in the mid 1950's with some still highly important research. It was,

therefore, important for the historical context and the development of creativity in educational contexts, to include those in the review. Most of the references to older literature was found by reading the reference list of the newer articles in the literature review.

The following literature review was done according to the steps below through a nesting of the phenomenon (see Krumsvik & Røkenes, 2016):

1. I went through the searches from the initial search and made a list of all relevant hits. I downloaded the articles that was open access or available within the University's database.
2. I read the abstract of the articles and made further exclusions of articles that seemed irrelevant for my project based on the abstract.
3. I went through the articles that had cited the articles from my initial search. The new articles were handled according to step 2.
4. I went through the articles that had cited the articles found in step 3 and followed this procedure until I had no more relevant articles left. All new articles followed the procedure of step 2.
5. I went through the reference list of each article and picked out articles that showed promise based on the headlines. I read the abstracts and kept the relevant ones. I then conducted the same operations as in step 3 and 4.
6. I conducted an initial sorting of the articles by themes, before reading the articles. See List 1 for an overview of developed themes.
7. I read the articles, which excluded several more in the process.
8. I noted down important aspects of each article in a word document named the same as the themes in step 6.

List 1: Sorting of articles by themes in the literature review

Articles that…
- Discuss why creativity is important - Discuss creativity related to domain - Map signs of creativity in science education - Discuss assessment of creativity - Present definitions and way of seeing creativity and scientific creativity - Present factors that support or inhibit creativity - Present teachers' and teacher students' implicit beliefs of creativity - Present teaching designs that support creativity - Investigate how different abilities and methods influence students' creativity - Assess models that intend to support creativity

3.3.2.2 Description of the design for learning and creativity

The design for learning and creativity was developed by the researcher in collaboration with the two teachers based on the *principles for creativity* and Sandoval's (2014) conjecture map for designing conjectures in a learning environment (Figure 3). The design was named 'Mission Mars' where students in fifth and sixth grade, working in small groups, received a mission to invent a product that would make it possible for them to live on Mars. A project which centred around moving to Mars was chosen based on the teachers' knowledge about what theme would nurture the students' internal motivation based on their interests. The project also provided opportunities for students to come up with several innovative and creative solutions.

Based on the knowledge gained from the literature review, the high-level conjectures for the project were developed as a set of *principles for creativity*. Table 2 presents an overview of the developed principles, a short description of the principles and relevant references. The principles were presented to the teachers during the workshop in the beginning of the project and later used in the development of the design for learning.

Table 2: High-level conjectures of facilitating students' creativity

High-level conjectures of facilitating students' creativity	**Description of the conjectures**	**Relevant references**
Students need sufficient knowledge and skills	Declarative knowledge (subject knowledge) procedural knowledge (knowledge about creative work methods and creative thinking skills)	(e.g., Cropley, 1997; Hadzigeorgiou et al., 2012; Scott et al., 2004; Soh, 2017)
A social/psychological learning environment that supports students' creativity	Base the learning on the students' interest and motivation (build on the students' internal motivation, and provide freedom of choice and ownership of the learning)	(e.g., Amabile, 1998, 2011; Amabile et al., 1996; Beghetto & Kaufman, 2014; Cole et al., 1999; Cremin et al., 2006; Erez, 2004; James, 2015; Péter-Szarka, 2012; Puccio & Cabra, 2010)
	A pedagogic learning environment that encourages, reward and values creativity	(e.g., Beghetto, 2007b; de Souza Fleith, 2000; Fasko, 2001; James, 2015; Sak, 2004; Tighe et al., 2003)
	An open, safe, and democratic environment	(e.g., Al-Abdali & Al-Balushi, 2016; Beghetto & Kaufman, 2014; Davies et al., 2013; James, 2015; Sawyer, 2015)
	A relationship between students, and students and teacher, based on respect and belief in each other's abilities and ideas	(e.g., Cropley, 1997; Davies et al., 2013; Hadzigeorgiou et al., 2012; Sak, 2004; Sawyer, 2015)
	Teachers taking an inclusive approach to teaching by exploring students' ideas and asking open-ended questions	(e.g., Gregory et al., 2013; Sawyer, 2004, 2015; Scardamalia & Bereiter, 2006)

	Proper balance between freedom and structure	(e.g., Beghetto, 2007b; Beghetto & Kaufman, 2014; Davies et al., 2013)
A physical environment that supports students' creativity	Access to sufficient resources and materials	(e.g., Amabile, 1998; Amabile et al., 1996; Beghetto & Kaufman, 2014; Cropley, 1997; Davies et al., 2013; James, 2015)
	Flexible use of time, and sufficient time	(e.g., Cremin et al., 2006; Davies et al., 2013; Sternberg & Williams, 1996)
	Flexible use of space, inside and outside – variations of context	(e.g., Davies et al., 2013)
Methods that facilitate creativity	Student-centred, inquiry and problem-based activities	(e.g., Hadzigeorgiou et al., 2012; Kind & Kind, 2007)
	Focus on collaboration, group work and discussions	(e.g., Davies et al., 2013; James, 2015)
	Include elements of creative expressions from other domains, like art and ICT	(e.g., Hadzigeorgiou et al., 2012; Kind & Kind, 2007)

The embodied conjectures of the design (the task structures, the participant structures, the discursive structures, and materials and tools) (see Sandoval, 2014) were based on the high-level conjectures as the principles were further developed and explored before included in the design. I will now present the embodied conjectures of the design.

The task structures of 'Mission Mars':

According to the principles for supporting students' creativity (Table 2), the students needed sufficient subject knowledge to be able to come up with creative ideas. The

design, therefore, included a visual presentation about the conditions on Mars and the possibilities of moving to Mars based on relevant innovation and research. One of the teachers lead the presentation in the beginning of the implementation of each cycle. The students were also encouraged to seek information during the project with the use of internet, books, etc.

The design followed the procedures of a student-centred, open-ended inquiry- and problem-based activity, where the students collaborated on defining a problem, generated several solutions to the problem, decided on the best possible solution to the problem, planed and built a model of the idea before they presented the idea to the rest of the class. The procedure (illustrated in Figure 4) was developed by integrating the model of inquiry-based learning developed by The Norwegian Centre for Science Education (see Mork, 2016) and the procedural phases of engineering design developed by National Science Teaching Association (2021). The model was developed as a cyclic model where one phase followed the other, but the procedure could also be used in a more flexible manner. For example, *planning and building the model* could yield more questions and problems that needed solving, which provided the need to jump back to a further *exploration of the problem* or *finding new solutions*.

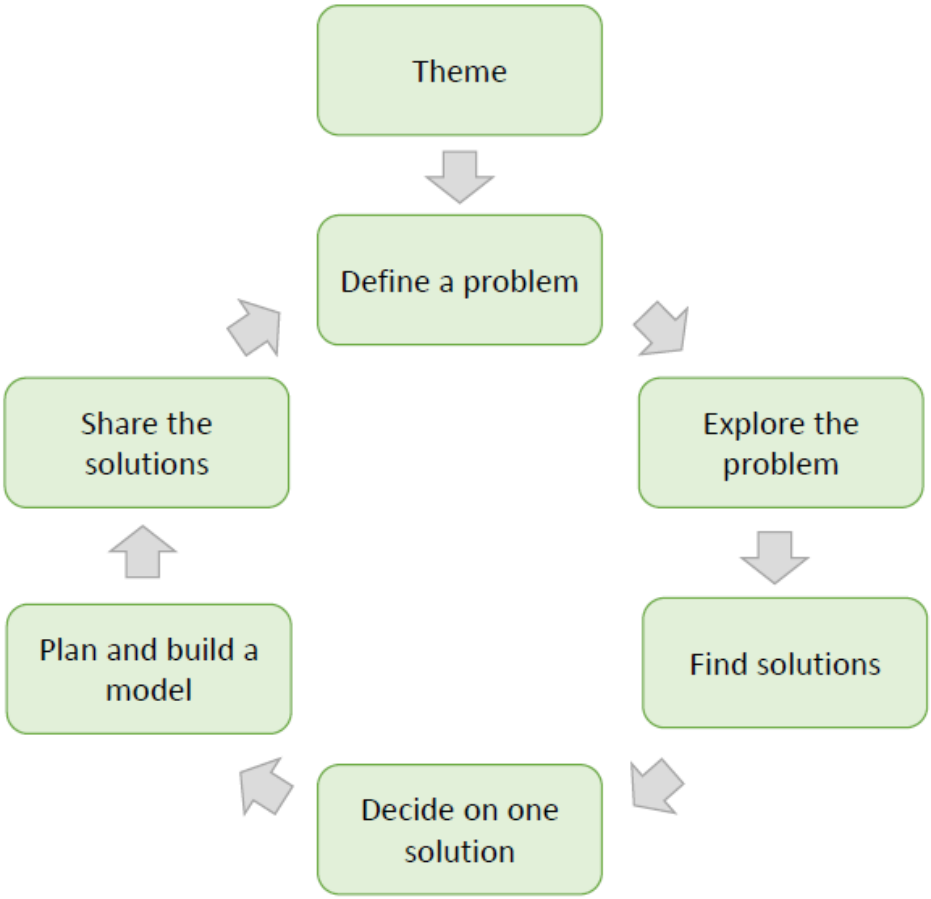

Figure 4: Procedural phases of the design for learning and creativity

The participant structures of 'Mission Mars':

The *principles for creativity* (Table 2) suggested that creativity was best nurtured during group work, collaboration and through discussions. The students were, therefore, placed in groups of 4 to 5 students where they collaborated in coming up with creative ideas.

The discursive practices of 'Mission Mars':

The design for learning and creativity included descriptions of the teachers' task to make the process (illustrated in Figure 4) explicit to the students. The teachers' job was to

describe, discuss and model the process for the students, with the aim of providing the students with sufficient procedural knowledge.

The design also included strategies for teachers to develop a safe environment built on mutual respect. The teachers' job was to listen to the students' ideas, comments, and arguments, and explore the ideas together with the students by asking open-ended questions and cuing them within task constraints.

The physical environment of 'Mission Mars', including tools and materials:

'Mission Mars' lasted over a period of two half and one whole school days, often with a few days of incubation between the active days, providing the students with sufficient and flexible time. The active days were set within the context of an arts and craft classroom, in addition to access to several group rooms. This provided the students with the opportunity to vary their workplace and use the space in a flexible manner.

The project included elements of design and technology, as the students were supposed to build a model of their creative idea. The students had access to materials normally found in arts and crafts classrooms, and technological equipment like batteries, motors, solar panels, wires, etc. The researcher also brought reusable materials borrowed from *REMIDA – centre for creative reuse* in Trondheim, and the students were encouraged to bring materials from home.

3.4 Research participants

The two teachers in the study were selected purposive due to access after they volunteered to participate in the project. I reached out to headmasters of several schools, and the headmaster from the school agreed to participate and recruited two teachers for the study. At the time of the recruitment and during the first two cycles of implementation, the teachers were positioned as 'teacher specialists' at the school. A

teacher specialist is a skilled teacher who is given the opportunity by the Norwegian Directorate for Education and Training to participate in professional development courses and training and at the same time work as a driving force for better quality teaching in his or her subject at the school. The teacher is provided with time and money to educate themselves, in addition to educate and contribute to a strengthening of the collective professional community and the development of the school as a learning organisation (Norwegian Directorate for Education and Training, 2021b). Working as 'teacher specialists' also provide more time for the teachers to participate in various research projects, such as this PhD-study.

The participating teachers were one female teacher, called Trillian, and one male teacher, called Arthur. Trillian had worked as a science teacher for sixteen years, and Arthur had worked as a science teacher for nineteen years, both in primary school. Both were educated teachers, and both had earlier participated in in-service courses about inquiry-based learning and science literacy.

The developed teaching design was implemented in three primary science classes. The two teachers worked as the classes' science teachers in the regular education and knew the students well. The classes that participated in the study were two fifth grade classes and one sixth grade class, age 10-12. Table 3 presents an overview of the number of students in each class.

Table 3: Overview of students in the study

Grade	Number of students	Number of groups
Students cycle 1, sixth grade	28	7
Students cycle 2, fifth grade	34	8
Students cycle 3, fifth grade	34	8

3.5 Data collection

The research made use of multiple data-collection methods. The main methods for collecting data were interviews with teachers and video-recordings of student groups. Audio-recordings of teachers during implementation and video-recordings of whole classes were collected to supplement the main data-collection methods in case audio was bad or missing in some of the teacher-students' interventions or in case something important happened outside the group-cameras' view. In addition, students' drawings, written work, and photographs of finished products were collected in case the researcher needed to check the students' ideas more closely in their drawings, written work, or finished products. In this part, I will describe the use of the main data-collection methods used in the thesis.

3.5.1 Interviews

Data from interviews were used to answer the research question in Article III. Five interviews were conducted in the study, four individual interviews and one group interview. The purpose of the interviews was twofold; (1) to gain insight into the teachers' implicit beliefs about creativity (data foundation for Article III), and (2) allowing the teachers to talk freely about creativity to gain insight into their theoretical language according to creativity, creating a good foundation for collaboration. The first two individual interviews with the two teachers were, therefore, conducted before starting the researcher-teacher collaboration.

The group interview was conducted after the first cycle of the project. Group interview was chosen so the teachers could reflect together and build on each other's saying. After the third and last cycle of the project, two final individual interviews with the two teachers were conducted. Individual interviews were chosen so the teachers could talk freely about their own personal experiences with the project and thoughts about creativity.

Interview is the most suitable method for obtaining a comprehensive and detailed descriptions of the research participants' thoughts, feelings, and experience (e.g., Johannessen et al., 2010; Thagaard, 2009). I used semi-structured interviews in the study, because peoples' experiences and perceptions are best reflected when the research participant can help decide what is addressed in the interview, as described by Johannessen et al. (2010).

A qualitative interview is often described as a conversation with meaning, where the meaning arises as a result of a research question (Smith et al., 2009). I, therefore, developed three different interview guides, one for the first two individual interviews, one for the group interview and one for the last two individual interviews (see Appendix D-F). The interview guide for the first two individual interviews were tested on three other teachers with similar background and experience, but from another primary school. These interviews allowed me to test whether the teachers understood the questions and whether the teachers were able to answer the questions related to the intent of the questions.

Following the premise of a semi-structured interview, the interview guide was handled in a flexible manner and in a way that I did not control the conversation (see also Fejes & Thornberg, 2015). The interview guide did not steer the conversations as several of the questions in the interviews came up naturally during the conversations. Hence, the interview guide functioned as an aid when the conversation came to a stop or if the teachers did not enter certain important aspects during the conversations.

To make sure that the research participants' experience was the focus of the interviews, the questions were mainly open-ended. The focus of the interviews was not about collecting facts, but discovering meaning (see Fejes & Thornberg, 2015). By asking open-ended questions, I opened for the research participants' own understanding, without the researcher's previous knowledge, prejudices, and preunderstanding characterising the questions. This is what Husserl calls "freedom from suppositions the *Epoche*", a Greek word that means "to stay away from" or "abstain" (Moustakas, 1994, p. 85). The research participants were encouraged to talk freely, and the researcher participated

with limited verbal input during their narrative. The conversations were driven further with the use of nods, sounds like m-m, encouraging phrases as "can you tell me more about…" or repeating of the research participant's word or sentence to encourage a continuing of their narrative.

The interviews began with a question that let the research participants talk their way into the theme and think aloud about the phenomena, for example "What do you think when you hear the word creativity?". The following questions were based on the research participant's response and followed mainly the same open form such as "talk more about…", "can you say something about…", etc. At the end of the interviews, the researcher summed up what the research participants had said. This opened for the research participants to comment if something was misunderstood or misinterpreted, or to add something to their narrative.

The interviews were recorded on a digital recorder to make sure that the researcher was fully focused on the research participant and the progress of the interview. The individual interviews lasted between 11 to 39 minutes, as one of the teachers included more examples and elaborations in the narrative than the other, and the group interview lasted about 46 minutes. Notes were not written during the interviews, but as soon as possible after the interviews were conducted, the recordings were listened to and the researcher's thoughts that occurred during the interviews were written down. This was a step towards analysis, as the process would necessarily include some interpretations.

3.5.2 Video-observation

Creativity cannot always be formulated in words, written work, or finished products. Video-observation provided, therefore, important data for the study as creativity also can be observed in the process of working on creative tasks. Data from video-observation were used to answer the research questions in Article I and Article II.

Observation is a method where the researcher looks, listens and records the ongoing interaction in a specific context (Silverman, 2006). Social interaction happens between the participants in the moment, and the best way to capture what really happens in the interaction is by observing (Bakeman & Quera, 2011). Video-observation also secures documentation of movement, body language and speech, and was chosen to gain valid knowledge about how students approached the creative process and how interactions between teacher and students unfolded during the work on a creative task (see Johannessen et al., 2010). It was important to observe the participants in natural settings as these types of data could provide more accurate information than e.g., self-reports. Self-reports can be difficult as it might be hard for the participants to recall events of interests (Gall et al., 2007), and there is a chance for discrepancy between what the participants claim to do and what they actually do. Video-observation was, therefore, important to complement the teachers' interviews.

To gain access to the students' work and interactions, I chose to place one camera on each group of students. In addition, two whole class cameras were placed in case the students did something interesting outside the group cameras' reach. Four of the groups per cycle were provided with head mounted action cameras, and the rest of the groups were provided with video cameras on tripods facing the groups' table.

Video-observation created a way for the me to study processes with focus on both verbal and non-verbal behaviour within moment-to-moment sequences (see Bakeman & Quera, 2011). Unlike standard observational methods, video-observation allowed me to study these interactions several times, and therefore, allowed me to "dig into" the interaction and look for complex phenomena that would be impossible to observe directly (see Blikstad-Balas, 2017).

3.5.2.1 The researcher's role in video-observation

Video-observation enabled me to observe and listen to the students' interactions, seemingly unobtrusively. The students' awareness of the camera seemed to disappear

within the first minutes of the lesson, and it seemed that the presence of cameras did not interfere substantially with the students' work. Still, the video data picked up incidents where the students were especially aware of the researcher's presence. Although I was less present personally, the presence was evident in the students' conversations. Their 'saying' and social interaction in these incidents was changed by the presence of cameras, and the students related to the researcher through conversations about the camera, as shown in Figure 5 and 6. In the first example (Figure 5), one of the students was worried that she was not being filmed by the student wearing the action camera and pointed out the presence of the camera directly. In the other example (Figure 6), one student did something that was not relevant to the project and was corrected by another student. The student remined the other about the presence of the camera and that the camera had filmed everything the students did.

Figure 5: Researcher's presence in observation through the presence of cameras – example one from the data material

Figure 6: Researcher's presence in observation through the presence of cameras - example two from the data material

In other examples, students addressed the researcher directly through the camera. This was done when the students held their model in front of the camera and explained into the camera how the model worked.

The students' focus on the cameras during their work, although the examples were few, showed that the researcher impacted the praxis architecture of the classroom. The researcher also impacted the material-economic space by adding a camera to the classroom environment and the socio-political space as the students were affected by the cameras by filming each other (see Lofthus, 2017). The relationship between the students was, therefore, somewhat different than normal because of the camera's presence.

3.6 Analytical approaches and data analysis

Based on a pragmatic framework, the analysis methods were chosen to best answer the research questions of the thesis. When interpreting qualitative data, the aim was to

develop an organised, plausible and transparent description of the data's meaning (Larkin & Thompson, 2011). To answer the various research questions, I could not follow the line of one single analysis method. In this part, I will therefore, present the different analytical approaches used in the three articles of the thesis: Conversation Analysis (CA), Constructivist Grounded Theory (GT) analysis, and Interpretative Phenomenological Analysis (IPA).

3.6.1 Conversational Analysis as an analytical approach for exploring conversational practices between teacher and students (Article I)

Conversation Analysis (CA) was chosen to analyse conversational practices between teacher and students to answer the research questions in Article I. CA is a methodological approach to the study of interaction and social action. CA builds on the premise that "social life is established, sustained, and changed in and through the coordinated interaction of people" (Sahlström, 2009, p. 104) and "that people perform the actions of everyday life by the way they *design their turns* in the *sequential organization* of talk" (Antaki, 2011, p. 2). In Article I, the aim was to identify patterns of talk, and by doing so, discover and make explicit the practices through which participants produced and understand conduct in conversations (see Drew, 2005).

3.6.1.1 Applied Conversational Analysis

Traditionally, CA research focused on and emerged from studies of mundane conversation. However, this did not mean that the basic concepts and findings from 'pure CA' could apply to more institutional talk. Have (1999) differentiated between 'pure CA' and 'applied CA', where the former focused on identifying the local practices of turn-taking, sequential organisation, etc., as phenomena in themselves, while the latter drew attention to how these local practices were embedded within larger structures as institutional rules, instructions, etc. These are structures found in, for

example, schools and classrooms. Based on 'Applied Conversation Analysis', the analysis in Article I shed light on the workings of such classroom interactions, and the analysis can result in suggested improvements of practice (see Antaki, 2011).

The classroom used in the study was an arts and craft room. The classroom was defined as an institution in a way that it was roped off from casual life with physical barriers, by the presence of certain props and furniture, and most important, by the different rules of talk embedded in a school context (Antaki, 2011). Classroom interaction is mostly characterised by conversations between teacher and students, where the teacher is the actor who, for the most times, controls the interaction. "The teacher is the one who mainly imparts knowledge to students, generally corrects students and controls turn-taking and sequence organi[s]ation, and who has greater rights to initiate and close sequences" (Gardner, 2013, p. 593). In classrooms, there is an interactionally asymmetry, where the teacher has the institutional right to ask questions and evaluate responses, as well as the right to choose activities and when to move from one activity to another (see e.g., Cazden, 2011).

3.6.1.2 Transcription of video-recordings in CA

The data comprised video-recordings of teacher-students' interactions, which provided insight into how the classroom talk naturally unfolded during the work on 'Mission Mars'. CA is a deeply empirical tradition where the readers are provided with the resources they need to check on the analysis reported (Sidnell, 2010). The CA transcript provided and captured details of the interaction that might be interactionally significant (see Wooffitt, 2005). The present study was based on data transcribed according to Jefferson's (2004) manual for transcribing in-talk-interactions. The transcripts included detailed descriptions of turns and sequences, the onset of simultaneous speech, timing of gaps within and between turns, emphasis of talk, volume, speed, and sound stretching, but also audible breathing and non-lexical items like "hmm", "ee", etc. Table 4 presents the transcription conventions used in this study.

Table 4: Transcript conventions used in Article I

Transcription symbols	Meaning of the symbols
(0.5)	Time gap, one-tenth of a second
(.)	Pause in talk, less than two-tenth of a second
[]	Overlapping talk
=	'Latching' between utterances
'	Slight rising intonation
?	Rising intonation, not necessarily a question
.	Falling or final intonation, not necessarily the end of a sentence
,	'Continuing' intonation, not necessarily a close boundary
::	Stretching of the immediately preceding sound
Word	Stress or emphasis of underlined item
°word°	Softer or quieter tone than otherwise
<word>	Slower speech rate than otherwise
>word<	Faster speech rate than otherwise
-	Cut-off or self-interruption in the prior word or sound
(xxx)	Inaudible talk
(( ))	Transcriber's comments and description of non-verbal activities

3.6.1.3 Analytical procedure with the use of CA

The analysis was conducted in two phases, a macro analysis and a micro analysis, based on Clayman and Gill's (2004) conversation analysis levels. During both phases of the analysis, I focused on *what* was being done in the conversations between the teacher and the students and *how* the conversations unfolded (see Clayman & Gill, 2004).

Heritage (2005) said that all institutional talk has an overall structural organisation of activities of communicative projects, that is composed in a particular order. The macro analysis aimed to identify these overarching structures in the conversations. While trying to maintain an open mind, I read all the transcripts several times until a pattern of interest emerged in the 49 interactions.

Once the overarching activities in the interactions were discovered, a micro analysis was conducted to identify conversational components within the overall structure (sequences of action or type-specific characteristics, singular actions that comprise sequences and specific lexical choices etc. that occurred within turns at talk). The micro analysis explored what was being done during the interactions, how the conversational patterns of talk influenced the conversations between the teacher and the students, and how such actions influenced the students' creative process. The result of the analysis is further discussed in Article I.

3.6.2 Constructivist Grounded Theory as an analytical approach to investigate students' approaches to the creative process (Article II)

Constructivist grounded theory was used to analyse the video-recorded data in article II. By analysing the students' interactions and conversations during the work in 'Mission Mars', Article II explored how students approached the creative process. Grounded theory was chosen as the study took an inductive approach to the data material and discussed the result in light of theories and previous findings. The aim was to develop a theoretical model that was grounded in the data themselves to better understand how students approached the creative process (Charmaz, 2014; Thornberg & Frykedal, 2015). Theory is, according to Charmaz (2006), about conceptualising the phenomenon under study in a way that they can be understood in more abstract terms.

Grounded theory was launched during the 1960th by Barney Glaser and Anselm Strauss (Glaser & Strauss, 1967) as a reaction to the tension between qualitative and quantitative research in social science. Critical to the deductive approach of quantitative

researchers, where theories were used as the basis for research on practice, and to the inductive qualitative research in sociology that were criticised for its lack of theoretical grounding (Charmaz, 2014), Glaser and Strauss developed a systematic alternative to quantitative research and the inductive qualitative research. In their version of grounded theory, the researchers should develop techniques for discovering theory in the data where the theories were supposed to be grounded in systematic work with the empirical data (Rennstam & Wästerfors, 2015).

After Glaser and Strauss, other versions of grounded theory emerged, where the most leading version probably was constructivist grounded theory (Thornberg & Frykedal, 2015). This study followed the ideas of Charmaz' constructivist grounded theory that emphasises that theories are not stable phenomena that could be discovered in the data but rather tentative and constructed in the interaction between researcher and participants (Rennstam & Wästerfors, 2015). Charmaz (2006) said:

> I assume that neither data nor theories are discovered. Rather, we are part of the world we study and the data we collect. We construct our grounded theories through our past and present involvements and interactions with people, perspectives, and research practices. (p. 10)

Hence, the constructed theories depend on the researcher's view and are not viewed as a separate phenomenon that can be discovered (see Charmaz, 2006).

Grounded theory literature refers to various analytical approaches, but all approaches consist of phases of coding, categorising, writing memos and constant comparison between the various parts (Charmaz, 2014; Corbin & Strauss, 2014; Glaser & Strauss, 1967). In the following chapters, I will describe the analytical process in Article II, from transcription to analysis in two phases: (1) the initial phase and (2) the focused phase (see Charmaz, 2014). I will also describe the use of memos and the constant comparative method.

3.6.2.1 Transcription of video-recordings and data reduction

The video-recordings of students working in groups on the project 'Mission Mars' were transcribed verbatim. In addition, I wrote down observations of what students did during and between talking. The transcription was done using the software program NVivo following the transcription system developed by Du Bois (1991). After transcribing, I excluded situations that dealt with topics outside the scope of the article, in addition to interactions or parts of interactions where audio was missing or unclear. During the entire analysis process, I wrote down memos of own ideas around connections and categories in a separate document. Writing memos allowed me to spontaneously reflect on ideas about coding, categories and the relationship between codes.

3.6.2.2 The analytical process

The transcriptions were first coded through initial coding (see Charmaz, 2014) (referred to as open coding in Corbin and Strauss (2014)), where I coded small segments of the data material. I then conducted a focused coding, where I identified the most prominent initial codes and named these larger segments of the data material (see Charmaz, 2014; Rennstam & Wästerfors, 2015).

Initial coding:

I conducted the initial analysis of the transcription, analysing group by group. I printed the transcripts and read through them thoroughly several times. I then coded each transcript line-by-line directly on the prints, labelling each data segment that held meaning according to the research objective. The line-by-line analysis is typical for open coding described in Corbin and Strauss (2014). The labelling of the initial coding was held closely to the participants' saying and action, so abstraction of codes was not undertaken during the first step of analysis.

During the coding process, the new and old codes were constantly compared to each other, and codes that described the same phenomenon were named the same (see e.g., Thornberg & Frykedal, 2015). Ideas and suggestions for further categorising were written down in memos during the entire phase.

Focused coding:

After the initial coding, I conducted the second phase of the analysis, what Charmaz (2014) calls focused coding. In this phase, I looked for the codes that were most meaningful and central in the data. The codes that stood out as most central were the most frequent codes throughout the dataset, or important ones based on the researcher's previous knowledge of creativity and the creative process. I used coloured labels to mark similar codes which also helped me sort the data. Marking similar codes with different colours was a way to bring the separate codes together again in a coherent whole, referred to as axial coding (Charmaz, 2014).

Through constant comparing the different focused codes and relating them to previous memos, a causal and consequential relationship between the categories were noticed, and emergent themes were developed. This process is originally referred to as selective or theoretical coding (Charmaz, 2006, 2014; Corbin & Strauss, 2014; Thornberg & Frykedal, 2015). The emergent themes are presented in Article II. In the article, the analytical process is grounded in the data as verbatim extracts from the transcriptions are presented.

3.6.3 Interpretative Phenomenological Analysis as an analytical approach to investigate teachers' implicit beliefs (Article III)

The analysis of the five interviews with the two teachers in this study was built on phenomenology, as the study explored the meaning and importance the teachers

placed on the phenomenon of creativity, and not the phenomenon itself (see Fejes & Thornberg, 2015; Patton, 2002). I used Interpretative Phenomenological Analysis (IPA) since it made it possible to explore how the science teachers gave meaning to their understanding of creativity as a phenomenon. By conducting an IPA-study I had the opportunity to include elements of 'giving voice' and 'making sense' by taking into account the research participants' claims and worries, while offering an interpretation of the material (see Larkin & Thompson, 2011).

Phenomenology is the philosophical study of 'being', and according to Larkin and Thompson (2011), phenomenology is divided into two historical phases; transcendental phenomenology after Husserl and hermeneutic, or existential phenomenology, after Heidegger and Merley-Ponty. Husserl is concerned with identification and to 'bracket off' our own assumptions of a phenomenon to reveal the phenomenon's universal essence the way it appears to our consciousness (Larkin & Thompson, 2011). 'Bracket off' means to put aside our culture, context, history, etc. to view a phenomenon without these aspects influencing our understanding. IPA is phenomenological in the way that it is concerned with exploring the phenomenon on its own terms and because it follows Husserl's encouragement to 'go back to the things themselves' instead of trying to define the experience in abstract and predefined categories (Smith et al., 2009). IPA is not concerned with identifying the universal essence of a phenomenon, but builds rather on the ideas of Husserl's successors, Heidegger and Merley-Ponty. They believe Husserl's reduction is too abstract because our observations always build on *something*. Phenomenology can be meant as descriptive, but can only be interpretative upon completion (Larkin & Thompson, 2011).

IPA consists of an interpretative element and is, hence, influenced by hermeneutics – the theory of interpretation, as both IPA and hermeneutic theory see humans as interpretative beings. The research participants' accounts will always reflect their attempt to create meaning of their understanding of the phenomenon (Smith et al., 2009). This study, therefore, acknowledged that the research participants' narrative was an interpretation of their understanding of the phenomenon and that the researchers'

treatment of the empirical data was an interpretation of the research participants' creation of meaning. I was, therefore, engaged in a double hermeneutics, as I attempted to create meaning out of the research participants' attempt to create meaning (see e.g., Smith et al., 2009). I could only access the research participants' understanding through their narrative, and in the process of analysis, I included more of myself, while attending to the lived experience of the research participants. The result of the analysis was then a product of this collaboration (Smith et al., 2009).

3.6.3.1 Transcription of interviews in IPA

The interviews were transcribed in a semantic manner, based on the system developed by Du Bois (1991). This included a transcription of all the words being said by everyone present in the interviews, including pauses, talk dynamics and other sounds than pure words. Doing a semantic transcription made it easier to remember the dynamics from the interview situations and to base the subsequent analysis on the original conversations.

3.6.3.2 The analytical process

An IPA-study is characterised by a set of procedures moving from the special (the idiographic) and the descriptive to the interpretative, and a set of common principles which obligate to understand the research participants' narrative (Reid et al., 2005). Describing the research participants' understanding idiographic means to describe the participants' unique and personal understanding of the phenomenon without taking into consideration whether the research participant is telling the truth or not (see Fejes & Thornberg, 2015).

The analysis in this study followed Smith et al.'s (2009) suggested procedure in six steps; (1) reading and re-reading, (2) initial coding (called initial noting in Smith et al. (2009)), (3) developing emergent themes, (4) searching for connections across emergent

themes, (5) moving to the next case, and (6) looking for patterns across cases. I conducted an analysis of the interviews separate before looking for patterns between the interviews. Since the data material consist of multiple interviews with the same two teachers, I treated interviews from each teacher separate. The analytical steps are further described below and excerpts from the study's analytical process are used to illustrate the procedures.

Step 1: Reading and re-reading

The first step was about getting to know the data, and making sure that the research participant became the focus of the analysis. Smith et al. (2009) suggest that we slow down the reading, and not rush to reduce and sum up the material. In this step, I both listened to the interviews and read through the transcription multiple times, while taking notes of my initial thoughts and ideas. These notes reflected elements of the interview situation and general spontaneous thoughts and ideas that appeared during the reading.

As I went deeper into the material, it became natural for me to write more structured comments, and I moved towards step 2, initial coding.

Step 2: Initial coding

In this step I started out with a new copy of the transcription, without the notes from step 1. I went through the material in a chronological manner and wrote down everything that seemed interesting, at the same time trying to keep an open mind. I differentiated between three types of comments; (1) descriptive comments, (2) linguistic comments and (3) conceptual comments (see Smith et al., 2009). The descriptive comments were written in normal text (see table 5) and focused on the content of the research participant's narrative. These comments highlighted key phrases and content that gave structure to the research participant's thoughts and

experience. The linguistic comments were written in italic (see table 5) and focused on the language used by the research participant, e.g., repetition, pressure on words and sentences, etc. The conceptual comments were underlined and followed by a question mark (see table 5) and focused on the interrogative and conceptual level of the narrative. Smith et al. (2009) say that writing conceptual comments is like executing an interrogation of the narrative, by questioning the meaning of what is said. The writing of conceptual comments, therefore, functioned as a dialogue between own pre-understanding and new understanding of the research participant's narrative.

I started the process by describing the content through descriptive comments, before focusing on the linguistics. I then finished off with focusing on the conceptual comments. As I began to go deeper into the material, it became easier to shift the area of focus more rapidly between the different types of comments.

Table 5: Examples from the analysis - initial coding and developing themes

Developing themes	**Excerpt from the transcription**		**Clarifying comments**
Group dynamic determines the degree of task openness	Arthur:	Yes @@ Because here I know- they can 'handle it. They can actually 'receive such tasks and actually carry it out. But like- the group I had last year then I know that if they were given this task… then it most likely would result in pure nonsense. They… empty out or they would do something they most likely were not supposed to do.	You can open up more for students that are less outgoing as the teacher is confident that they will master and carry out the task.
		Ja @@ For det her vet jeg- de her 'takler det. De her kan faktisk 'få en slik oppgave og faktisk gjennomføre den. Men sånn- som med den gruppa jeg hadde i fjor så vet jeg at hvis jeg gir de den her oppgaven… så blir det mest sannsynlig bare tull.	*Pressure on 'handle it', which may enhance the importance of students being able to carry out a task and*

	Researcher:	De… tømmer ut eller de gjør noe de mest sannsynlig ikke skulle gjort. Yes.	*handle the openness.* Is the feeling of being able to finish something and complete a task the way the teacher planned essential for organizing and implement an open-ended task? Is that a premise for allowing students to be creative?
	Arthur**:**	Ja. And then you don't 'provide such tasks. Og da 'gir du ikke slike oppgaver.	
Creativity is based on freedom	Trillian:	'Be 'free. It is to be 'free. 'Yes. 'Vær 'fri. Det å være 'fri. 'Ja	Creativity is to be free to unfold. *Pressure on 'free' twice, which may point to the importance of freedom related to creativity. Pressure on 'unfold' and 'use oneself'.* Does this mean that freedom and less structure is a premise for creativity?
	Researcher:	Yes. Ja.	
	Trillian:	Free to 'unfold. To 'use.. oneself? Eh= Fri til å 'utfolde seg. Til å 'bruke.. seg selv? Eh=	
Student engagement and focus	Arthur:	I think they were 'really good. That is, I did not expect that. That they were so focused on the task and that they.. sat and 'discussed. No, I thought we had to- I thought it	Surprised that the students were that enduring.

during discussions		would be more like <SIT Yes, we go for this. We are finished. Just give us access to the equipment so we can start to build something SIT>	Surprised about students' engagement during discussions.
Students enduring in the idea generating phase		Jeg synes de var 'kjempeflinke. Altså, det hadde jeg ikke forventet. At de var så inni oppgaven og at de.. satt og 'diskuterte. Nei, der trodde jeg at vi måtte- Jeg tenkte egentlig at det ble sånn <SIT yes, vi tar det. Vi er ferdige. Bare få ut utstyret så vi kan begynne å bygge noe SIT>	Thought introduction of materials would have to come earlier in the process.
	Trillian:	Yes @@@	*Pressure on 'really good' which may point to a surprising observation.*
		Ja @@@	
	Arthur:	Right? That's what I thought we- that we had to stop them multiple times like <SIT no, no, you cannot start now SIT>. I was completely certain that that would become our biggest job that day.	*Pressure on 'discussion' that may point to an unexpected area of students' focus.*
		Sant? Det er det tenkte jeg at vi- at vi måtte stoppe de mange ganger for at altså <SIT nei, nei, dere får ikke lov til å begynne nå SIT>. Jeg var helt sikker på at det var det som kom til å bli den største jobben den der dagen.	<u>Can this mean that the teacher does not think the students are able to or interested in participating in discussions about the problems and ideas without material and building becoming an issue?</u>

Step 3: Developing emergent themes

After including comments in step 1 and step 2, the data material had grown. In step 3, I therefore needed to reduce the level of detail in the material by looking at similarities and patterns in the comments. The similarities were then put together under the same developing theme (see Smith et al., 2009). The naming of the themes reflected, in most cases, the original words and thoughts of the research participant. In some of the themes, I based the name of the theme on the research participant's own words and then expanded (or added) to the name without ascribing an interpretative element to it. Table 5 presents an excerpt from this process.

By identifying developing themes, I moved away from the narrative flow in the interview and attempted to sort the data in a more structured way. The volume of details was reduced, while the complexity in the material was preserved. In the process of dividing the transcription into themes, I also ensured that the parts were interpreted in light of the whole interview, and vice versa, by checking the themes up against the original transcription.

Step 4: Searching for connections across emergent themes

In this step, I identified, with the use of *abstraction* (Smith et al., 2009), a pattern between the different themes from step 3 and put similar themes in clusters of superior themes (see Fejes & Thornberg, 2015; Smith et al., 2009). As I looked at the developing themes in combination with the whole material, it became clear that several of the themes could form a combined cluster. The content of the themes, rather than the thematic naming, determined the new organisation of clusters. The clusters were then given a more theoretical label, based on my interpretative approach to the themes and theoretical knowledge. In doing this work, it became clear that not every theme from step 3 was relevant to the research question. These themes were excluded from the coding system, and the complexity of codes further reduced.

Step 5: Moving to the next case

As pointed out earlier, each of the interviews were analysed separately, according to IPA's idiographic commitment (Smith et al., 2009). I attempted, as far as it could be done, to 'bracket off' the ideas from the previous case before analysing the next. To do so, I decided to take a few days off before moving from one case to the next. This was a challenging process, and it was quite demanding to come up with new labels for the themes and clusters in the new case. I do, however, not see 'coming up with all new labels for each case' as the point with 'bracketing' in IPA. Instead, I see the act of 'bracketing' as a way of keeping an open mind and not forcing themes and clusters from one on to the other. the overview of clusters and themes (Table 6) shows that some clusters and themes are present in all cases, and some are special to one case.

Step 6: Look for patterns between the different cases

This was the first time I looked at all the cases at the same time, and in this step, I looked for similarities and differences between the cases. By doing so, I moved the analytical process towards a more theoretical level by asking myself how one case could clarify another case, which themes were most potent etc. I printed the overview of themes and clusters for all cases and laid them out before me. I then compared the cases and highlighted the similarities and differences between them. In this process, some of the clusters and themes were given more suitable names because of similarities between cases. When changing a name, I also looked at the original transcripts to make sure the new label was loyal towards the original narrative.

The result of this process is presented in Table 6, which shows how themes are put together in clusters and how themes are distributed between each research participant.

Table 6: Overview of clusters and themes

Clusters	Themes	Occurrence across cases*
Teachers' description of creativity	he ability to come up with multiple solutions and opportunities	T1, T3
	The ability to do or think differently	T1, A1, A3, T3
	Curiosity is creativity	A1, T3
Supporting creativity with freedom from structure	Freedom	T1, A3
	Open-ended tasks	A1, T1, A3
	Freedom to choose, independence and co-determination	A1, T1, A3, T3
	Frames and structure inhibit creativity	A1, T1, A2, T2, T3
	Goal-oriented learning inhibit creativity	A1, T1
	A massive curricula and time-pressure inhibit creativity and interaction with students	A1, T1, A2, T2, A3, T3
Supporting creativity through student activity	Investigation and problem-solving support creativity	A1
	Play-based learning support creativity	A1
	Participation and activity are important for supporting creativity	A1, T1
	Practical learning methods and construction support creativity	A1, T1, A3, T3
	Access to equipment, materials, and unusual elements supports creativity	A1, A2, T3
	Activity not always related to construction, but problem-solving discussions	T1
	Variation supports creativity	T1, A3

Teachers' self-efficacy as creativity inhibitors	Group dynamic and student attitudes determines teacher security	A1, A2, T2, T3
	Group size determines teacher openness	A1, T1
	Openness is terrifying	A1, T1
	Feeling of security determines teachers' focus on creativity	A1, T1, T3
	Tolerance for mistakes support creativity	T1, A3
	Teachers' need for control	T1, A3
	Professional self-confidence important to support creativity	T1, T3
	Knowledge about the students enhances teacher security	T1
	More time leads to braver and more open teachers	T2
	Teachers' insecurity in the idea-phase may stress the process	A3, T3
Teachers' inherent product focus	Need to finish the task	A1, A3, T3
	Result most important for both teachers and students	A3, T3
	Prototype makes the dissemination of the idea easier for the students	A3
Learning outcomes from supporting creativity	Memorable learning situations	A1, A3
	Joy of learning, pride and feeling of mastery	A1, A2, A3, T3
	Subject knowledge	A1, T1, A2, T2, A3, T3
	Creativity and joy of creation	A2
	Endurance	A2, T2, A3, T3
	Activity and engagement	A2, T2, A3, T3

	Argumentation skills	A2, T2
	Independence	A2
	Collaboration skills	A3, T3
	Awareness about the importance of subject knowledge in creative processes	T3
Teachers' beliefs about the need for student-teacher interactions	Guidance based on the need for student activity	T2
	Guidance when students need help moving further and start working	T2, A3
	Guidance for conflict handling and conflict solving	T2, A3
	Students do not need guidance	T2, A3
	More time may change guidance practice	T2
	Good guiding intentions are lost on behalf of traditional teaching	A2, T2
	More teachers may improve guiding practice	A2, A3, T3
	Too much guiding may inhibit creativity	A2, A3, T3

** A denotes Arthur, T denotes Trillian and 1-3 denotes interview 1, interview 2 and interview 3*

Conducting this analysis gave me a better understanding of the teachers' implicit beliefs about creativity. Illustrating the result in this way gave structure and overview of the empirical data, which in turn formed the basis for further discussion and further interpretation of the research participants' attempt to create meaning to their lived experience about the phenomenon of creativity.

3.7 Research credibility

"All research is concerned with producing valid and reliable knowledge in an ethical manner" (Merriam & Tisdell, 2016, p. 237). Validity and reliability are seen as criteria for research quality in quantitative research (e.g., Johannessen et al., 2010). Several researchers also use these terms in order to assess the quality of qualitative research, although they emphasise that criteria for trusting a qualitative study need to be different than "if discovery of a law or testing a hypotheses is the study's objective" (Merriam & Tisdell, 2016, p. 238). This thesis is conducted within a qualitative research tradition that seeks to describe, understand, and explain flux, multifaceted, and highly contextual social phenomena. Several researchers, therefore, suggests other terms to assess qualitative research quality, for example, *trustworthiness*, *credibility*, *dependability*, *transferability* and *confirmability* (e.g., Lincoln & Guba, 1985). However, others are critical to introducing different criteria for quality and different practices (e.g., Johannessen et al., 2010). In the following, I therefore choose to base the discussion on the criteria of validity and reliability to assess the credibility of the study.

3.7.1 Reliability

Merriam and Tisdell (2016, p. 250) conceptualise reliability as "the extent to which research findings can be replicated". The issue of reliability in qualitative research is, however, disputed in social science. Qualitative research seeks to describe and explain the world as those in the world experience it, and because human behaviour is context dependent and never static, there is no way to repeat measures and establish reliability in the traditional sense (Johannessen et al., 2010; Merriam & Tisdell, 2016). This thesis ontological assumption is that reality is not seen as something objective but something that is continually constructed through interactions and interpretations, and that knowledge is constructed through interactions among actors in the research field. In addition to the research participants' behaviour and ideas being context dependent and changeable, the researchers work is subjective and based on his or her interaction and

interpretation of the research field and phenomena. Therefore, reliability in qualitative research is more concerned with showing that the results are consistent with the data collected (Lincoln & Guba, 1985; Merriam & Tisdell, 2016), by making the research process as transparent as possible.

According to Johannessen et al. (2010), the researcher can enhance the consistency and reliability by providing the reader with thorough description of the context and the research process. Doing so makes the research process more transparent for the reader (e.g., Krumsvik, 2019). This is consistent with what Lincoln and Guba (1985) refer to as an *audit trail*, a detailed account of how the study is conducted, how the data is analysed and of the researcher's decisions during the research process (Merriam & Tisdell, 2016). The reliability and transparency of this study are enhanced as the thesis describe, in detail, the choices the researcher has done during the research process with regards to the choice of theme, theory and methods. The methods and analysis are described thoroughly, and the articles present excerpts of the transcriptions and categories developed. The thesis also includes a description of the literature review, which provides insight into how the theoretical background for the thesis is developed. As Merriam and Tisdell (2016) note, journal articles tend to have a very abbreviated audit trail or methodology section due to space limitations. Therefore, the thesis provides a more detailed account of the research process and the different choices made by the researcher. Detailed descriptions of the data collection and data analysis contribute to the reader being able to follow the researcher's trail towards the result and conclusion of the study (e.g., Merriam & Tisdell, 2016).

According to Kvale (1997), a study's reliability can be strengthened if more than one researcher transcribe the same data material. The transcriptions of the interview data and video recordings are conducted by the researcher alone. However, reliability is strengthened as well documented transcription conventions are used when conducting this work. In Article I, the video recordings are transcribed according to Jefferson's (2004) manual for transcribing in-talk-interactions. The detailed transcription includes descriptions of turns and sequences, the onset of simultaneous speech, timing of gaps

within and between turns, emphasis of talk, volume, speed, and sound stretching, in addition to audible breathing and non-lexical items. The details provided in the transcripts provide the reader with a detailed image of the original interaction, strengthening the transparency of the study. In Article II and III, the video-recordings and interviews are transcribed in a semantic manner, including pauses, talk, dynamics and other sounds than pure words, based on the system developed by Du Bois (1991). Although not as detailed as the transcripts from Article I, the transcriptions allow the reader to follow the original conversations between the students (Article II) and between the researcher and the teacher (Article III). Before transcribing the video- and interview data, the researcher also considered and studied how these transcription conventions are used in similar studies.

Doing all the transcription work, I became more familiar with the empirical data, which helps strengthening the validity of the study (see Krumsvik, 2019). As this study depends on video-recorded data and recorded interview data, I could replay sequences of talk and interactions over and over. The recordings are replayed many times to create highly detailed transcripts, according to the conventions used. This is also a way to avoid confirmation bias (see e.g, Jordan & Henderson, 1995). By replaying parts of the recordings, I also experienced that my first understanding of what is going on in the interactions changed. Hence, video-recordings strengthens the reliability of this study as the researcher can study the interactions thoroughly several times, until reaching a point of saturation.

Reliability is also dependent on the concrete material and recording equipment used in the study (Kvale, 1997). In the interviews, I used two digital recorders at the same time in case one of the recorders malfunctioned during the interviews. Hence, I did not lose any talk during the interviews, and I could doublecheck the back-up recordings if a word or a sentence was unclear in the main recordings. Video-recordings were conducted with the use of one camera for each student group (3-4 stationary cameras and 4 go-pro cameras), in addition to two cameras facing the entire classroom. Because the students moved freely in the classroom, I could not capture everything that was done

on the groups' cameras, but I was able to retrieve some information and interaction that was lost through the cameras overlooking the entire classroom. In addition, the two teachers wore digital recorders around their neck, which made it possible to retrieve talk that was missing in the video-recordings in cases where the sound was bad or missing, or in cases where the student wearing the go-pro left the interaction or faced a different way.

Prior to the first individual interviews with the two teachers in the study, I conducted trial interviews with three teachers with similar background as the two teachers in the study, but from another primary school. The trial interviews enabled me to assess whether the questions in the interview guide were fully understood by the teachers, if the questions were leading, multiple or ambiguous, or if the questions contributed to shaping the teachers' answers in any way. This is important with regards to the reliability of the interviewer, but also to the validity of the interviews (Krumsvik, 2019). The three trial interviews were conducted within the context of a PhD-course – Qualitative Research Methods of Analysis (PLU8022). In addition to receiving supervision in developing the interview guide, I practiced transcribing the recordings according to the conventions used in the IPA-study (see Du Bois, 1991; Smith et al., 2009) and analysed the data. In the process, I received important feedback from the lecturer of the course. Trial interviews for the group interview and the final individual interviews in the study were not conducted. However, at the time of the interviews, I knew the teachers well and could, therefore, better adjust the questions according to their experience and vocabulary related to creativity.

It is also important that the interviews are conducted in similar ways. According to Fog (2004) reliability is strengthened when there is consistency within each interview and between the interviews, as this may limit the impact of the subjective element naturally present in every interview. The interviews in this study were all conducted in similar ways, where the researcher asked mainly open-ended questions. This allowed the research participants to answer the question in length and opened for the participants to steer the conversations and focus on the participants' narrative. I tried to limit my

influence on the research participants' answer by participating with limited verbal input, while driving the conversation further with the use of nods, sounds like m-m, encouraging phrases as "can you tell me more about…" or repeating of the research participants' words and sentences to encourage a continuing of their narrative.

3.7.2 Validity

Smith (2015) defines validity as a judgement about how well the research has been carried out, and whether the findings of the research are regarded trustworthy and useful. Validity is often differentiated between internal validity and external validity, where the internal validity deals with the question of how research findings match reality and external validity is concerned with the extent to which the findings of a study can be applied to other situations (Merriam & Tisdell, 2016). The following discussion builds on this differentiation.

3.7.2.1 Internal validity

Based on the ontological view, this study was not concerned with capturing an objective "truth" or "reality". It was, therefore, important to use different strategies to make sure to increase the "credibility" of the findings. A common strategy to strengthen internal validity of a study is by *triangulation* (Merriam & Tisdell, 2016). Triangulation involves the researcher using multiple methods, multiple sources of data, multiple researchers (investigator triangulation), or multiple theories to confirm emergent findings (Denzin, 1978; Lincoln & Guba, 1985; Patton, 2002; Thagaard, 2009).

According to Merriam and Tisdell (2016), triangulation using multiple methods of data collection involves, for example, checking what someone tells you in an interview against what you observe on site or read in documents. In this study, I used both interviews and video-observation to identify what was done and what could be done to support students' creativity in science. By comparing what the teachers told in the

interviews with my observation in practice, I could identify incidents where, for example, the teachers articulated that they were supporting creativity through student-teacher interactions in the interviews with observations that showed difficulties in doing so. This strategy enabled me to identify situations – with the use of different sources - that needed more information or deeper exploring.

Triangulation using multiple sources of data is another way of ensuring internal validity, as well as reliability of a study (see Merriam & Tisdell, 2016). In this study, video-data and interview transcripts were the only objects for in-depth analysis. However, field notes from direct observation in the classroom, collected documents and photographs of students' work, informal conversations with students and teachers, alongside protocols from meetings with the teachers were additional sources of background data. These additional sources were important and valuable to gain more insight into the whole context and to check findings and interpretations from the primary sources. Use of several cameras, in addition to digital recorders on the teachers during the implementation, also allowed me to gain a more complete picture of the reality of the study as I could retrieve information that was missing or unclear on one camera from another camera or in the digital recording. This strengthened the validity of the study as it helped cover more of the reality as understood by the participants (see Merriam & Tisdell, 2016).

According to Creswell and Poth (2018) and Patton (2002), internal validity, as well as reliability, can be strengthened if more than one researcher conduct the analytical work and categorisation of the transcripts (referred to as investigator triangulation). I did all the analytical work on my own for all three articles in the thesis. In retrospect, I should have considered to include other researchers during the categorisation and analytical work. This would have made it possible to discuss other possible analytical viewpoints of the data material to strengthen the reliability of the analytical work. However, other researchers have read and viewed the result of the analytical work of the study and made comments about uncertainties in the work. The internal validity is, therefore, strengthened through "peer examination" (see Merriam & Tisdell, 2016). In addition,

Article I and Article II are assessed through "peer review", further strengthening the validity of the study (Merriam & Tisdell, 2016).

The three articles of the thesis explored students' creativity and how to support students' creativity from three perspectives: student, teacher and interactions between student and teacher. The different perspectives opened for the use of different analytical methods and perspectives to best answer the different research questions. In addition, the articles built on different parts of the theoretical background. This coincided with triangulation of multiple theories (Denzin, 1978; Lincoln & Guba, 1985; Patton, 2002; Thagaard, 2009).

Another important strategy for strengthening the validity of a study is member checking. Member checking involves asking the research participants to give feedback on the preliminary or emergent findings to rule out the possibility of misinterpretation of meaning and identify own biases and misunderstandings (Lincoln & Guba, 1985; Merriam & Tisdell, 2016). Between the implementations in the classrooms, I presented preliminary findings from the video-observations to the teachers, and we discussed whether they found the findings relatable. However, the findings often reflected situations the teachers were unaware of during the implementation and, therefore, functioned more as suggestions for further developing the design for learning and creativity as well as informing the teachers about what was observed. In retrospect, I could also have allowed the teachers to comment on the transcriptions of the interviews and later the analysis of the interviews. On the other hand, I conducted three interviews with each teacher on the same subject, which allowed me to identify incidents where the teacher's narrative was inconsistent. The original plan of the study was also to allow the teachers' insight into the result of the study and the opportunity to comment on the result. However, because of the Covid-19 pandemic placing so much extra pressure on teachers, I decided to postpone this until the world was calmer again.

3.7.2.2 External validity

External validity, also called transferability (Lincoln & Guba, 1985), involves the question of whether the results of a study are able to transfer to another setting (Merriam & Tisdell, 2016). A common understanding of external validity is to think in terms of "*reader and user generalisability*", where the reader is left to determine whether the study applies to his or her particular situation (Merriam & Tisdell, 2016). However, the researcher is obliged to enhance the possibility of the reader being able to compare the "fit" with their situations, by employing different strategies.

One way to strengthen the transferability of this study is to provide rich, thick descriptions of the context and findings of the study (see Merriam & Tisdell, 2016). The thesis describes in detail the choices and doings of the researcher in the research process (further discussed under chapter 3.7.1 - Reliability, related to the researcher's audit trail). Thick descriptions related to transferability are descriptions of the findings with adequate evidence presented in form of quotes and excerpts from the transcriptions (Merriam & Tisdell, 2016). All three articles present excerpts and quotations from the transcription to support the findings and the developed categories, allowing the reader to gain insight into the context of the findings.

Another strategy for enhancing external validity is related to the study sample, as variations in the sample allow for the possibility of a greater range of application by the readers (Merriam & Tisdell, 2016). The study is very context dependent as it follows two teachers and three classes of students from the same school, working on the same project. This may limit the transferability of the study. The study may have enhanced the transferability if the students worked on different tasks or in different contexts. However, the different ways students approach the creative process can be relevant for other contexts as well. The study also explores two teachers' conceptualisation and strategies for supporting creativity, which is a small sample size if generalisation is the aim. However, the study aims at understanding the teachers' actions through a long-term collaboration, several interviews, and observations, which allows for a thorough understanding of the situation and context.

3.8 Ethical considerations

The study has been conducted in accordance with the guidelines of the National Committee for Research Ethics in the Social Sciences and the Humanities (NESH, 2016). Prior to the research project, the Norwegian Centre for Research Data (NSD) was notified. The notification entailed providing detailed description of the research project and attachment of informed-consent letters of invitations and interview guides. The approval from NSD is presented in Appendix A and the informed consent letters are presented in Appendix B and C. Informed consent, freedom of participation and right to confidentiality were communicated to all research participants prior to the data collection. Teachers, students, and students' parents/caregivers gave their written consent to participation in the research project.

The thesis is mostly based on video data of both teachers and students, which requires special responsibility regarding the protection of human dignity and integrity. The students were under the age of 15, which required parental consent when taking part in the research (NESH, 2016). Both students and parents/caregivers, therefore, signed and returned the informed consent prior to the data collection. The informed consent sheet provided the students and parents/caregivers with information about the study and information about the right to withdraw at any point of the study without any consequence. The informed consent also included information about alternative options of education in case the students did not want to attend. The alternative was to participate in the same class but outside the camera's view. Luckily, all students wanted to participate in the study. Both teachers in the study also signed and returned the informed consent sheet prior to the researcher-practitioner collaboration in the study. They were given information about the study in both written and verbal form.

Prior to the video observations, both teachers and the researcher informed the students about the research project and how cameras would be placed several places in the classroom. The students were also given the opportunity to ask questions to the researcher about the study. The students were notified each time the cameras were turned on and off. This was important as the researcher had a special responsibility to

protect the students and make sure that they understood what they were participating in, despite of their parents' consent (Hov & Neegaard, 2020). Although the students were aware of the cameras present in the classroom, they did not seem to put much emphasis on their presence, with the expectation of a few incidents further described in chapter 3.5.2.1 – *The researcher's role in video-observation*. I did not, however, experience conversations of severe private character during the recordings that compromised the students' privacy. Conversations and incidents not relevant for the project were excluded from the material in the transcription.

All research data were stored on two secure external hard drives. In transcribing the data, all names were replaced with pseudonyms to maintain participant anonymity. The teachers were called Trillian and Arthur, and students were called B1, B2 etc. (B for boy) and G1, G2, etc. (G for girl) in addition to their group number.

3.8.1 Ethical considerations related to researcher-practitioner collaboration

Qualitative research demands a special ethics code because of the special relationship between researcher and the subject (e.g., Marshall, 1992). This was especially important in this study due to the close and long-term collaboration with the two teachers.

The two teachers expressed a very positive attitude towards participating in the study and were very pleased to have the opportunity to discuss their own practice and receive feedback from someone outside of their school. Several times during the collaboration, both teachers expressed how much they valued this experience. Even so, it was important for me, as the outside researcher, to acknowledge that me being there also suddenly placed the teachers in situations where everything they said and did was recorded, placing the teacher in type of assessment situations. They had to deal with the fact that questions were asked about their actions and choices in the classroom, and they had to justify them (maybe first and foremost for themselves). Bandura (1977) says that people's self-efficacy can be lowered if they experience a situation stressful or

threatening. It was, therefore, important that the teachers felt safe and included in the project. The project placed focus on creativity and how to support creativity in the science classroom, and both teachers expressed that this was a new experience for them and a different way of thinking. To make this a positive and encouraging experience for the teachers, I therefore tried my best to build the collaboration on the teachers' ideas and input, while introducing the theories and ideas of a creativity supportive learning. The design for learning and creativity was developed based on the teachers' idea of what theme would engage and motivate the students, and the teachers' professional experience was very important for how and when the various parts of the design should be implemented. As a researcher with little experience of teaching at a primary level (except for shorter periods as a substitute teacher), the teachers' professional knowledge was highly important for the implementation and planning of the design. It was also very important that the teachers felt ownership of the project. I believe my intentions of teacher ownership succeeded, both because I experienced the teachers making further plans outside of the project's schedule (they came up with new ideas and changes that they presented to me during our meetings), and because they decided to make the project permanent in the fifth grade for the years to come.

Gudmundsdottir (1992) points out that "informants are often keen to please their researchers […] The scene is set for compelling stories that sparkle in their narrative truth" (p.6). Hence, there is a possibility that teachers participating in research feel the need to present a more positive image about their practice and ideas, in order to please the researcher. During interviews, I felt the teachers talked very freely and open about their ideas related to supporting creativity in the classroom, including problematic aspects. I did not feel that the teachers tried to sugar-coat or exaggerate anything to please me as a researcher. The first interviews functioned as a way for me to gain insight into the teachers' knowledge and vocabulary related to creativity, so the following collaboration was built on common grounds and the distance between the researcher and the teachers was minimised.

Developing the design for learning and creativity together with the teachers also meant including strategies for supporting students' creativity through teacher-student dialogue. Planning and discussing these strategies together with the teachers left me with the impression that we agreed about what to in during the implementations and what was considered important when interacting with students. Analysing the video-observations and interviews made me, on the other hand, realise that we may have talked passed each other, as the teachers did not include (or thought that they included but did not include) the strategies we planned when they interacted with the students. However, I do not think this was a result of teachers trying to please me as a researcher by providing me with ideas and thoughts they believe I wanted, or because of lack of knowledge. Rather, it may be due to heightened expectations by the researcher based on a belief that the teachers' background from inquiry teacher courses made them better equipped to implement such strategies in the classroom. I may have believed that they understood and knew more than they did. However, the observations pointed me towards exploring the difficulties in supporting students' creativity through interactions, which may be a more valuable contribution towards future implementation of similar designs. Researching how to support students' creativity also means exploring what do not contribute to supporting students' creativity. This may not have been the teachers' intention with the interaction, potentially making the teachers disappointed about the result. I, therefore, focused on situations that showed positive aspects, while at the same time making the teachers aware of the problematic aspect of the interaction, when talking with the teachers. However, the teachers expressed that they apricated such feedback and was open towards discussing alternative possibilities. As a researcher, it was especially important to highlight possibilities, and not "mistakes" observed in supporting students' creativity in the discussions.

4 Summary of articles

The overall research problem of the thesis is: *How can creativity be facilitated in primary science education?* In this chapter, I present a summary of results related to the five sub-questions, which are discussed in depth in the three articles of the thesis. The summary focuses on the purpose and the main findings of the articles. In the thesis, conditions that facilitate creativity in an educational context are examined from three perspectives: (1) the student perspective through video-observation (Article II), (2) a student-teacher interaction perspective through video-observation (Article I), and (3) the teacher perspective through interviews (Article III).

The three perspectives aim to cover the complexity of a classroom environment related to Sandoval's (2014) conjecture map (see figure 3, page 45). Article I explores the observable interactions between teacher and students, and how the interactions affect students' creativity. Article II explores interactions between students working on the project 'Mission Mars' and the products (creative ideas) they develop during the creative process to understand how the students approach the creative process. Article III explores creativity as a phenomenon from the teachers' perspective based on the teachers' narrative of creativity in general and their experience of creativity during and after the cycles of design, implementation, and evaluation of the project 'Mission Mars'.

4.1 Article I

Fredagsvik, M. S. (2021). The challenge of supporting creativity in problem-solving projects in science: A study of teachers' conversational practices with students. *Research in Science & Technological Education*, 1-17. Doi: 10.1080/02635143.2021.1898359

The research questions for article I were: (1) *how do teachers respond to students' creative ideas during the phase of identifying problems and generating ideas in a creative science project?* and (2) *how do teachers' responses to students' creative ideas*

impact the students' creative process? The purpose of the study was to get insight into how teachers respond to students' creative ideas during the work on the creative science project 'Mission Mars' and how interactions between teacher and students impact the students' creative process. Conversation analysis was used to analyse the interactions between teacher and students across 49 video-recorded interactions. The study showed that teachers play an important role in developing students' creative ideas. The analysis showed how teachers, after the students shared their creative ideas, evaluated the students' ideas as either preferred or dis-preferred according to the teacher's own preference of a good idea. The teachers displayed preference either by encouraging the students to write down or draw their idea or by providing positive encouragement through verbal or non-verbal utterances. After displaying preference towards an idea, the teachers turned away from the conversation and moved on to the next group. The teachers displayed dis-preference by either ignoring the idea or undermining the idea with the use of irony or humour, or by interrupting the students' narrative when presented a problematic aspect of the idea. They then followed up with questions and arguments to make the students realise the problematic aspect of the idea. The students were given the opportunity to repair their idea according to the teacher's preference, and if they succeeded doing so, the teacher displayed preference towards the idea, before turning away from the conversation. The teacher's evaluative stance towards the students' creative ideas determined how the conversations with the students unfolded and which ideas the students chose to work on further in the project. This might be because the students saw the teacher's display of preference as a confirmation towards proceeding the work with the idea. The result points to a challenging aspect of supporting students' creativity. The way the teachers displayed preference may have led to missed opportunities for guiding the students in their creative process and may have hindered the students to convert their mini-c creative ideas into little-c creative ideas.

4.2 Article II

Fredagsvik, M. S. (2021). Student approaches to creative processes in an open-ended project in science. Submitted to *International Journal of Science Education*. (Revised and under a second review)

The research questions for the second article were: (1) *how do students in fifth- and sixth grade display creative thinking while working on an open-ended project in science?* and (2) *how do students include science knowledge during the creative process?* The purpose of the study was to develop a conceptual understanding of the ways students approach a creative project and how they relate to knowledge during this process. Constructivist grounded theory was used to analyse video-recordings of students working on the project 'Mission Mars'. The analysis showed that students approached the creative process in six different ways: (1) by adaptation, (2) by transfer, (3) by synthesis, (4) by originality, and (6) by need. Throughout the exploratory phase and the evaluative phase of the creative process, the students created new ideas and arguments for or against ideas by adapting science knowledge. During the exploratory phase of the creative process, the students often transferred ideas from other domains, real life experience, movies, cartoons, internet, etc. and included them into their creative ideas. During the same phase, students also combined two or more ideas to create new ideas or presented original ideas that could not be traced back to previous information or knowledge. When providing arguments for or against ideas, the students also argued based on the ideas practicality or need related to the context of Mars or the project itself. The result indicated that science education could focus on nurturing creativity without minimising subject knowledge in the process as the students were able to make use of science knowledge during creative tasks.

4.3 Article III

Fredagsvik, M. S. (2021). Teachers' self-efficacy and the freedom paradox: Teachers in primary schools' beliefs of creativity in science education. *NorDiNa*. (Submitted)

The research question for the third article was: *What are primary teachers' beliefs about creativity and how to support students' creativity when developing and implementing a creativity-supporting, open-ended science project?* The purpose of the study was to explore two experienced primary teachers' beliefs about creativity during collaboration with the researcher on developing and implementing a science project aimed at supporting students' creativity in three different classes. Interpretative phenomenological analysis was used to explore how the teachers ascribed meaning to the phenomenon creativity. The analysis showed that the teachers described creativity as seeing multiple solutions and opportunities to a problem or a task, and the ability to come up with unique solutions or use unusual methods. The teachers also emphasised that creativity can be supported in an environment with focus on freedom from structure and that creativity is best nurtured when students take an active part in their own learning. The analysis showed that teachers often identified the building part of a design process as the creative phase of the project, and that factual knowledge was viewed as less important results of such creative tasks. When it came to the creative process, both teachers believed that the students needed little teacher guidance, although they saw that good teacher-student interaction could result in better and different guidance and responses. Mostly, the teachers emphasised that the students needed guidance when faced with problems, disagreements, or lack of activity. The result indicated that the teachers' self-efficacy in facilitating and supporting students' creativity was affected by their conceptualisation of creativity and their contextual opportunities and constraints of a classroom. The result indicated, for example, that the teachers emphasised the importance of freedom as important for facilitating creativity, but that their self-efficacy hindered them to create the assumed amount of freedom needed.

5 Discussion

This chapter discusses the key findings of the thesis, based on the results from the exploration of the five sub-questions of the thesis. The findings related to the sub-questions and the three articles contributes to answer the overall research problem: *How can creativity be facilitated in primary science education?* A synthesis of the five sub-questions results in three conditions for facilitating creativity in primary science education: (1) capitalising on the students' creative thinking abilities, (2) a shift in thinking towards a more collaborative student-teacher interaction, and (3) increasing teachers' creative self-efficacy.

The three conditions for facilitating creativity in primary science education all strengthen the rationale for embedding creative learning in an educational context and the findings recognise the teachers' active and agentic role in facilitating students' creativity, as emphasised in creativity literature and social cognitive literature. The first condition recognises students' creative thinking abilities and encourages to acknowledge and capitalise on this competence in teacher-student interactions, yet stresses the difficulties in doing so in teaching due to teachers' narrow conceptions of creativity. The second condition acknowledges that students' creative potential can be strengthened through teacher-student interactions but emphasises that a shift from teachers' evaluative and product-oriented focus in creative tasks to a more collaborative and explorative interaction is necessary. The third condition highlights the need for increasing teachers' creative self-efficacy to strengthen their ability to include creativity supportive elements in the everyday teaching and combat a heavy reliance on classroom control and product-oriented standards. The discussion sheds light on difficulties in supporting students' creative potential in the classroom, and the three conditions function as enablers of creative learning. The synthesis of each condition is discussed more thoroughly in the next sections.

5.1 Capitalising on the students' creative thinking abilities

A first condition for facilitating creativity in the science classroom is to capitalise on the students' creative thinking abilities. Creative thinking means the students' ability to divergently come up with multiple or alternative ideas using given information, and the ability to convergently narrowing them down into the best suitable solution or idea (Brophy, 1998; Cropley, 2006; Liu & Lin, 2014; Sternberg, 2006). The result from the exploration of the third research question (Article II) shows that students can come up with several ideas to solve their identified problems related to living on Mars. The ideas originate from introducing original and new thinking, by adapting known concepts and ideas from the science domain, by transferring ideas and concepts from other domains and use them in this new context, and by synthesising and combining different ideas to make new ideas. Creative thinking is often related to divergent thinking in creativity literature, and is defined as people's ability to produce a great number (fluency) of various (flexibility) ideas that are unusual and unique (original) and richly detailed (elaboration) (e.g., Aktamış et al., 2005; DeHaan, 2009; Diakidoy & Constantinou, 2001; Mukhopadhyay & Sen, 2013). Results from Article II show that the students are able to make use of associative thinking strategies related to divergent thinking in what Finke et al. (1992) call the generative phase of the creative process. The students also show signs of being able to redefine and evaluate the ideas towards contextual aspects. They do this by providing arguments for or against ideas with the use of science knowledge, by providing arguments based on practical usage related to the context of Mars or the context of the project itself, or providing arguments based on what is needed on Mars. Hence, the students show signs of being sensitive to the problem and being able to use their analytical thinking by acknowledging and evaluating their ideas towards the contextual constraints of the project, the problem, or the context of Mars in what researchers call the evaluative and convergent phase of the creative process (see DeHaan, 2009; Finke et al., 1992; Guilford, 1967). To capitalise on the students' creative thinking abilities, teachers first need to acknowledge that many students in their classroom possess a wide variety of knowledge and skills related to creativity (see e.g., Aljughaiman & Mowrer-Reynolds, 2005). Several researchers claim that teachers' beliefs

are important indicators of their behaviour in the classroom (Bryan, 2012; Hofer & Pintrich, 1997; Skiba et al., 2010; Waters-Adams, 2006) and that their beliefs towards students' creative abilities may affect the development of students' creative potential (Barbot et al., 2015; Beghetto, 2006; Beghetto & Kaufman, 2014; Liu & Lin, 2014; Skiba et al., 2010). In this sense, capitalising on students' creative thinking abilities is to believe in the students' capabilities and is, therefore, the opposite of presupposing that students come as 'tabula rasa'.

Findings presented in Article I and Article III are consistent with research on teachers' beliefs about creativity that have identified that teachers generally value creativity and believe that creativity can be developed and nurtured in the classroom but that these beliefs are rarely translated into creativity-fostering practices (Bereczki & Kárpáti, 2018). The teachers in this study speak highly about creativity and see the students as creative individuals. However, findings from Articles I and III also show that the teachers find it difficult to support and nurture students' creativity. First, findings from Article III show that the teachers associate creativity with practical activity and the ability to create something, presenting a product-oriented view of creativity. This is consistent with previous research which show that teachers tend to see opportunities for scientific creativity in practical work, rather than in discussions (Newton & Newton, 2010b) and that creativity is associated with the ability to create something physical (Kaufman & Beghetto, 2009). Second, findings from article I show that the teachers' beliefs about creativity affect their classroom behaviour as teachers tend to focus on exploring the product rather than the process of creative thinking when interacting with the students. Findings presented in Article I show that teacher-students interactions follow the patterns of a typical I-R-E conversation (see e.g., Mehan, 1979), where the teacher initiates the conversation by encouraging the students to share their idea(s), the students share their idea(s) and the teacher evaluates the idea(s) as either preferred or dis-preferred. Follow-up questions are mainly used if the idea is not fully understood, or the teacher detects a problematic aspect with the idea. In those cases, the teacher asks questions to make the students realise the problematic aspect, allowing them to 'repair' the idea or reject the idea. Emphasis on the creative product and taking an evaluative

stance towards the students' ideas may lead to teachers not realising the intellectual and creative efforts made by the students (Runco, 2005).

The teachers can capitalise on the students' creative thinking abilities by making few adjustments to their teaching and behaviours in the classroom. Instead of emphasising students' creative products, they may focus more on exploring the process leading up to the product. Allowing the students to explore and articulate how their ideas are developed rather than what their final answer is, may lead to a better acknowledgment of the dynamic process of creativity-in-the-making (Moran & John-Steiner, 2003). According to the framework of ideational code-switching, teachers should emphasise students' creative potential rather than creative outcomes (Kaufman & Beghetto, 2009, 2013).

When students articulate their creative process, the teachers also allow them to demonstrate their cognitive abilities and higher-order thinking skills, an important aspect of all learning (Bloom et al., 1956; Forrester, 2008). Findings in Article II show that the students demonstrate signs of creative thinking on the higher levels of Bloom's taxonomy as presented by Anderson and Krathwohl (2001). These are skills demonstrated when students collaborate with their peers as shown in Article II, but not demonstrated in interactions with the teachers, as shown in Article I. Realising the cognitive aspects of creative thinking may make teachers place greater value on creativity as an important part of the students' learning and not as something additional to the regular education. In this way, supporting students' creative potential may become more relevant to science education and student learning.

Focusing more on exploring students' creative thinking abilities may also make the creative process more explicit for the students. This is supported by studies which suggest that explicit teaching of the creative process may inspire creative development (Ma, 2006; Scott et al., 2004). By guiding the students in their creative thinking and by demonstrating and pointing out the different thinking strategies used, the students may become more aware of their own creative process and their own creative abilities. This is consistent with the theory of social modelling or observational learning (Bandura,

1986), which suggests that when teachers demonstrate creative thinking, the students are likely to imitate (see also Beghetto & Kaufman, 2014; Davies et al., 2013; Sak, 2004; Sawyer, 2015). Becoming aware of their creative abilities may in turn enhance the students' creative self-efficacy, and further influence their motivational belief in mastering creative tasks (e.g., Bandura et al., 1999).

Findings from Article II also show that students can make use of scientific knowledge when developing their ideas in collaboration with their peers. Domain knowledge and skills are identified as important in order to make creative contributions as creativity is seen as situated, and therefore dependent on the nature of the context or the domain (Alexander, 1992; Amabile, 1996; Baer & Kaufman, 2005; Blamires & Peterson, 2014; Diakidoy & Constantinou, 2001; Han, 2003; Lubart & Guignard, 2004; Mukhopadhyay, 2013; Newton & Newton, 2014). However, other researchers state that what distinguishes novice creators from more able creators is not the amount of knowledge per se, but the ability to use and organise this knowledge on a higher cognitive level (e.g., Schmidt, 2011). Providing opportunities for students to develop and use creative thinking should, therefore, be encouraged in practice also in early school years (Newton & Newton, 2014).

Despite the importance of knowledge, findings from Article III show that the teachers report that learning content knowledge is not the main aim of such creative projects. However, content knowledge is seen as a bonus rather than a goal in itself. This is consistent with previous research claiming that teachers tend not to identify knowledge as an important factor for creativity (Diakidoy & Kanari, 1999). The teachers' beliefs about the role of scientific knowledge in creative processes are also reflected in their classroom behaviours. Findings from Article I show that teachers do not take the time to listen thoroughly and explore the students' ideas together with the students, but evaluate the ideas to excel the students' creative process further towards the practical building phase of the project. The teachers do not follow up the students' use of science knowledge to explore the concepts further and develop them into more correct understandings. If the teachers focus more on exploring how students develop their

ideas, they may be able to identify how students make use of content knowledge in the process. Article II also shows that even if students attempt to include content knowledge in their ideas, it is not always completely understood or used correctly. Because of their age and experience, more guiding and exploring of the different science concepts together with a teacher may enhance students' understanding and learning. This is consistent with the framework of ideational code-switching (Beghetto & Kaufman, 2007). The framework highlights the importance of skilled others (teachers) to recognise the value of mini-c creativity and at the same time introduce the novice learners (students) to the conventions and knowledge of the domain in order to support students' creativity from mini-c expressions to little-c creative ideas (Beghetto & Kaufman, 2014). Creativity literature also highlights the importance of teachers motivating their students to master sufficient content knowledge, so they have a solid base for divergent thinking (Cropley, 1997; Hadzigeorgiou et al., 2012; Scott et al., 2004; Soh, 2017).

Capitalising on the students' ability to use science knowledge in their creative thinking can make the important role of domain-specific knowledge and skills in scientific creativity more explicit for the students. Scientific creativity is an essential aspect of the nature of science (NOS) and plays an important role in many scientific processes and scientific ideas (Aktamış & Ergin, 2008; Aydeniz & Bilican, 2014; Hadzigeorgiou et al., 2012; Kind & Kind, 2007; Liang et al., 2009; Liu & Lin, 2014; Meyer & Lederman, 2013; Osborne et al., 2003; Urhahne et al., 2011). Hence, further emphasis on how students apply their knowledge and reasoning skills to come up with and develop creative ideas can reflect this important aspect of professional science (Hadzigeorgiou et al., 2012), and further make the creative process and school science more authentic and meaningful for students (Meyer & Lederman, 2013). Realising the importance of scientific creativity in the process of developing scientific knowledge and engaging in scientific investigation and problem-solving may also make teachers value creativity as something naturally occurring in science education, rather than something additional and something segregated from the usual curricula (Beghetto, 2007b).

The result from this study shows that the teachers only to some degree capitalise on the students' creative competence. By not paying more attention to the process aspect of students' creativity, the teachers miss out on important insight into the students' cognitive thinking abilities. They miss out on opportunities to build on the students thinking' and explore their ideas further, with the aim of developing the students mini-c expressions into little-c creative ideas. They also miss out on the opportunity to develop students' knowledge further by exploring the science concepts in the students' ideas more thoroughly. The result from the exploration of the fifth research question (Article III) points towards potential variables influencing teachers' willingness to focus on the process aspect. Low creative self-efficacy, fear of steering the students' creativity towards own ideas and thinking, fear of losing control over the students and fear of demotivate students by not being able to present a finished product at the end might be some possible variables explaining why the teachers focus on the students' creative thinking and the creative process to a bare minimum. This is further discussed in chapter 5.3 - *Building teachers' creative self-efficacy*.

5.2 A shift in thinking towards a more collaborative student-teacher interaction

Second, a shift in thinking towards a more collaborative student-teacher interaction represents a need to fundamentally change the way teachers interact with students during creative processes. Student-teacher interactions aimed at supporting creativity places the learner as a central contributor in the process (student-centred) yet recognise the need for teacher-student collaboration in the process (see e.g., Barbot et al., 2015; Chan & Chan, 1999; Cropley, 1997; Csikszentmihalyi, 1997; Diakidoy & Kanari, 1999; Henriksen et al., 2016; Toh, 2003). Literature on how teachers can support students' creative potential suggest that teachers should act as fellow collaborators that follow up on the students' ideas together with the students, provide sufficient feedback with the use of open-ended questions and cue the students within the domain and task

restraints (Beghetto, 2007b; Beghetto & Kaufman, 2007; Sawyer, 2004, 2015; Scardamalia & Bereiter, 2006). Findings from Article I show that the teachers' interactions with students during the creative process are characterised by teacher-initiated dialogues with focus on gaining information about the students' ideas. The ideas are then evaluated by the teacher as either preferred or dis-preferred before the teacher moves away from the conversation. The shift involves moving from evaluative dialogues from student-initiated teacher-student collaboration. Focus on student-centred dialogues and the teacher as a collaborator has the potential to involve students as equal partners in the creative process. This may provide the students with opportunities to reflect upon their ideas and employ self-evaluation, which in turn can lead to students valuing their own creativity (see Ahmadi & Besançon, 2017; Cropley, 1997; Soh, 2017). A teacher who welcomes students' creative expression and explores the ideas together with the students also displays that he or she values creativity by showing interest for and acceptance of creative expressions. This is proven positive for students' creative development (Beghetto, 2005, 2007b; Fasko, 2001; Tighe et al., 2003).

Findings from Article III show that the teachers emphasise the need for students to be free from constraints and allowing them to choose and develop ideas free from the teacher's involvement. In this way, facilitating students' creative potential places guiding as laissez-faire for the teacher. As I have argued above, this is contradictory to what creativity literature describes the teachers' role to be. As shown in Article III, the teachers' emphasis on freedom from constraints may be due to their misconception of creativity as being something new and original, without taking the notion of appropriateness into consideration. This misconception of creativity is consistent with previous research (Aljughaiman & Mowrer-Reynolds, 2005; Andiliou & Murphy, 2010; Bereczki & Kárpáti, 2018; Diakidoy & Kanari, 1999; Kettler et al., 2018; Liu & Lin, 2014). The findings related to research question five (Article III) show that the teachers aim at not steering the students' creative process towards the teacher's own thinking and ideas. They see this as diminishing students' ownership of their ideas and fear a negative impact on their motivation. Creativity literature and Social cognitive theory-literature (SCT), on the other hand, suggest that teachers' involvement and collaboration in the

creative process may strengthen students' own expectations to mastery of the task when students are made to believe in his or her creative abilities (e.g., Bandura, 1993; Rubenstein et al., 2018; Sawyer, 2004, 2015; Scardamalia & Bereiter, 2006). Teachers who communicate high expectations towards students and support students' creative process can positively impact on the students' self-confidence and beliefs in their own capabilities (Amabile, 1996; Pintrich & Schunk, 2002; Tighe et al., 2003). This implies that interactions that focus on students' creative thinking skills, instead of evaluation of their ideas, can build students' creative self-efficacy. Attention to learning goals and task constraints is an important part of the creative process (e.g., Beghetto, 2007b; Beghetto & Kaufman, 2014). If students do not know the goals or criteria for the teacher's feedback, they might be excluded from developing understanding of how to develop appropriate and novel ideas. Creativity literature emphasises the importance of freedom for choice and discovery, but also recognises the importance of helping students realising that there are constraints and conventions when communicating their personally meaningful ideas (Beghetto & Kaufman, 2014). A shift in thinking towards a more collaborative student-teacher interaction should, therefore, continue to support the notion of freedom but also include the support of students in evaluating whether their ideas are appropriate for the given situation.

Despite the teachers' fear of involving themselves in the students' creative process, findings from Article I show that teachers quickly evaluate the students' ideas against their own preference. However, their evaluative stance is not directly communicated to their students but is more indirectly communicated through various conversational practices. This implies that the teachers' evaluative practice is not an intentional act by the teachers and should be made explicit to the teachers to change practice. The teachers' behaviour may not be due to a lack of wanting to execute evaluation towards the students' creative expression but a result of school tradition, which still is described as focused on outcomes and standardised procedures rather than leaving room for students own questions, solutions and ways of solving problems (Askew, 2013; Duschl & Bybee, 2014; Hume & Coll, 2010; Wong & Hodson, 2009; Ødegaard et al., 2020). Making the teachers realise how they display preference towards the students' ideas

may lead to the teacher behaving differently through postponing judgement of the students' ideas. Postponing judgement may then lead to teachers taking more time to listen to and allow students to formulate and develop their ideas further in order to support their creative process (see Cropley, 1997; Soh, 2017). Interactions where teachers are not afraid of exploring ideas together with students, including expressing own thinking in the process, allow the students to view other people's viewpoint and develop their ideas based on different perspectives, varied experience and knowledge (Friedrich & Mumford, 2009; Gregory et al., 2013; Sawyer, 2015; Soh, 2017). This may in turn lead to students realising how to transform their mini-c creative expressions into little-c creative ideas (see e.g., Beghetto & Kaufman, 2014).

How teachers facilitate creativity through dialogue and interactions has consequences for the students' creative process and creative products. Findings from Article I show that after the teachers provide the students with an evaluation of their idea(s), the students either reject the idea based on negative feedback or see the positive feedback as sign of finishing the idea-generative process and move to the next phase of the project - the building phase. Positive evaluation results in the students not developing their idea further, which in many cases result in ideas that lack a thorough description and meaning. Hence, a shift from evaluative and distanced teachers to collaborative teachers is required if creativity supportive interactions can be used as a pedagogical tool. The strong connection between teachers' evaluative stance towards the students' ideas and the students' further work on the ideas highlights the relevance of an emphasis on a more collaborative teacher-student interaction in the classroom, consistent with the framework of ideational code-switching (Beghetto, 2007b; Beghetto & Kaufman, 2007).

A central aim for the development of creativity in the classroom, as well as in the ordinary education, is that students are motivated to generate and express their ideas and questions (Gregory et al., 2013). Teachers' evaluative stance may also result in students refraining from participating in the creative process and express their thinking because of the fear of being judged. The teachers' implicit focus on evaluating the

students' ideas at an early stage in the creative process also refrain the teachers from listen to and respectfully consider the students' ideas. A shift in thinking towards a more collaborative teacher-student interaction means that teachers take the time to explore, listen to and consider the students' ideas. In this way they show the students that they value and respect the intellectual risk taken by the students when expressing their creative thinking (Beghetto & Kaufman, 2014; Cropley, 1997; Hadzigeorgiou et al., 2012). According to the SCT framework, teachers who display creative behaviour and display that creativity is valued and rewarded, shape the students' creative behaviour (Bandura, 1986; Beghetto & Kaufman, 2014; Davies et al., 2013; Sak, 2004; Sawyer, 2015). The teacher functioning as social models for the students requires, however, emotional ties between the teacher and students (Soh, 2017), which emphasises the importance of mutual respect and trust in the classroom (Beghetto & Kaufman, 2014; Davies et al., 2013; Sawyer, 2015). As the teacher is a central role model of creativity in the classroom, an explicit aim for creativity supporting education should be to include more open-ended questions, collaborative exploration of students' ideas and cuing according to the conventions of the domain or the task. More explicit teaching and modelling might have the potential to encourage students to ask more questions and express numerous original and various ideas, related to divergent thinking. Collaborative exploration and cuing might have the potential to encourage students to develop their ideas further, redefine them to meet the conventions of the domain or task and narrow the number of ideas into the best idea that is both novel and appropriate, related to convergent thinking (see e.g., Aktamış et al., 2005; Cropley, 2006; Diakidoy & Constantinou, 2001; Liu & Lin, 2014; Mukhopadhyay & Sen, 2013). Through dialogues and modelling, students have better chance at identifying criteria and goals as well as developing creative thinking skills.

5.3 Increase teachers' creative self-efficacy

A third condition for facilitating creativity in the science classroom is to increase teachers' creative self-efficacy. Creative self-efficacy is not only teachers' belief in their

own creative abilities, but also their belief in the value of including creativity supportive methods and strategies in their teaching, and in their ability to support and foster students' creativity. According to Davies et al. (2014) and Rubenstein et al. (2013) teachers need to believe in their own skills and abilities to facilitate students' creative growth. Creativity literature claims that teachers' beliefs are important indicators of their behaviour in the classroom (Bryan, 2012; Hofer & Pintrich, 1997; Ozkal, 2014; Pajares, 1992; Skiba et al., 2010; Waters-Adams, 2006). This indicates that teachers' creative self-efficacy directly impacts how teachers focus on and implement creativity supportive strategies and methods in class. This is further supported by SCT literature, which claims that people's self-efficacy may determine how individuals self-regulate themselves, their behaviour, and the environment (Bandura, 1986, 1991). Findings from Article III show that the teachers value creativity as an important aspect of science education, but that they have doubt in their own creative abilities and in their own competence in supporting students' creativity. However, the findings indicate that the teachers' wish to support and facilitate creativity in the classroom conflicts with their and the schools' intention to cover all the curricula. This places creativity as something additional to the regular learning instead of a natural part of science education as highlighted in NOS literature (e.g., Osborne et al., 2003). Teachers' belief in creativity as something additional to the regular curricula is also found in similar studies (Beghetto, 2007b). Creativity literature also claims that teachers who are positive towards fostering creativity and recognise the importance of creativity are better equipped for supporting students' creativity (e.g., Akcanca & Cerrah Ozsevgec, 2018; Aljughaiman & Mowrer-Reynolds, 2005; Davies et al., 2014; Rubenstein et al., 2013; Sak, 2004). Positive feelings and positive experiences towards including creativity supportive strategies is also important for building people's self-efficacy, according to SCT literature (Bandura, 1977).

Coinciding with previous research (e.g., Newton & Newton, 2009; Newton & Newton, 2010a), the teachers in this study express that creativity is best nurtured when students have sufficient freedom and little and no structures and frames (Article III). Findings from Article III indicate that teachers may be afraid of, or at least sceptical to, meeting

the perceived conditions of freedom for supporting students' creativity. The teachers in this study also focus mainly on the novelty aspect of creativity when describing how they conceptualise the phenomenon. This coincides with previous studies (Aljughaiman & Mowrer-Reynolds, 2005; Andiliou & Murphy, 2010; Bereczki & Kárpáti, 2018; Diakidoy & Kanari, 1999; Kettler et al., 2018; Liu & Lin, 2014). In doing so, they undermine the importance of appropriateness of creativity. As Article III indicates, this misconception of creativity can be one of the reasons why teachers believe creativity can only flourish when students are given completely freedom. Findings from Article III also show that the teachers are hesitant to interfere in the students' creative process. This is further supported by observations and findings from Article I, which show that the teachers do not explore and develop the students' ideas together with the students but focus mostly on listening to the students explaining their ideas before making evaluative claims towards the students' ideas. The teachers are afraid to limit the students' freedom by pointing them towards the teachers' own ideas, also minimising the students' sense of ownership of their ideas.

The teachers' conception of creativity as including the need for freedom and not the need for constraints and structures may also impact their creative self-efficacy. The teachers express that they are sceptical to open up and allow students to act outside the controlled atmosphere of traditional teaching. They are sceptical to provide the students with freedom and openness due to a belief that doing so will make them loose control of the students (Article III). The teachers justify their need for control by the structural constraints of schools. Both teachers express that they will probably dare to allow more freedom and less structure in their classroom if there are fewer students or more teachers in the classroom, or they have more time. This indicates that structural constraints in schools affect the teachers' creative self-efficacy. If the teachers expect trouble or loss of control when providing the students with the perceived amount of freedom, they might try to minimise the possibility of such results by avoiding these situations. In the interviews related to Article III, the teachers express that they fear to open up based on previous experiences of students not being able to handle open-ended tasks and freedom, and that attempts of providing the students with freedom

result in some chaos. These previous stressful experiences may have elicited emotional arousal which impact the teachers' personal self-efficacy (Bandura, 1977). These emotions may impact their expectations of similar situations in the future, leading to the teachers trying to avoid the situations that create such feelings (Bandura, 1977; Skaalvik & Skaalvik, 2018). Another explanation might be that the teachers try to minimise chaos in the classroom because chaos is seldom positive for students' learning outcome. Anyhow, teachers will do their best of minimising loss of control and conflict in their teaching. This is also evident in findings from Article I, which show that much of the teachers' guiding is focused on minimising conflict and maintaining control instead of focusing on the subject. This may in turn lead to fewer possibilities for students to demonstrate their creative thinking in the classroom.

Findings from Article I also show that the contextual constraints in school impact the ways teachers interact with students during creative processes. Observations related to Article I show that the teachers spend little time on each group and do not take the time to really listen, explore and further develop the ideas together with the students, as advised in the framework of ideational code-switching (Beghetto, 2007b; Beghetto & Kaufman, 2007). Findings from Article III indicate that this may be due to the teachers' wish to cover and help all the groups during this phase, resulting in minimal time focusing on each group. This indicates that the high number of students per teacher may hinder such activities in the regular education. However, the minimal focus on creativity supportive dialogues with the students may also point to a lack of personal confidence in doing so. According to Bandura (1993) people plan and anticipate the consequences of future events before executing own actions, and people's personal agency to make causal contributions between the personal, behavioral and environmental influences, is posited in people's beliefs in their own self-efficacy. If teachers anticipate that they will not succeed in conducting such dialogues, whether this is because they lack confidence in doing so or whether they avoid doing so because of a belief that such situations will cause chaos and trouble for the other students, supporting students' creativity may seem as conflicting with the teachers' personal agency in the educational context.

According to Bandura (1977), self-efficacy is determined by people's former experience in performing a task, both by succeeding in person or by observing others succeeding in similar tasks and in similar situations. Therefore, building teachers' creative self-efficacy should be done by providing the teachers with positive experiences of including creativity supportive strategies and methods in their teaching, both by allowing them the opportunity to do so themselves in a controlled and positive environment and by allowing them to observe others succeed in doing so. As the teachers' creative self-efficacy in this study is, among others, influenced by their conceptual understanding of creativity, more knowledge about the concept of creativity as well as more knowledge about how to support students' creative potential is needed. Increased knowledge about the full aspect of creativity may also help minimise the contextual hinders for supporting creativity as perceived by the teachers in this study. This is supported by creativity literature that claims that teachers need to understand the nature of creativity, be able to identify opportunities for creativity, and know how to foster it in order to support students' creativity (Beghetto & Kaufman, 2010; Blamires & Peterson, 2014; Newton & Newton, 2014). Understanding how structures and frames are important aspects of creativity may motivate teachers to include creativity supportive strategies and methods within the structured context of school education.

Increasing teachers' self-efficacy is important to support and facilitate students' creative potential in school. Teachers' belief in their own mastery of supporting creativity and including creativity supportive strategies and methods have direct impact on the students' possibilities to share and develop creative thinking in a creativity supportive environment and participate in activities that include the notion of creativity in their learning. The teachers' former experiences and emotions related to creativity supportive situations or situations that are similar, affect their creative self-efficacy. Therefore, for the teachers to establish personal agency towards supporting creativity, increasing teachers' creative self-efficacy should focus on providing teachers with positive experiences. The result also indicates that school culture, school contexts and curricula may hinder the teachers' belief in their ability to support students' creativity. The result suggests that we need to focus more on the possibilities within the existing

curricula and within the existing structures, to build teachers' creative self-efficacy. A discussion about whether todays' school culture and structure are sufficient for supporting students' creativity in schools is beyond the scope of this thesis but should be explored in further research.

6 Implications, methodological reflections, and conclusion

6.1 Theoretical implications

Several implications can be drawn from the result of the thesis, and some involve suggestions for further research. Though we have seen an increasing attention to how we can support students' creativity in schools and how teachers conceptualise creativity, there seems to be little research that move beyond the theoretical level and aim to inform educational practice and decisions (Richardson & Mishra, 2018). Previous research points to a distance between the national and international aims of supporting creativity and the realities in classrooms (e.g., Levine, 2007; Sawyer, 2015). The present study aims at minimising the gap between literature and theories on creativity and educational practice. This is done by conducting research in the context of the classroom and by exploring how creativity is supported in primary science classrooms in the context of employing the advice and literature in the development and implementation of a design for learning and creativity. The results suggest that there is potential in developing students' creativity based on students' knowledge and creative abilities, but also that teachers are highly influential on how students can build creative ideas beyond their initial mini-c ideas. Whether the teachers' influence on students' creative process and creative ideas reported in the empirical study is present in other contexts remains to be seen and suggests an important arena for research.

In the thesis I claim – based on the results of the empirical study – that teachers' conceptualisation of creativity affects their actions when interacting with students during the work on creative ideas. The thesis also claims that teachers' self-efficacy beliefs affect their agency towards supporting creativity. The thesis, therefore, adds to the empirical findings to how elements of teachers' beliefs interact and impact their classroom behaviour, as suggested by Bereczki and Kárpáti (2018) and Mullet et al. (2016). As this study is based on the exploration of two teachers from the same school,

this claim could need some further exploration with a larger sample and samples from different contexts.

Previous research also indicate that there are cultural differences as well as similarities in teachers' beliefs about creativity (e.g., Choe, 2006). Due to the lack of sufficient research within a Norwegian context, this study, despite the small sample, adds to the empirical research and understandings of the context of a Norwegian primary school. However, a complete understanding of cultural influences of creativity and creativity practice would require a comparative approach, which could elicit more clearly how different cultural traditions may lead to different conceptualisations and beliefs about creativity. The present study indicates that conditions like students creative thinking abilities, interactions between teacher and students and teachers' creative self-efficacy affect the possibilities of supporting and facilitating creativity in science education. However, further research is needed to explore whether these conditions are due to cultural traditions or different school cultures between different schools in Norway.

The study is based on a collaboration between researcher and practitioners, including discussions and a short teacher course on strategies for supporting students' creativity. Hence, the researcher may influence the teachers' belief of creativity and how to support creativity. However, the empirical research indicates that basing the 'learning' on lectures and discussions do not lead to the expected result. However, a SCT framework suggests that learning occurs through modelling and experience, and that this may in turn affect teachers' self-efficacy beliefs in conducting similar actions (e.g., Bandura, 1977). More research within a SCT framework is needed to explore whether more explicit training can alter teachers' understanding and actions in the classroom. The thesis implies that to alter teachers' conceptualisation and actions it is necessary to take into account the teachers' educational aims and teaching context, their conception of creativity and their creative self-efficacy.

6.2 Practical implications

The articles in the thesis are descriptive in nature and do not itself provide answers to how we can facilitate creativity in primary science education. The synthesis of the findings presented in the discussion presents conditions for facilitating creativity and is, therefore, normative in nature. However, I will propose that the implications and conditions presented should be considered when discussing how we can support and facilitate students' creativity in Norwegian schools. The teachers' perceptions and actions are situated in the specific Norwegian school context and based on comprehensive experience and knowledge about this context and about students. They thus represent an important source for increasing our understanding of the potential of supporting creativity in schools, and to further its development in compulsory schools in Norway.

The study suggests that teachers' expertise and conceptualisation of creativity impact on the possibility for students to realise their creative potential in school. It is, therefore, of great importance that teachers receive practice and experience with including creativity-supportive strategies and methods in their teaching, and concrete experiences of how the inclusion of such strategies and methods affect the students' creative and professional development. Positive experience with the use and implementation of such strategies is likely to enhance the teachers' creative self-efficacy, and according to a SCT framework, teachers may acquire such knowledge and experience through modelling (Bandura, 1977). Hence, it is important that teacher education and in-service courses facilitate teachers' experience with such ideas and strategies in practice, by direct experiences or by observing others.

Article I indicates that teachers, maybe without knowing, affect students' creative process through verbal and non-verbal conversation practices. Results from this study can contribute to teachers becoming more aware of how these practices impact on the students' ideas and creative development and indicate what can be altered in their practice.

The study also suggests that there are connections between the teachers' behaviour in the classroom and their knowledge and creative self-efficacy. This implies that by increasing the professional expertise and gaining sufficient and positive experience with supporting creativity, the teachers may possibly be better equipped to implement such strategies in their daily teaching. More research about whether such explicit experience and practice can influence how teachers support students' creative potential to a greater extent is needed, as suggested in chapter 6.1 – *Theoretical implications*.

The study also shows that teachers' creative self-efficacy is affected by the contextual constraints of the school and curricula. The thesis emphasises the need to include creativity supportive strategies and methods in the daily education. However, for schools and teachers to be able to prioritise creativity, it is crucial that creative competence is valued and clearly stated in the governing documents for the school. At the same time, research on creativity must be more available for schools and policy makers to change practice. To understand what is needed in schools, teachers should be more included in research and in the development of school policy. This study serves as an empirical contribution to understand what needs to be done to change practice in school.

6.3 Methodological reflections

A PhD-study is an educational journey where the PhD student are given the opportunity to learn more about conducting research. Working on the thesis was a great opportunity for me to immerse myself in the huge field of philosophical and methodological directions that define social science research. The choice to include several analysis methods in the thesis was, therefore, based partly on my curiosity and interest to learn and immerse myself in the different methods and analytical approaches. By learning more about the different methods through reading of methodological and philosophical literature, in addition to research literature that made use of the different methods, I was able to base my methodological choices in the thesis on critical reflections and

awareness to what the empirical data means and why we conduct certain interpretations of the social reality. Alvesson and Sköldberg (2008) say in their book *Tolkning och reflektion*, that the epistemological and ontological awareness of a research project are more important than the specific work methods and techniques used to analyse "reality". The methodological choices in the thesis are based on a pragmatic framework that emphasises the value of choosing the methodological approaches that the researcher judge will produce a warranted assertability of knowledge (see Maarouf, 2019). Therefore, the choice of research approaches and methods is guided by the research questions in the study. The thesis also builds on the idea that different methods can produce different understandings of a phenomenon because of the way the different methods position the researcher to transact with the world (Johnson & Onwuegbuzie, 2004; Teddlie & Tashakkori, 2010). The result of the thesis can, therefore, not be seen as the only correct solution to the research problem under study. It rather sees the research process as a (re)construction of social reality where the researcher's interpretations and perspectives are seen as one of several truths (see Charmaz, 2014). Hence, my choices during the research process highlight certain understandings of the research problem and (thus) may neglect alternative interpretations.

The research questions in Article I focuse on how teachers respond to students' creative ideas during a specific phase in the creative process, and further how this affect the students' creative process. The research questions point to a need for the researcher to have an empirical focus where the aim is to describe and explain what the teachers do during the conversations with the students, rather than making interpretative claims towards social practices by identifying classroom talk as *dialogic*, *exploratory*, or *good practice* (see also Skovholt, 2018; Stivers & Sidnell, 2013). Because of this focus, Conversation Analysis (CA) is chosen as it provides an opportunity to work empirically with classroom talk. It also provides a framework for analysing interactions between teacher and students, in addition to enabling the researcher to identify specific conversational practices at a turn-to-turn level (see e.g., Emanuelsson & Sahlström, 2008). The result of the analysis does not present evidence to which types of

conversational practices that facilitate students' creativity, but it does provide insight, based on actual empirical findings, of how the teacher-students interactions unfold and how these interactions affect the students' creative work. This can make CA suited to inform practice, much because its data material are publicly observable phenomenon which make them well suited for training interventions (Richards, 2005).

CA's empirical and surface-oriented focus has also been the focus for criticism, especially for being merely descriptive (see e.g., Sahlström, 2009). The detailed analysis may also be perceived as too detailed outside the science of language study. However, I believe this detailed analysis can provide a valuable contribution to the field of science education as the methodology allows for the complexities of social interaction to be shown and understood by the way they are presented by the research participants. By doing CA, the analyst is also liberated from having to make interpretative claims on behalf of the participants doing the interaction (Sacks et al., 1978). Because CA is empirically grounded it also establishes a natural link between research and practice, which again makes the methodology well suited to generate the sort of discoveries that can inform practice (Richards & Seedhouse, 2005).

The research questions in Article II focus on how students approach the creative process and how they relate to science knowledge during this process. The aim is to explore how students act during the work with a creative task in practice, but also to lift the *how* towards a more abstract level. Constructivist grounded theory (GT) is chosen as it helps me to figure out how practice approaches can bring forth new perspectives and contribute to the building of theories. During the process of theory building, the researcher "are obliged to be reflexive about what we bring to the scene, what we see, and how we see it" (Charmaz, 2006, p. 15). A constructivist grounded theory approach is hence more interpretative, as the researcher needs to reflect about own interpretations as well as those of their research participants (Charmaz, 2014). By making interpretative claims towards both the empirical data and the analysis process, the empirically grounded claims are lifted up towards a more abstract and theoretical level.

The research question in Article III focuses on exploring the teachers' beliefs about creativity based on several interviews with the teachers. Belief is defined as a type of knowledge that is "subjective, experience-based, [and] often implicit" (Pehkonen & Pietilä, 2003, p. 2), or as personal judgement formulated from experiences (Raymond, 1997). The definitions indicate that beliefs can be both conscious and subconscious (Leatham, 2006). Exploring teachers' beliefs require me to make interpretative claim towards the teachers' narratives. Interpretative Phenomenological Analysis (IPA) is, therefore, a well-suited method to use as the aim is to enter the research participants' world.

In addition to describe and exemplify how different analysis methods can contribute to answer an overall research problem, the thesis has also demonstrated the importance of making informed and critical choices regarding the choice of methods for analysing data related to the different research questions. The three articles provide a description of the phenomenon from three different perspectives: (1) the student-teacher interaction perspective (Article I), the student perspective (Article II), and (3) the teacher perspective (article III). The methods used to analyse the data made it possible to provide description of the phenomenon from the different perspectives grounded in the empirical material and analysed through the interpretative eyes of the researcher. Silverman (2005) claims that only after establishing how people construct meaning and actions can the analyst pursue why they act as they do. Being able to view the phenomenon from these three perspectives and through three ways of analysing the data made it possible to dive deeper into the *why* participants act the way they do and say the things they do. A synthesis of the three articles made it, therefore, possible to suggest three conditions for facilitating creativity in primary science education, and hence answer the overall research problem of the thesis.

Answering the overall research problem is only possible by viewing all the articles at the same time, as each article can only reflect one of several perspectives present in a complex educational environment. Working on the different articles, one by one, therefore added to my understandings of the phenomenon. Knowing what I know now,

at the end of the PhD-journey, and after analysing all the data in the thesis, the content of the three articles - at least the first two - could maybe be different if written today. However, the four years have been a learning process towards a more complete understanding of the phenomenon, which is also reflected in the three articles.

6.4 Conclusion

To meet the aims of the 21st-century, schools need to focus more on developing competencies like creativity, critical thinking, collaboration and communication (UNESCO, 2013). This study has explored how we can support creativity in primary science education and has identified three conditions for facilitating creativity in schools. The three conditions for facilitating creativity in primary science education are: (1) capitalising on the students' creative thinking abilities, (2) a shift in thinking towards a more collaborative student-teacher interaction, and (3) increasing teachers' creative self-efficacy. The conditions highlight the importance of teacher agency in facilitating and supporting students' creativity in the classroom. Biesta (2015) expresses concern about research that indirectly emphasise that teachers are either the problem or the solution to everything. The result of this study, however, suggests that teachers play an important part to support students' creativity, through facilitation as well as through direct interaction with the students. The implications are supported by creativity literature which emphasise that teachers are the ones responsible for preparing the students for an uncertain future (Barbot et al., 2015; Chan & Chan, 1999; Csikszentmihalyi, 1997; Diakidoy & Kanari, 1999; Henriksen et al., 2016). Literature on creativity also place the teachers in the forefront for facilitating students' creative potential, as being the ones creating learning opportunities for creativity in the classroom (Cole et al., 1999), as well as acting as role models and mentors for the students (Kampylis et al., 2009).

The three conditions for facilitating students' creativity are identified as important steps towards developing a creativity supportive environment where students' agentic

engagement become more central. I do not, however, believe that the conditions are neither clear-cut nor dependent on one single agent. I believe change is depended on both teachers and students having sufficient knowledge about creativity and creative thinking and that both teachers and students are active participants in creative processes. In addition, school and collegial support is crucial for successful change of practice. Teachers are placed within a school culture and meets the expectations from colleagues, students, parents, as well as the rest of the society. I do, however, based on the empirical findings of this study, believe that a good place to start is with the teachers. A more knowledgeable and self-efficacious teacher may be better equipped to facilitate and support students' creativity and further impact on and enhance the students' creative self-efficacy and abilities, even within the context and constraints of the school and the curricula.

References

Ahmadi, N., & Besançon, M. (2017). Creativity as a stepping stone towards developing other competencies in classrooms. *Education Research International, 2017*, 1-9.

Akcanca, N., & Cerrah Ozsevgec, L. (2018). Effect of Activities Prepared by Different Teaching Techniques on Scientific Creativity Levels of Prospective Pre-School Teachers. *European Journal of Educational Research, 7*(1), 71-86.

Aktamış, H., & Ergin, Ö. (2008). The effect of scientific process skills education on students' scientific creativity, science attitudes and academic achievements. Asia-Pacific forum on science learning and teaching, 9(1), 1-21.

Aktamış, H., Pekmez, E. Ş., Can, B. T., & Ergin, Ö. (2005). Developing Scientific Creativity Test. *Obtenido de: http://www. clab. edc. uoc. gr/2nd/pdf/58. pdf. Consultada, 23*(01), 1-6.

Al-Abdali, N. S., & Al-Balushi, S. M. (2016). Teaching for creativity by science teachers in grades 5–10. *International Journal of Science and Mathematics Education, 14*(2), 251-268.

Alexander, P. A. (1992). Domain knowledge: Evolving themes and emerging concerns. *Educational psychologist, 27*(1), 33-51.

Aljughaiman, A., & Mowrer-Reynolds, E. (2005). Teachers' conceptions of creativity and creative students. *The Journal of Creative Behavior, 39*(1), 17-34.

Alvesson, M., & Sköldberg, K. (2008). *Tolkning och reflektion: Vetenskapsfilosofi och kvalitativ metod* (2 ed.). Narayana Press.

Amabile, T. M. (1983). *The social psychology of creativity*. Springer-Verlag.

Amabile, T. M. (1996). *Creativity in context*. Westview Press.

Amabile, T. M. (1997). Motivating creativity in organizations: On doing what you love and loving what you do. *California management review, 40*(1), 39-58.

Amabile, T. M. (1998). *How to kill creativity* (Vol. 87). Harvard Business School Publishing Boston, MA.

Amabile, T. M. (2011). *Componential theory of creativity*. Harvard Business School Boston, MA.

Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of management journal, 39*(5), 1154-1184.

Amabile, T. M., Schatzel, E. A., Moneta, G. B., & Kramer, S. J. (2004). Leader behaviors and the work environment for creativity: Perceived leader support. *The Leadership Quarterly, 15*(1), 5-32.

Anderson, L. W., & Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Longman.

Andiliou, A., & Murphy, P. K. (2010). Examining variations among researchers' and teachers' conceptualizations of creativity: A review and synthesis of contemporary research. *Educational Research Review, 5*(3), 201-219.

Antaki, C. (2011). Six Kinds of Applied Conversation Analysis. In C. Antaki (Ed.), *Applied Conversation Analysis: Intervention and Change in Institutional Talk* (pp. 1-14). Palgrave MAcmillian UK.

Askew, M. (2013). Issues in teaching for and assessment of creativity in mathematics and science. In D. Corrigan, R. Gunstone, & A. Jones (Eds.), *Valuing assessment in science education: Pedagogy, curriculum, policy* (pp. 169-182). Springer.

Aydeniz, M., & Bilican, K. (2014). What do scientists know about the nature of science? A case study of novice scientists' views of NOS. *International Journal of Science and Mathematics Education, 12*(5), 1083-1115.

Baer, J., & Kaufman, J. C. (2005). Whence creativity? Overlapping and dual aspects skills and traits. In J. C. Kaufman & J. Baer (Eds.), *Creativity across domains: Faces of the muse* (pp. 313-320). Lawrence Erlbaum Associates.

Bakeman, R., & Quera, V. (2011). *Sequential analysis and observational methods for the behavioral sciences*. Cambridge University Press.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84*(2), 191-215.

Bandura, A. (1986). *Social foundations of thought and action : a social cognitive theory*. Prentice-Hall.

Bandura, A. (1989). Human agency in social cognitive theory. *American psychologist, 44*(9), 1175-1184.

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational behavior and human decision processes, 50*(2), 248-287.

Bandura, A. (1993). Perceived Self-Efficacy in Cognitive Development and Functioning. *Educational psychologist, 28*(2), 117-148. https://doi.org/10.1207/s15326985ep2802_3

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual review of psychology, 52*(1), 1-26.

Bandura, A., & Cervone, D. (1983). Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of personality and social psychology, 45*(5), 1017-1028.

Bandura, A., Freeman, W., & Lightsey, R. (1999). *Self-efficacy: The exercise of control*. Springer.

Barbot, B., Besançon, M., & Lubart, T. (2011). Assessing creativity in the classroom. *The Open Education Journal, 4*(1), 123-132.

Barbot, B., Besançon, M., & Lubart, T. (2015). Creative potential in educational settings: Its nature, measure, and nurture. *Education 3-13, 43*(4), 371-381.

Beghetto, R. A. (2005). Does assessment kill student creativity? *The educational forum, 69*(3), 254-263.

Beghetto, R. A. (2006). Creative self-efficacy: Correlates in middle and secondary students. *Creativity Research Journal, 18*(4), 447-457.

Beghetto, R. A. (2007a). Does creativity have a place in classroom discussions? Prospective teachers' response preferences. *Thinking Skills and Creativity, 2*(1), 1-9.

Beghetto, R. A. (2007b). Ideational code-switching: Walking the talk about supporting student creativity in the classroom. *Roeper Review, 29*(4), 265-270.

Beghetto, R. A. (2009). In search of the unexpected: Finding creativity in the micromoments of the classroom. *Psychology of Aesthetics, Creativity, and the Arts, 3*(1), 2-5.

Beghetto, R. A., & Kaufman, J. C. (2007). Toward a broader conception of creativity: A case for" mini-c" creativity. *Psychology of Aesthetics, Creativity, and the Arts, 1*(2), 73-79.

Beghetto, R. A., & Kaufman, J. C. (2010). Broadening conceptions of creativity in the classroom. In R. A. Beghetto & J. C. Kaufman (Eds.), *Nurturing creativity in the classroom* (pp. 191-205). Cambridge University Press.

Beghetto, R. A., & Kaufman, J. C. (2014). Classroom contexts for creativity. *High Ability Studies, 25*(1), 53-69.

Bereczki, E. O., & Kárpáti, A. (2018). Teachers' beliefs about creativity and its nurture: A systematic review of the recent research literature. *Educational Research Review, 23*, 25-56.

Besançon, M., & Lubart, T. (2008). Differences in the development of creative competencies in children schooled in diverse learning environments. *Learning and individual differences, 18*(4), 381-389.

Biddle, C., & Schafft, K. A. (2015). Axiology and anomaly in the practice of mixed methods work: Pragmatism, valuation, and the transformative paradigm. *Journal of mixed methods research, 9*(4), 320-334.

Biesta, G. J. (2015). *Good education in an age of measurement: Ethics, politics, democracy*. Routledge.

Blamires, M., & Peterson, A. (2014). Can creativity be assessed? Towards an evidence-informed framework for assessing and planning progress in creativity. *Cambridge Journal of Education, 44*(2), 147-162.

Blikstad-Balas, M. (2017). Key challenges of using video when investigating social practices in education: contextualization, magnification, and representation. *International Journal of Research & Method in Education, 40*(5), 511-523.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: Cognitive domain* (Vol. 1). Longman Group.

Brewer, J., & Hunter, A. (1989). *Multimethod research : a synthesis of styles* (Vol. 175). Sage Publications.

Brewer, J., & Hunter, A. (2005). *Foundations of multimethod research : synthesizing styles* (2nd ed. ed.). SAGE.

Brophy, D. R. (1998). Understanding, measuring, and enhancing individual creative problem-solving efforts. *Creativity Research Journal, 11*(2), 123-150.

Bryan, L. A. (2012). Research on science teachers' beliefs In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (Vol. 1, pp. 477-495). Springer.

Carr, D. (2003). Philosophy and the Meaning ofEducation'. *Theory and research in education, 1*(2), 195-212.

Cazden, C. B. (2011). *Classroom Discourse: The Language of TEaching and Learning* (2 ed.). Heinemann.

Chan, D. W., & Chan, L.-K. (1999). Implicit theories of creativity: Teachers' perception of student characteristics in Hong Kong. *Creativity Research Journal, 12*(3), 185-195.

Chander, S. (2012). Little c creativity: A case for our science classroom: An Indian perspective. *Gifted Education International, 28*(2), 192-200.

Charmaz, K. (2006). *Constructing Grounded Theory*. Sage.

Charmaz, K. (2014). *Constructing Grounded Theory* (2 ed.). Sage.

Choe, I.-S. (2006). Creativity - A sudden rising star in Korea. In J. C. Kaufman & R. J. Sternberg (Eds.), *The International Handbook of Creativity* (pp. 395-420). Cambridge University Press.

Clayman, S. E., & Gill, V. T. (2004). Conversation Analysis. In M. Hardy & A. Bryman (Eds.), *Handbook of Data Analysis* (pp. 589-606). Sage Publications.

Clegg, P. (2008). Creativity and critical thinking in the globalised university. *Innovations in Education and teaching International, 45*(3), 219-226.

Cole, D. G., Sugioka, H. L., & Yamagata-Lynch, L. C. (1999). Supportive classroom environments for creativity in higher education. *The Journal of Creative Behavior, 33*(4), 277-293.

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

Craft, A. (2001). Little c creativity In A. Craft, B. Jeffrey, & M. Leibling (Eds.), *Creativity in education* (pp. 45-61). Continuum.

Craft, A. (2005). *Creativity in Schools: Tensions and Dilemmas*. Abingdon, Oxon: Taylor and Francis. https://doi.org/10.4324/9780203357965

Craft, A. (2006). Fostering creativity with wisdom. *Cambridge Journal of Education, 36*(3), 337-350.

Craft, A., & Hall, E. (2015). Changes in the landscape for creativity in education. In A. Wilson (Ed.), *Creativity in Primary Education* (3 ed., pp. 6-24). Sage publications.

Cremin, T., Burnard, P., & Craft, A. (2006). Pedagogy and possibility thinking in the early years. *Thinking Skills and Creativity, 1*(2), 108-119.

Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research*. Sage.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed. ed.). Sage.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry & research design : choosing among five approaches* (4th ed., international student ed. ed.). Sage.

Cropley, A. J. (1997). Fostering Creativity in the Classroom: General Principles. In M. A. Runco (Ed.), *The Creativity Research Handbook* (Vol. 1, pp. 83-114). Hampton Press.

Cropley, A. J. (2006). In praise of convergent thinking. *Creativity Research Journal, 18*(3), 391-404.

Cropley, A. J., & Cropley, D. (2008). Resolving the paradoxes of creativity: An extended phase model. *Cambridge Journal of Education, 38*(3), 355-373.

Csikszentmihalyi, M. (1997). *Flow and the Psychology of Discovery and Invention*. Harper Collins.

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education—A systematic literature review. *Thinking Skills and Creativity, 8*, 80-91.

Davies, D., Jindal-Snape, D., Digby, R., Howe, A., Collier, C., & Hay, P. (2014). The roles and development needs of teachers to promote creativity: A systematic review of literature. *Teaching and teacher education, 41*, 34-41.

Davies, L. M., Newton, L. D., & Newton, D. P. (2018). Creativity as a twenty-first-century competence: an exploratory study of provision and reality. *Education 3-13, 46*(7), 879-891.

Davies, T. (2006). Creative teaching and learning in Europe: Promoting a new paradigm. *The curriculum journal, 17*(1), 37-57.

Dawson, V., D'Andrea, T., Affinito, R., & Westby, E. L. (1999). Predicting creative behavior: A reexamination of the divergence between traditional and teacher-defined concepts of creativity. *Creativity Research Journal, 12*(1), 57-66.

Design-Based Research Collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational researcher, 32*(1), 5-8.

de Souza Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review, 22*(3), 148-153.

DeHaan, R. L. (2009). Teaching creativity and inventive problem solving in science. *CBE—Life Sciences Education, 8*(3), 172-181.

Demir, S., & Şahin, F. (2014). Assessment of open-ended questions directed to prospective science teachers in terms of scientific creativity. *Procedia-Social and Behavioral Sciences, 152*, 692-697.

Denzin, N. K. (1978). *The research act : a theoretical introduction to sociological methods* (2nd ed. ed.). McGraw-Hill.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The Discipline and Practice of Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE Handbook of Qualitative Research* (3 ed., pp. 1-19). Sage.

Dewey, J. (1948). *Reconstruction in philosophy* (Enl. ed. with a new introduction by the author. ed., Vol. 48). Beacon.

Dewey, J. (1958). *Experience and nature*. Dover.

Diakidoy, I.-A. N., & Constantinou, C. P. (2001). Creativity in physics: Response fluency and task specificity. *Creativity Research Journal, 13*(3-4), 401-410.

Diakidoy, I. A. N., & Kanari, E. (1999). Student teachers' beliefs about creativity. *British Educational Research Journal, 25*(2), 225-243.

Diseth, Å., Danielsen, A. G., & Samdal, O. (2012). A path analysis of basic need support, self-efficacy, achievement goals, life satisfaction and academic achievement level among secondary school students. *Educational Psychology, 32*(3), 335-354.

Drew, P. (2005). Conversation Analysis. In K. L. Fitch & R. E. Sanders (Eds.), *Handbook of Language and Social Interaction* (pp. 71-102). Lawrence Erlbaum Associates.

Du Bois, J. W. (1991). Transcription design principles for spoken discourse research. *Pragmatics, 1*(1), 71-106.

Duschl, R. A., & Bybee, R. W. (2014). Planning and carrying out investigations: An entry to learning and to teacher professional development around NGSS science and engineering practices. *International Journal of STEM education, 1*(1), 1-9.

Elaldi, S., & Batdi, V. (2016). Comparing Effects of Different Applications on Pre-Service Teachers: A Meta-Analysis. *Journal of Education and Training Studies, 4*(7), 70-81.

Emanuelsson, J., & Sahlström, F. (2008). The price of participation: Teacher control versus student participation in classroom interaction. *Scandinavian Journal of Educational Research, 52*(2), 205-223.

Erez, R. (2004). Freedom and creativity: An approach to science education for excellent students and its realization in the Israel arts and science academy's curriculum. *Journal of Secondary Gifted Education, 15*(4), 133-140.

European Commission (2015). *Science Education for Responsible Citizenship: Report to the European Commission of the expert group on science education*. E. Union.

Fasko, D. (2001). Education and creativity. *Creativity Research Journal, 13*(3-4), 317-327.

Fejes, A., & Thornberg, R. (2015). *Handbok i kvalitativ analys* (2. utök. uppl. ed.). Liber.

Fetters, M. D., & Molina-Azorin, J. F. (2017). *The Journal of Mixed Methods Research starts a new decade: The mixed methods research integration trilogy and its dimensions*. SAGE Publications Sage CA: Los Angeles, CA.

Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative cognition: Theory, research, and application*. MIT Press.

Fog, J. (2004). *Med samtalen som udgangspunkt : det kvalitative forskningsinterview* (2. rev. udg. ed.). Akademisk Forlag.

Forrester, J. C. (2008). Thinking creatively; thinking critically. *Asian Social Science, 4*(5), 100-105.

Friedrich, T. L., & Mumford, M. D. (2009). The effects of conflicting information on creative thought: A source of performance improvements or decrements? *Creativity Research Journal, 21*(2-3), 265-281.

Fryer, M. (1996). *Creative teaching and learning*. Paul Chapman Publishing Ltd.

Gajda, A., Beghetto, R. A., & Karwowski, M. (2017). Exploring creative learning in the classroom: A multi-method approach. *Thinking Skills and Creativity, 24*, 250-267.

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational research: An introduction* (8 ed.). Allyn and Bacon.

Gardner, R. (2013). Conversation Analysis in the Classroom. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 593-611). Blackwell Publishing.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research.* . Aldine de Gruyter.

Glaveanu, V. P. (2011). Children and creativity: A most (un)likely pair? *Thinking Skills and Creativity, 6*(2), 122-131. https://doi.org/10.1016/j.tsc.2011.03.002

Gorozidis, G., & Papaioannou, A. (2011). Teachers' self-efficacy, achievement goals, attitudes and intentions to implement the new Greek physical education curriculum. *European physical education review, 17*(2), 231-253.

Gregory, E., Hardiman, M., Yarmolinskaya, J., Rinne, L., & Limb, C. (2013). Building creative thinking in the classroom: From research to practice. *International Journal of Educational Research, 62*, 43-50.

Gudmundsdottir, S. (1992). The interview as a joint construction of reality. annual meeting of the American educational research association, San Francisco,

Guilford, J. P. (1950). *Creativity American psychologist*. 'the Haworts Press.

Guilford, J. P. (1967). *The nature of human intelligence*. McGraw-Hill.

Guvenc, H. (2011). Autonomy support and self–efficacy perceptions of primary school teachers. *Educational Admistration: Theory Practice, 17*(1), 99-116.

Hadzigeorgiou, Y., Fokialis, P., & Kabouropoulou, M. (2012). Thinking about creativity in science education. *Creative Education, 3*(05), 603-611.

Han, K. S. (2003). Domain-specificity of creativity in young children: How quantitative and qualitative data support it. *The Journal of Creative Behavior, 37*(2), 117-142.

Harrits, G. S. (2011). More than method?: A discussion of paradigm differences within mixed methods research. *Journal of mixed methods research, 5*(2), 150-166.

Hathcock, S. J., Dickerson, D. L., Eckhoff, A., & Katsioloudis, P. (2015). Scaffolding for creative product possibilities in a design-based STEM activity. *Research in Science Education, 45*(5), 727-748.

Have, P. t. (1999). *Doing conversation analysis : a practical guide*. Sage.

Heilmann, G., & Korte, W. B. (2010). The role of creativity and innovation in school curricula in the EU27: A content analysis of curricula documents. *European Commision*, 1-74.

Henriksen, D., Mishra, P., & Fisser, P. (2016). Infusing creativity and technology in 21st century education: A systemic view for change. *Journal of Educational Technology & Society, 19*(3), 27-37.

Heritage, J. (2005). Conversation Analysis and Institutional Talk. In K. L. Fitch & R. E. Sanders (Eds.), *Handbook of Language and Social Interaction* (pp. 103-147). Lawrence Erlbaum.

Hesse-Biber, S. (2015). Introduction: Navigating a turbulent resaerch landscape: Working the boundaries, tensions, diversity, and contradictions of multimethod and mixed methods inquiry. In S. Hesse-Biber & R. B. Johnson (Eds.), *The Oxford Handbook of Multimethod and Mixed Methods Research Inquiry* (pp. xxxiii-liii). Oxford University Press.

Hesse-Biber, S., Rodriguez, D., & Frost, N. A. (2015). A qualitative driven approach to multimethod and mixed methods research In S. Hesse-Biber & R. B. Johnson (Eds.), *The Oxford Handbook of Multimethod and Mixed Methods Research Inquiry* (pp. 3-20). Oxford University Press.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of educational research, 67*(1), 88-140.

Hong, M., & Kang, N.-H. (2010). South Korean and The US Secondary School Science Teachers' Conceptions of Creativity and Teaching for Creativity. *International Journal of Science and Mathematics Education, 8*(5), 821-843.

Hov, A. M., & Neegaard, H. (2020). The potential of chest mounted action cameras in early childhood education research. *Nordic Studies in Science Education, 16*(1), 4-17.

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education, 24*(4), 389-403.

Hui, A. N., Chow, B. W., Chan, A. Y., Chui, B. H., & Sam, C. (2015). Creativity in Hong Kong classrooms: Transition from a seriously formal pedagogy to informally playful learning. *Education 3-13, 43*(4), 393-403.

Hume, A., & Coll, R. (2010). Authentic student inquiry: the mismatch between the intended curriculum and the student - experienced curriculum. *Research in Science & Technological Education, 28*(1), 43-62.

Hunter, A., & Brewer, J. (2015). Designing Multimethod Research. In S. Hesse-Biber & R. B. Johnson (Eds.), *The Oxford Handbook of Multimethod and Mixed Methods Research Inquiry* (pp. 185-205). Oxford University Press.

Isaksen, S. (1995). Four P's in the pod: Some comments regarding the status and structure of the creativity domain and field. *International Creativity Network, 5*(1), 3-3.

James, M. A. (2015). Managing the classroom for creativity. *Creative Education, 6*(10), 1032-1043.

Jefferson, G. (2004). Glossary of transcript symbols with an introduction. In G. H. Lerner (Ed.), *Conversation Analysis: Studies from the first generation* (pp. 13-31). John Benjamins Publishing Company.

Jeffrey, B., & Craft, A. (2004). Teaching creatively and teaching for creativity: distinctions and relationships. *Educational studies, 30*(1), 77-87.

Johannessen, A., Christoffersen, L., & Tufte, P. A. (2010). *Introduksjon til samfunnsvitenskapelig metode* (4 ed.). Abstraks.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. *Educational researcher, 33*(7), 14-26. https://doi.org/10.3102/0013189x033007014

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of mixed methods research, 1*(2), 112-133.

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The journal of the learning sciences, 4*(1), 39-103.

Jordanous, A. (2016). Four PPPPerspectives on computational creativity in theory and in practice. *Connection Science, 28*(2), 194-216.

Kampylis, P., Berki, E., & Saariluoma, P. (2009). In-service and prospective teachers' conceptions of creativity. *Thinking Skills and Creativity, 4*(1), 15-29.

Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four c model of creativity. *Review of general psychology, 13*(1), 1-12.

Kaufman, J. C., & Beghetto, R. A. (2013). Do people recognize the four Cs? Examining layperson conceptions of creativity. *Psychology of Aesthetics, Creativity, and the Arts, 7*(3), 229-236.

Kettler, T., Lamb, K. N., Willerson, A., & Mullet, D. R. (2018). Teachers' perceptions of creativity in the classroom. *Creativity Research Journal, 30*(2), 164-171.

Kind, P. M., & Kind, V. (2007). Creativity in science education: Perspectives and challenges for developing school science. *Studies in Science Education, 43*(1), 1-37.

Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy: An Overview. *Theory into practice, 41*(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2

Krumsvik, R. J. (2019). Validitet i kvalitativ forskning. In R. J. Krumsvik (Ed.), *Kvalitativ metode i lærerutdanninga* (pp. 191-204). Fagbokforlaget.

Krumsvik, R. J., & Røkenes, F. M. (2016). Litteraturreview i PhD-avhandlingen. In R. J. Krumsvik (Ed.), *En doktorgradsutdanning i endring. Et fokus på den artikkelbaserte ph.d.-avhandlingen* (pp. 51-92). Fagbokforlaget.

Kuhn, T. S. (1962). *The structure of scientific revolutions*. University of Chicago Press.

Kvale, S. (1997). *Interview : en introduktion til det kvalitative forskningsinterview*. Hans Reitzels Forl.

Larkin, M., & Thompson, A. R. (2011). Interpretative phenomeological analysis. In D. Harper & A. Thompson, R (Eds.), *Qualitative Research Methods in Mental Health and Psychotherapy: A Guide for Students and Practitioners* (pp. 99-116). John Wiley & Sons.

Leatham, K. R. (2006). Viewing mathematics teachers' beliefs as sensible systems. *Journal of Mathematics Teacher Education, 9*(1), 91-102.

Levine, A. (2007). Educating Researchers. *Education Schools Project*.

Liang, L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2009). Preservice teachers' views about nature of scientific knowledge development: An international collaborative study. *International Journal of Science and Mathematics Education, 7*(5), 987-1012.

Lin, C., Hu, W., Adey, P., & Shen, J. (2003). The Influence of CASE on Scientific Creativity. *Research in science education (Australasian Science Education Research Association), 33*(2), 143-162. https://doi.org/10.1023/A:1025078600616

Lin, Y.-S. (2011). Fostering creativity through education–a conceptual framework of creative pedagogy. *Creative Education, 2*(03), 149-155.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

Liu, S.-C., & Lin, H.-s. (2014). Primary teachers' beliefs about scientific creativity in the classroom context. *International Journal of Science Education, 36*(10), 1551-1567.

Lofthus, L. (2017). Bruk av teori for økt refleksivitet i praksis. Praksisarkitektur som rammeverk for å belyse forskerens plass i datageneringen. In L. Frers, K. Hognestad, & M. Bøe (Eds.), *Metode mellom forskning og læring: Refleksjon i praksis* (pp. 35-55). Cappelen Damm Akademisk.

Lubart, T., & Guignard, J.-H. (2004). The generality-specificity of creativity: A multivariate approach. In R. J. Sternberg, E. L. Grigorenko, & J. L. Singer (Eds.), *Creatvitiy: From potential to realization* (pp. 43-56). American Psychological Association.

Lucas, B. (2001). Creative teaching, teaching creativity and creative learning. In A. Craft, B. Jeffrey, & M. Leibling (Eds.), *Creativity in education* (pp. 35-44). Continuum.

Ma, H.-H. (2006). A synthetic analysis of the effectiveness of single components and packages in creativity training programs. *Creativity Research Journal, 18*(4), 435-446.

Marshall, P. A. (1992). Research ethics in applied anthropology. *IRB: Ethics & Human Research, 14*(6), 1-5.

Meador, K. S. (2003). Thinking creatively about science suggestions for primary teachers. *Gifted Child Today, 26*(1), 25-29.

Mehan, H. (1979). *Learning Lessons*. Harvard University Press.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research : a guide to design and implementation* (Fourth edition. ed.). Jossey-Bass, a Wiley Brand.

Mertens, D. M., & Tarsilla, M. (2015). Mixed Methods Evaluation. In S. Hesse-Biber & R. B. Johnson (Eds.), *The Oxford Handbook of Multimethod and Mixed Methods Research Inquiry* (pp. 426-446). Oxford University Press.

Meyer, A. A., & Lederman, N. G. (2013). Inventing creativity: An exploration of the pedagogy of ingenuity in science classrooms. *School Science and Mathematics, 113*(8), 400-409.

Ministry of Education and Research (2020). *The Education Act*. https://lovdata.no/dokument/NLE/lov/1998-07-17-61#KAPITTEL_1

Ministry of Education and Research (2021). Core curriculum: The joy of creating, engagement and the urge to explore. https://www.udir.no/lk20/overordnet-del/opplaringens-verdigrunnlag/1.4-skaperglede-engasjement-og-utforskertrang/?lang=eng

Moran, S., & John-Steiner, V. (2003). Creativity in the making: Vygotsky's contemporary contribution to the dialectic of development and creativity. In R. K. Sawyer, V. John-Steiner, S. Moran, R. J. Sternberg, D. H. Feldman, J. Nakamura, & M. Csikszentmihalyi (Eds.), *Creativity and development* (pp. 61-90). Oxford University Press.

Mork, S. M. (2016). *Nøkler til naturfag: Sluttrapport*. https://www.naturfagsenteret.no/binfil/download2.php?tid=2165781

Moustakas, C. (1994). *Phenomenological Research Methods*. SAGE Publications.

Mukhopadhyay, R. (2013). Problem solving in science learning-some important considerations of a teacher. *IOSR Journal of Humanities and Social Science, 8*(6), 21-25.

Mukhopadhyay, R., & Sen, M. K. (2013). Scientific creativity-A new emerging field of research: Some considerations. *International Journal of Education and Psychological Research, 2*(1), 1-9.

Mullet, D. R., Willerson, A., Lamb, K. N., & Kettler, T. (2016). Examining teacher perceptions of creativity: A systematic review of the literature. *Thinking Skills and Creativity, 21*, 9-30.

Maarouf, H. (2019). Pragmatism as a supportive paradigm for the mixed research approach: Conceptualizing the ontological, epistemological, and axiological stances of pragmatism. *International Business Research, 12*(9), 1-12.

[NACCCE] National Advisory Committee on Creative and Cultural Education, N. (1999). *All our futures: Creativity, culture and education*. DfEE Publications Sudbury.

National Science Teaching Association (2021). *Science and Engineering Practices*. https://ngss.nsta.org/practicesfull.aspx

Neisser, U. (1963). The multiplicity of thought. *British Journal of Psychology, 54*(1), 1-14.

NESH. (2016). *Guidelines for research ethics in the social sciences, law ans the humanities* (4 ed.). The National Committee for Research Ethics in the Social Sciences and the Humanities.

Newton, D. P., & Newton, L. D. (2009). Some student teachers' conceptions of creativity in school science. *Research in Science & Technological Education, 27*(1), 45-60.

Newton, L. D., & Newton, D. P. (2010a). Creative thinking and teaching for creativity in elementary school science. *Gifted and Talented International, 25*(2), 111-124.

Newton, L. D., & Newton, D. P. (2010b). What teachers see as creative incidents in elementary science lessons. *International Journal of Science Education, 32*(15), 1989-2005.

Newton, L. D., & Newton, D. P. (2014). Creativity in 21 st-century education. *Prospects, 44*(4), 575-589.

Norwegian Directorate for Education and Training (2021a). *Curriculum in Natural science (NAT01-04)*. https://www.udir.no/lk20/nat01-04?lang=eng

Norwegian Directorate for Education and Training (2021b). *Evaluering av lærerspesialistordningen - En delrapport*. https://www.udir.no/tall-og-forskning/finn-forskning/rapporter/evalueringen-av-larerspesialistordningen--en-delrapport

Norwegian Directorate for Education and Training (2021c). *Hvorfor har vi fått nye læreplaner?* https://www.udir.no/laring-og-trivsel/lareplanverket/stotte/hvorfor-nye-lareplaner/

Norwegian Directorate for Education and Training (2021d). *Natural Science (NAT01-04): Core elements*. https://www.udir.no/lk20/nat01-04/om-faget/kjerneelementer?lang=eng

Norwegian Directorate for Education and Training (2021e). *Natural science (NAT01-04): Relevance and central values*. https://www.udir.no/lk20/nat01-04/om-faget/fagets-relevans-og-verdier?lang=eng

Norwegian Directorate for Education and Training (2021f). *Natural science (NAT01-04): Schedule*. https://www.udir.no/lk20/nat01-04/timetall?lang=eng

Norwegian Directorate for Education and Training (2021g). *Natural Science subject curriculum (NAT1-03)*. https://www.udir.no/kl06/NAT1-03/Hele/Komplett_visning/?lplang=http://data.udir.no/kl06/eng

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What "ideas-about-science" should be taught in school science? A Delphi study of the expert community. *Journal of research in science teaching, 40*(7), 692-720.

Ozkal, N. (2014). Relationships between teachers creativity fostering behaviors and their self-efficacy beliefs. *Educational Research and Reviews, 9*(18), 724-733.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of educational research, 62*(3), 307-332.

Patston, T. J., Cropley, D. H., Marrone, R. L., & Kaufman, J. C. (2018). Teacher implicit beliefs of creativity: Is there an arts bias? *Teaching and teacher education, 75*, 366-374.

Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed. ed.). Sage Publications.

Pehkonen, E., & Pietilä, A. (2003). On relationships between beliefs and knowledge in mathematics education. Proceedings of the CERME-3 (Bellaria) meeting,

Péter-Szarka, S. (2012). Creative climate as a means to promote creativity in the classroom. *Electronic Journal of Research in Educational Psychology, 10*(3), 1011-1034.

Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education : theory, research, and applications* (2nd ed. ed.). Merrill Prentice Hall.

Plucker, J. A., & Beghetto, R. A. (2004). Why creativity is domain general, why it looks domain specific, and why the distinction doesn't matter. In R. J. Sternberg, E. L. Grigorenko, & J. L. Singer (Eds.), *Creativity: From potential to realization* (pp. 153-168). American Psychological Assosiation.

Plucker, J. A., Beghetto, R. A., & Dow, G. T. (2004). Why isn't creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research. *Educational psychologist, 39*(2), 83-96.

Puccio, G. J., & Cabra, J. F. (2010). Organizational creativity: A systems approach. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge handbook of creativity* (pp. 145-173). Cambridge University Press.

Raymond, A. M. (1997). Inconsistency between a beginning elementary school teacher's mathematics beliefs and teaching practice. *Journal for research in mathematics education, 28*(5), 550-576.

Reid, K., Flowers, P., & Larkin, M. (2005). Exploring lived experience. *The psychologist, 18*(1), 20-23.

Rejskind, G. (2000). TAG teachers: Only the creative need apply. *Roeper Review, 22*(3), 153-157.

Rennstam, J., & Wästerfors, D. (2015). *Från stoff till studie-Om analysarbete i kvalitativ forskning*. Studentlitteratur AB.

Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan, 42*(7), 305-310.

Richards, K. (2005). Introduction. In K. Richards & P. Seedhouse (Eds.), *Applying Conversation Analysis* (pp. 1-15). Palgrave Mcmilan.

Richards, K., & Seedhouse, P. (2005). *Applying conversation analysis*. Palgrave Macmillan.

Richards, R. (2001). Creativity and the schizophrenia spectrum: More and more interesting. *Creativity Research Journal, 13*(1), 111-132.

Richardson, C., & Mishra, P. (2018). Learning environments that support student creativity: Developing the SCALE. *Thinking Skills and Creativity, 27*, 45-54.

Rubenstein, L. D., McCoach, D. B., & Siegle, D. (2013). Teaching for creativity scales: An instrument to examine teachers' perceptions of factors that allow for the teaching of creativity. *Creativity Research Journal, 25*(3), 324-334.

Rubenstein, L. D., Ridgley, L. M., Callan, G. L., Karami, S., & Ehlinger, J. (2018). How teachers perceive factors that influence creativity development: Applying a Social Cognitive Theory perspective. *Teaching and teacher education, 70*, 100-110.

Runco, M. A. (1995). Creativity and the future. In G. T. Kurian & G. T. T. Molitor (Eds.), *Encyclopedia of the Future* (Vol. 1, pp. 156-157). Macmillian.

Runco, M. A. (2003). Education for creative potential. *Scandinavian Journal of Educational Research, 47*(3), 317-324.

Runco, M. A. (2005). Motivation, competence, and creativity. In A. J. Elliott & C. S. Dweck (Eds.), *Handbook of achievement motivation and competence* (pp. 609-623). Guilford Press.

Rutland, M., & Barlex, D. (2008). Perspectives on pupil creativity in design and technology in the lower secondary curriculum in England. *International Journal of Technology and Design Education, 18*(2), 139-165.

Sacks, H., Schegloff, E. A., & Jefferson, G. (1978). A simplest systematics for the organization of turn taking for conversation. In J. Schenkein (Ed.), *Studies in the organization of conversational interaction* (pp. 7-55). Academic Press.

Sahlström, F. (2009). Conversation analysis as a way of studying learning—an introduction to a special issue of SJER. *Scandinavian Journal of Educational Research, 53*(2), 103-111.

Sak, U. (2004). About creativity, giftedness, and teaching the creatively gifted in the classroom. *Roeper Review, 26*(4), 216-222.

Sandoval, W. (2014). Conjecture mapping: An approach to systematic educational design research. *Journal of the learning sciences, 23*(1), 18-36.

Sawyer, R. K. (2004). Creative teaching: Collaborative discussion as disciplined improvisation. *Educational researcher, 33*(2), 12-20.

Sawyer, R. K. (2015). How to transform schools to foster creativity. *Teachers College Record, 118*(4), 1-23.

Scardamalia, M., & Bereiter, C. (2006). Knowledge Building. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 97-115). Cambridge University Press.

Schmidt, A. L. (2011). Creativity in science: Tensions between perception and practice. *Creative Education, 2*(05), 435-445.

Schunk, D. H. (1989). Social Cognitive Theory and Self-Regulated Learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-Regulated Learning and Academic Achievement* (pp. 83-110). Springer.

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2014). *Motivation in education : theory, research and applications* (4th. ed., new international ed. ed.). Pearson.

Scott, G., Leritz, L. E., & Mumford, M. D. (2004). The effectiveness of creativity training: A quantitative review. *Creativity Research Journal, 16*(4), 361-388.

Shaheen, R. (2010). Creativity and education. *Creative Education, 1*(03), 166-169.

Sidnell, J. (2010). *Conversation Analysis: An Introduction*. Blackwell Publishing.

Silverman, D. (2005). Instances or sequences? Improving the state of the art of qualitative research. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, 6*(3), 1-16.

Silverman, D. (2006). *Interpreting qualitative data: methods for analyzing talk, text and interaction* (3 ed.). Sage.

Skiba, T., Tan, M., Sternberg, R. J., & Grigorenko, E. L. (2010). Roads not taken, new roads to take: Looking for creativity in the classroom. . In R. A. Beghetto & J. C. Kaufman (Eds.), *Nurturing creativity in the classroom* (pp. 252-269). Cambridge University Press.

Skovholt, K. (2018). Establishing scientific discourse in classroom interaction teacher students' orientation to mundane versus technical talk in the school subject Norwegian. *Scandinavian Journal of Educational Research, 62*(2), 229-244.

Skaalvik, E. M., & Skaalvik, S. (2018). *Skolen som læringsarena : selvoppfatning, motivasjon og læring* (3. utg. ed.). Universitetsforl.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological bulletin, 119*(1), 3-22.

Smith, J. A. (2015). *Qualitative psychology : a practical guide to research methods* (3rd ed. ed.). Sage.

Smith, J. A., Flowers, P., & Larkin, M. (2009). *Interpretative Phenomenological Analysis: Theory, Method and Research*. Sage.

Soh, K. (2017). Fostering student creativity through teacher behaviors. *Thinking Skills and Creativity, 23*, 58-66.

Sternberg, R. J. (2006). The nature of creativity. *Creativity Research Journal, 18*(1), 87-98.

Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity: Prospects and paradigms. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 3-15). Cambridge University Press.

Sternberg, R. J., & O'Hara, L. A. (1999). Creativity and intelligence. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 251-272). Cambridge University Press.

Sternberg, R. J., & Williams, W. M. (1996). *How to Develop Student Creativity* ASCD.

Stivers, T., & Sidnell, J. (2013). Introduction. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 1-8). Blackwell Publishing.

Talens, J. (2016). Influence of problem–based learning on the creative thinking skills of physical science students of De La Salle Lipa. *Jornal of Education, Arts and Sciences, 2*(1), 15-90.

Teddlie, C., & Tashakkori, A. (2010). Overview of contemporary issues in mixed methods research. In C. Teddlie & A. Tashakkori (Eds.), *SAGE Handbook of Mixed Methods in Social & Behavioral Research* (2 ed., pp. 1-41). Sage Publications.

Thagaard, T. (2009). *Systematikk og innlevelse: en innføring i kvalitativ metode* (3 ed.). Fagbokforlaget.

Thornberg, R., & Frykedal, K. F. (2015). Grundad teori. In A. Fejes & R. Thornberg (Eds.), *Handbok i kvalitativ analys* (2 ed., pp. 44-70). Liber.

Tighe, E., Picariello, M. L., & Amabile, T. M. (2003). Environmental influences on motivation and creativity in the classroom. *The educational psychology of creativity*, 199-222.

Toh, W. S. (2003). Student-Centered educational beliefs and teacher education. *Jurnal Penyelidikan MPBL, 4*, 20-22.

Treffinger, D. J., Young, G. C., Selby, E. C., & Shepardson, C. (2002). Assessing Creativity: A Guide for Educators. *National Research Center on the Gifted and Talented*.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of educational research, 68*(2), 202-248.

Tuval-Mashiach, R. (2017). Raising the curtain: The importance of transparency in qualitative research. *Qualitative Psychology, 4*(2), 126-138.

UNESCO. (2013). *Twenty-first century skills*. http://www.ibe.unesco.org/en/glossary-curriculum-terminology/t/twenty-first-century-skills

Urhahne, D., Kremer, K., & Mayer, J. (2011). Conceptions of the nature of science—are they general or context specific? *International Journal of Science and Mathematics Education, 9*(3), 707-730.

Waters-Adams, S. (2006). The relationship between understanding of the nature of science and practice: The influence of teachers' beliefs about education, teaching and learning. *International Journal of Science Education, 28*(8), 919-944.

Weisberg, R. (1986). *Creativity: Genious and other myths*. Freeman.

Westby, E. L., & Dawson, V. (1995). Creativity: Asset or burden in the classroom? *Creativity Research Journal, 8*(1), 1-10.

Wong, S. L., & Hodson, D. (2009). From the horse's mouth: What scientists say about scientific investigation and scientific knowledge. *Science education, 93*(1), 109-130.

Wooffitt, R. (2005). *Conversation Analysis and Discourse Analysis: A Comparative and Critical Introduction*. SAGE Publlications.

Ødegaard, M., Kjærnsli, M., Karlsen, S., Kersting, M., Lunde, M. L. S., Olufsen, M., & Sæleset, J. (2020). *LISSI-Rapport: Tett på naturfag i klasserommet*.

Appendixes

Appendix A: Research approval from the NSD

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Authenticity and creativity in primary and lower secondary science education

Referansenummer

527958

Registrert

30.11.2018 av Maren Skjelstad Fredagsvik - Maren.S.Fredagsvik@usn.no

Behandlingsansvarlig institusjon

Universitetet i Sørøst-Norge / Fakultet for humaniora, idrett- og utdanningsvitenskap / Institutt for matematikk og naturfag

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Kjetil Reier-Røberg, Kjetil.Reier-Roberg@usn.no, tlf: 31009154

Type prosjekt

Forskerprosjekt

Prosjektperiode

01.01.2019 - 31.07.2021

Status

29.01.2019 - Vurdert

Vurdering (1)

29.01.2019 - Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 29.01.2019 samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD ENDRINGER
Dersom behandlingen av personopplysninger endrer seg, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. På våre nettsider informerer vi om hvilke endringer som må meldes. Vent på svar før endringer gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 31.07.2021.

LOVLIG GRUNNLAG

Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke behandles til nye, uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Kontaktperson hos NSD: Karin Lillevold
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Appendix B: Informed consent letter of invitation to teachers

Universitetet i Sørøst-Norge

Vil du delta i forskningsprosjektet

"Kreativitet i naturfag på barneskolen"?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å fremme og øke elevenes kreativitet i naturfag. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
I forbindelse med utvikling av ny læreplan i norsk skole vil det bli lagt spesielt vekt på hva elever trenger av kunnskap og evner i dagens og fremtidens samfunn, og i Stortingsmelding 28, Fag – fordypning – forståelse, en fornyelse av kunnskapsløftet (2016) argumenteres det for at innovative og kreative evner må fremheves i skolens læreplan. Det fremheves også at vurdering av elevers læring bør inkludere vurdering av elevers evne til å finne kreative løsninger på problemer.

Prosjektet vil forsøke å svare på de kravene som kommer med den nye læreplanen, samtidig som at prosjektet ønsker å være en del av skolens utviklingsarbeid. I samarbeid med engasjerte naturfagslærere skal prosjektet utvikle undervisningsopplegg i naturfag som ivaretar og fremmer elevens kreative og innovative evner i naturfag. I tillegg skal det utvikles vurderingskriterier som bidrar til å ivareta det kreative aspektet ved læring.

Prosjektet ønsker å ta utgangspunkt i skolens allerede eksisterende planer for undervisning, men det har samtidig et stort ønske om å inkludere teknologi og innovasjon i undervisningsopplegget. Undervisningsopplegget skal ha form som en utforskende prosess og naturvitenskapelig kreativitet vil være det underliggende fokuset til opplegget. Det forventes at lærerne i prosjektet gjennomfører undervisningen, og at det åpnes for at forsker kan observere elever, gjennomføre samtaler med elever og samle inn skriftlig materiale underveis. Undervisningsopplegg skal gjennomføres i tre omganger på tre forskjellige elevgrupper på egen skole, en gjennomføring ca. hvert halve år. Data fra gjennomføringen danner grunnlag for forbedring av opplegget til neste gjennomføring osv.

Foreløpig Tidsplan*

Når	Hva
Tidlig vår 2019	Intervju med lærere, hver for seg. Tidspunkt avtales individuelt. Tema: Kreativitet.
Tidlig vår 2019	Kick-off-møte. Her vil lærere og prosjektleder møtes og utveksle informasjon om prosjektet og vi vil sammen sette opp videre plan og starte felles idémyldring.
Tidlig vår 2019	Planlegging og utvikling av undervisningsaktiviteter og metoder ved de enkelte skolene.
Tidlig vår 2019	Første gjennomføring med klasse, gruppe 1.

Tidlig vår 2019	Videreutvikling og forbedring av undervisningsaktiviteter og metoder ved de enkelte skolene.
Sen vår 2019	Andre gjennomføring med klasse, gruppe 2.
Høst 2019	Videreutvikling og forbedring av undervisningsaktiviteter og metoder ved de enkelte skolene.
Høst 2019	Tredje og siste gjennomføring med klasse, gruppe 3.

* Tidspunkt avtales nærmere etter hva som passer de enkelte skolene og klassene.

Prosjektet er en del av mitt doktorgradsprosjekt i naturfagdidaktikk. Forskningsspørsmålene for denne oppgaven er 'På hvilken måte kan naturfagundervisningen bidra til å øke elevenes kreativitet i naturfag?' og 'På hvilken måte kan vurdering brukes og støtte opp under elevenes kreativitet i naturfag?'

Hvem er ansvarlig for forskningsprosjektet?
Universitet i Sørøst-Norge, Institutt for matematikk og naturfag.

Hva innebærer det for deg å delta?
Som lærer innebærer deltakelse i prosjektet å bidra, i samarbeid med medlærer og forsker, under planlegging av undervisningsopplegg og gjennomføre dette i tre omganger med tre forskjellige elevgrupper. Under gjennomføringen vil det samles inn data ved hjelp av lyd- og videopptak av hel klasse og av bestemte elevgrupper, samt samtaler med eler og lærer underveis. I tillegg vil skriftlig materialer og evt. produkter samles inn underveis i opplegget.

Jeg vil også be om et intervju med deg som lærer i forkant av studien, og på slutten av studien. Intervjuet vil ta form som en uformell samtale og omhandle din oppfatning av kreativitet i naturfag.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

- Det er kun forsker som har tilgang til opplysninger om deg.
- Navn og andre opplysninger vil anonymiseres løpende under transkribering, og lyd- og videopptak vil oppbevares på en ekstern lagringsenhet.

Deltakerne vil ikke kunne gjenkjennes i publikasjon.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes juli 2021. Personopplysninger og eventuelle opptak vil da anonymiseres og slettes.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Universitetet i Sørøst-Norge har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Universitetet i Sørøst-Norge ved prosjektansvarlig Maren Skjelstad Fredagsvik. E-post: maren.s.fredagsvik@usn.no, tlf: 92846244.
- Personvernombud ved Universitetet i Sørøst-Norge, Paal Are Solberg, på epost: personvernombud@usn.no.
- NSD – Norsk senter for forskningsdata AS, på epost (personvertjenester@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen

Maren Skjelstad Fredagsvik
Prosjektleder og doktorgradsstudent ved Universitetet i Sørøst-Norge

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Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *(sett inn tittel)*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i forskningsprosjektet 'Autentisitet og kreativitet i naturfag på barne- og ungdomsskolen'

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. juli 2021

(Signert av prosjektdeltaker, dato)

Appendix C: Informed consent letter of invitation to students and parents

Universitetet i Sørøst-Norge

Invitasjon til elever om deltakelse i forskningsprosjekt om kreativitet i naturfag

Bakgrunn og hensikt

Ønsker med dette å be om samtykke til at ditt barn kan delta i forskningsprosjekt som inkluderer video- og lydopptak.

I forbindelse med utvikling av ny læreplan i norsk skole vil det bli lagt spesielt vekt på hva elever trenger av kunnskap og evner i dagens og fremtidens samfunn, og det argumenteres for at innovative og kreative evner må fremheves i skolens undervisning.

I samarbeid med engasjerte naturfagslærere skal prosjektet forsøke å svare til kravene som kommer med ny læreplan og utvikle undervisningsopplegg i naturfag som ivaretar og fremmer elevens kreative og innovative evner.

Studien er en del av et doktorgradsprosjekt ved Universitetet i Sørøst-Norge.

Hva innebærer deltakelse i studien?

For eleven innebærer deltakelse en eller flere undervisningsøkter der fokuset er å fremme elevenes kreativitet i naturfag. Undervisningsøktene ledes av fagets lærere og gjennomføres i ordinær klasse. For å kartlegge hvordan undervisningsopplegget bidrar til fremme elevenes kreativitet vil forsker og lærere gjennomføre samtaler med elever underveis, både enkeltelever og elevgrupper. I tillegg vil forsker observere elevene i læringssituasjoner, samt samle inn skriftlig materiale som elevene produserer underveis i opplegget. Samtaler og observasjoner foregår både ved hjelp av video- og lydopptak, både av elevgrupper og hel klasse. Det er allerede hentet inn samtykke fra skoleledelse og deltakende lærere.

Undervisningsopplegget vil gjennomføres i ordinær naturfagsundervisning i [redacted].

Hva skjer med informasjonen som samles inn?

Personopplysninger, testresultater og annen skriftlig materiale, samt videomateriale oppbevares fortrolig i tråd med retningslinjene til Norsk Samfunnsvitenskapelig Datatjeneste. Personidentifiserende opplysninger vil bli slettet ved prosjektslutt og publisering av doktorgradsoppgave i juli 2021. All informasjon om deres barn vil bli anonymisert og behandlet på en slik måte at det ikke kan føres tilbake til det enkelte barn ved omtale og publisering.

Frivillig deltakelse

Det er frivillig å delta i studien. Hvis dere sier ja til deltakelse, har dere rett til å få innsyn i hvilke opplysninger som er registrert. Dere kan når som helst og uten å oppgi noen grunn trekke samtykket til å delta i studien uten at dette vil få noen negative konsekvenser. Dersom dere trekker dere fra studien, kan dere kreve å få slettet innsamlede materialer og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Dersom dere godkjenner at barnet deltar, undertegnes samtykkeerklæringen på neste side. Har du spørsmål til studien, kan du kontakte:

Maren Skjelstad Fredagsvik, mail: maren.s.fredagsvik@usn.no, mobil: 928 46 244.

Med vennlig hilsen

Maren Skjelstad Fredagsvik

PhD-student/Prosjektleder, Universitetet i Sørøst-Norge

✂ .....

Samtykke til deltakelse i studien

Jeg har mottatt informasjon om prosjektet, og er villig til å delta

Sett kryss:

☐ Jeg samtykker til å delta i prosjektet

.....

(signert av elev/prosjektdeltaker, dato)

.....

(Signert av foresatte til prosjektdeltaker, dato)

Appendix D: Interview guide (first individual interviews with the teachers)

Intervjuguide

Rammesetting

- Uformell samtale
- Informasjon om prosjektet og problemstillingen
  - Bakgrunn og formål med samtalen
  - Forklar hva intervjuet skal brukes til
  - Avklar spørsmål rundt anonymitet og taushetsplikt
  - Spør om respondenten har spørsmål eller om noe er uklart
  - Informer om lydopptak og sørge for samtykke til opptak
  - **START LYDOPPTAKER**

Erfaringer

Du arbeider på en barneskole i Trondheimsområdet ...

1. Hvor mange år har du jobbet i skolen?
2. Hvilke fag underviser du i?
3. Hva er din utdanningsbakgrunn?
4. Har du eller er du for tiden aktiv med videreutdanning, etterutdanning eller annen kursing?

Fokusering/tema

- Hva tenker du når du hører ordet kreativitet?
- Fortell litt om hva du tenker om kreativitet i naturfaget
- Hva er dine tanker rundt kreativitet i skolen og hvilken rolle kreativitet bør ha i skolen?
- Kan du si noe om hva du mener kjennetegner en kreativ elev?
  - I naturfag?
- Hvordan mener du vi best kan oppfordre til kreativitet i naturfag?
- Hva er dine tanker rundt din rolle som lærer å skulle stimulere elevenes kreativitet?
  - I naturfag?

Tilbakeblikk

- Oppsummering – går gjennom de viktige punktene som kom frem i løpet av intervjuet
- Avklaring – avklare misforståelser, spørre om man har forstått riktig dersom noe er uklart
- Er det noe mer du ønsker å legge til?

STOPP LYDOPPTAKER

Appendix E: Interview guide (group interview with the teachers)

Intervjuguide gruppeintervju

Gruppeintervjuet vil ta form som en uformell samtale mellom lærere og forsker. Det er ikke planlagt en bestemt intervjuguide på forhånd, men forsker vil notere ned noen stikkord før samtalen basert på innsamlet datamateriale og observasjoner underveis.

Appendix F: Interview guide (final individual interviews with the teachers)

Intervjuguide

Fortell litt om hvordan dere synes prosjektet har gått

Fortell litt om hvordan du opplevde arbeidsprosessen

- Samarbeid med forsker
- Samarbeid med kollega
- Arbeidet mellom rundene
- Utviklingen fra runde til runde
- Er det noe du kunne tenkt deg at vi gjorde annerledes?
- Er det noe vi kunne gjort mer av?
    - Mindre av?

Hva mener du elevene sitter igjen med etter endt prosjekt?

Hva mener du er det viktigste elevene sitter igjen med?

Kan du si noe om hvordan de forskjellige fasene i prosjektet fungerte?

- Finne problem
- Komme opp med ideer
- Bygge
- Presentere

Tiden elevene brukte på å samtale om ideer gikk ned utover prosjektet og rundene – fra over første dag til maks et kvarter siste runde – hva tenker du om det?

Utstyr – hvordan mener du valg av utstyr påvirker prosjektet/ideene? Tanker rundt dette?

Hva tenker du nå når du hører ordet kreativitet?

Fortell litt om hva du tenker om kreativitet i naturfag

Hvordan mener du prosjektet her fungerte ift. å støtte elevenes kreativitet i naturfag?

- Hvordan?

Kan du si noe om hvordan du opplever at elevene viste kreativitet?

Hvordan synes du prosjektet fungerte ift. din rolle å kunne støtte elevenes kreativitet?

Article I

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The challenge of supporting creativity in problem-solving projects in science: a study of teachers' conversational practices with students

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ABSTRACT

Background: Creativity is an important skill for the future society and developing students' creativity is an important part of science education. Working on a creative science project may help developing students' creative abilities, and the interaction between teacher and students during the work on defining a problem and solving the problem, is an ideal forum for supporting students' creativity.

Purpose: The purpose of the study is to get insight into how teachers respond to students' creative ideas during the works on a creative science project, and how the interaction between teacher and students may support or inhibit students' creative abilities.

Design and methods: Data in this study consist of 49 video-recorded interactions between two teachers and student groups working on a science project with the aim of supporting students' creative abilities. The interactions were analyzed with the use of Conversation Analysis (CA).

Results: Analysis shows that teachers play an important role in developing students' creative ideas. The analysis shows how teachers, after being told the students' creative ideas, evaluates the students' ideas as either preferred or dis-preferred according to the teacher's own preference. The teachers' evaluative stance towards the students' creative ideas determines how the conversations with the students unfold and make explicit which ideas the students should work further within the project.

Conclusion: Controlling the conversation based on the teacher's own preference may lead to missed opportunities regarding converting students' mini-c creative ideas into little-c creative ideas. Being able to create time and opportunity to explore and develop students' ideas, there is a need for fewer students per teacher and more focus on the process aspect of creativity rather than the product aspect.

KEYWORDS

Creativity; science education; problem solving; conversation analysis

Introduction

Creativity, as one of the 21st-century skills, is an important part of the knowledge, skills, and attitudes citizens need in the future society (UNESCO 2013). By developing students'

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creativity, they may be able to offer new perspectives, generate novel and meaningful ideas, raise new questions, and come up with solutions to ill-defined problems (Sternberg and Lubart 1999).

Teachers play an important role in developing students' creativity (Barbot, Besançon, and Lubart 2015). Research has shown that teachers may foster students' creative abilities and creative thinking by providing creative learning opportunities in the classroom (Cole, Sugioka, and Yamagata-Lynch 1999), and by acting as role models and mentors for the students (Kampylis, Berki, and Saariluoma 2009). Some of this research has resulted in concrete advices about how teachers can encourage creativity in school by creating an open and supportive classroom environment that reward and support creativity, by motivating and helping the students to be confident and to trust in their own creative abilities, and by creating a physical and contextual environment that supports creativity (Beghetto and Kaufman 2014; Craft 2005; Cropley 1997; Fleith 2000; Gregory et al. 2013; James 2015; Rejskind 2000; Sternberg and Williams 1996). Research has also shown that teachers' role in the creative process is to be a facilitator and fellow collaborator, by joining the students in the process of knowledge building and creation (Sawyer 2004; Scardamalia and Bereiter 2006). Teachers may encourage students' creativity through classroom talk (Beghetto 2007a), and by encouraging students' novel ideas and creative connections (Sternberg and Grigorenko 2004).

Nevertheless, there is a lack of research that examines how teachers make use of these pedagogical implications when they participate in dialogues with the students, and how they approach and respond to students' creative ideas. Research has, on the other hand, shown that many teachers struggle in developing a creative environment and integrate creativity into classroom routines (Eckhoff 2011; Raths 2001). Many teachers, although they value creativity, seem to follow 'inhibiting practices', like putting emphasis on the correct response reinforcing the fear of failure, putting emphasis on reproduction of knowledge, holding low expectations to students' creative potential, emphasizing obedience and passivity, and putting little emphasis on phantasy and imagination (Alencar 2002, in Kampylis, Berki, and Saariluoma 2009). Other studies indicate that teachers find it challenging to focus on creativity while meeting the demand of academic performance and time-constraint in the school context (Burnard and White 2008; Lee et al. 2006).

This study explores how teachers respond to students' creative ideas and students' creative process through interactions during the work on a creative open-ended science project, and how interacting with students during an idea phase of a creative process (identifying a problem, generate several solutions to the problem and deciding on the best possible solution) may facilitate students' creativity. The research questions are:

(1) How do teachers respond to students' creative ideas during the phase of identifying problems and generating ideas in a creative science project?
(2) How do teachers' responses to students' creative ideas impact the students' creative process?

These questions are addressed by means of the framework of *conversation analysis* (CA) to identify interactional patterns of conversations between teacher and students within the context of an open-ended science project called 'Mission Mars'. This includes identifying patterns of communications that inhibit or enhances students' creativity. The project

'Mission Mars' aim to support and facilitate students' creativity and is based on Amabile (1998) and her six KEYS for developing a learning environment for creativity; freedom, positive challenge, supervisory encouragement, work group support, sufficient resources and organized support, further adapted by James (2015) for classroom context, alongside other creativity supporting aspects identified during the literature review. Results from the study are discussed in light of theoretical perspectives on creativity and research on classroom conversation.

Theoretical underpinnings

Creativity and levels of creative magnitude

This study builds its' understanding of creativity on Hu and Adey (2002) definition of creativity as the creation of something original, which holds social or personal value, designed with a certain purpose in mind, using given information. According to James (2015, 1033), 'children are natural creatives. (. . .) exhibit[ing] their creativity in free play, investigation and exploration.' However, since their knowledge, understanding, and experience are naive compared to adults, children's creativity is often not perceived as particularly novel, nor useful by the adults. Therefore, children's creativity is sometimes disregarded, or devalued (James 2015).

This study positions creativity in young students as more personal and tied to their experience, and builds this on Beghetto's (2007a) argument that if the students' thoughts and solutions to a problem are meaningful and useful, they can be evaluated as creative. The difference of creative magnitude is further explained by the Four S-model of creativity (Beghetto and Kaufman 2007), which distinguishes between four levels of creative magnitude; big-c creativity of the extraordinarily gifted, pro-c creativity that occurs within a profession, little-c creativity of everyday life, and mini-c creativity experienced by learners interacting with new information and experiences. Students in primary school show mostly mini-c or little-c creativity (Beghetto 2007a). This study, therefore, builds on the premise that everyone has the potential to be creative, and that creativity can be developed and expressed in the learning processes through individuals' interpretations of information and inclusion of already existing structures of knowledge, related to mini-c creativity. Young students are able to come up with surprising and unusual ideas, despite that their knowledge and utility may be lower compared to adults and experts.

Creativity research often focuses on one or more of the four P's of creativity; person (the creative individual), process (the mental mechanisms that occur when a person is engaged in a creative act), product (the result of a creative act) and press (environmental factors) (Rhodes 1961). Based on this, nurturing creativity in the classroom is based on an interplay of both personal characteristics and the factors of the environment in which learning takes place (Cropley 2011). Bandura, Freeman, and Lightsey (1999) argue that beliefs, rather than truths, guide out goals, emotions, decisions, actions, and reactions, indicating that how teachers perceive creativity will impact their way of teaching. Research has shown that teachers' beliefs about creativity are often in misalignment with the scientific theories of creativity (Andiliou and Murphy 2010). This means that teachers need to know what creativity is and how to foster creativity in their classroom (Newton 2012), and create time and space for creativity (Cremin, Burnard, and Craft 2006).

Creating a creative environment and converting mini-c creativity into little-c creativity

In developing students' creativity, the teacher's job is to assist the students in converting mini-c creative experiences into little-c creative experiences, as conceptualized in the framework by Beghetto (2007a) and (Beghetto and Kaufman 2007). The framework consists of three teacher support techniques; (1) listening to students' ideas, (2) cueing students to the task constraints, and (3) giving students multiple opportunities to translate their ideas into products. Listening to students' ideas means listening to all ideas, because this encourages students' to take risks and express their thinking (Hathcock et al. 2015).

For an idea to be considered creative, it requires certain relevance (Plucker, Beghetto, and Dow 2004). Research argues, however, that too much emphasis on ideas' immediate relevance might cause the teacher to miss out on many creative ideas, and students' creative potential might go unnoticed (Runco 2004). Creating a safe environment for students to take risk requires that teachers accept unique ideas, even if they do not seem immediately relevant to the task (Beghetto 2007a). Teachers' dismissal of ideas may result students who do not wish to take the intellectual risk or effort to present creative expressions, and the students may fall into the exercise of figuring out what the teacher expects to see or hear (Beghetto 2007b; Black and Wiliam 2010). Students need to be free to express their creative ideas, and teachers and peers need to listen and explore their ideas with an open mind. Characteristics of the classroom conversation are hence essential for promoting creativity.

Classroom conversation

Research on classroom interaction shows that classroom conversations are mostly characterized by conversations between teacher and students, where the teacher is the actor who, for the most times, controls the interaction. 'The teacher is the one who mainly imparts knowledge to students, generally corrects students and controls turn-taking and sequence organization, and who has greater rights to initiate and close sequences' (Gardner 2013, 593). This can result in situations where

> [T]eachers do not have to explain their reason or justify their decisions to students. [. . .] And students, too, are encouraged to accept the authority of the teacher, not just in matters of classroom organization and activity, but in matters of science as well. (Lemke and Green 1990, 45)

This creates an interactional asymmetry, where the teacher has the institutional right to ask questions and evaluate responses, as well as the right to choose activity and decide when to move from one activity to another (see e.g. Cazden 2001). The teacher may also provide speaking rights to students and legitimate speakers during teacher-led group activities (see e.g. Cazden 2001).

Early studies on classroom interaction found that conversations between teacher and students often follow the patterns of Initiation-Response-Evaluation (IRE) (see McHoul 1978; Mehan 1979). The teachers initiate the conversation, often with a question, the student answer the question, and the teacher follows up with a feedback or an evaluation

(Gardner 2013). Research has shown that IRE-sequences are often used by the teacher to steer the direction of the sequence toward the teachers objective, and provide clues for more desired answers (Gardner 2013; Lee 2007). Gardner (2013) also highlights the opportunity for the teacher to expand the sequence with post-expansions if the student's response is seen as inadequate. A 'third-position turn can be a repair-initiation seeking a correction by the student in the fourth turn of sequence' (Gardner 2013, 598). By withholding the sequence completion third-position evaluation, the students may recognize that the teacher would prefer another answer, and will further extend the sequence (see Lee 2007; Lerner 1995). If students fail to self-correct to the satisfaction of the teacher, the teacher may initiate further repairs until correction is achieved. Conducting such repairs shift the focus from hearing and understanding the students' ideas to identifying errors in their telling (see Gardner 2013; McHoul 1990). To support students' learning and creativity, teachers are, instead, encouraged to promote *dialogic teaching* (Alexander 2006) and *exploratory talk* (Mercer 2000), building on the students' prior knowledge and providing feedback. Conducting dialogic teaching, the teacher treats students' contributions and answers 'as stages in an ongoing cognitive quest rather than as terminal points. And it nurtures the students' engagement, confidence, independence and responsibility' (Alexander 2006, 35). Alexander (2006) argues that teachers and students need to address learning tasks together, they need to listen to each other, share ideas and consider alternative viewpoints, students need to feel like they can articulate their ideas freely, without fear of embarrassment or 'wrong' answers, teachers and students need to build on each other's ideas and chain them into coherent lines of thinking and inquiry, and teachers need to facilitate dialogic teaching with particular educational goal in view. 'Exploratory talk' overlaps with 'dialogic teaching' having many of the same feature. However, it also emphasizes the visibility of reasoning processes. 'Exploratory talk is that in which partners engage critically but constructively with each other's ideas (Mercer 2000, 98). Such talk needs to be open-ended and speculative, enabling students to alter their developing mental representation or envisionment (Applebee et al. 2003).

Method

Participants and context

Data were collected from two fifth grade classes and one sixth grade class (age 10–12) in a Norwegian primary school (a total of 96 students divided into 23 groups) working on the project 'Mission Mars' during two half schooldays and on whole school day per class. Two science teachers from the school volunteered to participate in and develop the project 'Mission Mars' in collaboration with the researcher and teach the three classes during the implementation. Both teachers are educated science teachers and work as science teachers for the three classes. They have also participated in an in-service teacher course about inquiry-based teaching at the local University.

'Mission Mars' is an open-ended science project with the aim of nurturing students' creativity. The task for the students was to come up with an idea to a product that would make it possible to live on Mars, and then build a model of the idea. Preceding the project, the students read articles and texts about Mars, and one of the teachers led a half an hour presentation about the conditions on Mars and talked about the possibilities of moving to

Mars. After the presentation, the students were given the opportunity to share their thoughts about the subject. The students were then divided into groups of three to five students and asked to identify a problem and generate ideas for solving the problem. After deciding on one and developing one idea, the students built a model of the idea, before presenting the idea to the rest of the class.

Before developing the project, the teachers participated in a workshop about creativity, led by the researcher. The workshop focused on how to create a creative learning environment and which learning activities promote creativity. It also focused on how teachers can support creativity through dialogue. Building on their experience of inquiry-based teaching, the workshop focused on inquiry conversation and how to use this during the implementation. The teachers did not train explicitly in the use of conversational patterns, but participated in discussions about how to open up for students' ideas and thoughts, and help them to develop their ideas further.

The teachers and the researcher then developed the project on the six KEYS (Amabile 1998; James 2015): (1) *freedom* – an open-ended project where students are given freedom to choose how they will attain the goal of the project, giving the students a sense of ownership and increasing their intrinsic motivation and engagement, (2) *positive challenge* – projects' theme based on students engagement and interest, (3) *supervisory encouragement* – teachers prepared to facilitate the students' creativity by developing a safe environment built on mutual respect by listening to students' ideas, comments and arguments, and exploring the ideas together with the students by asking open-ended questions and cuing them within task constraints, (4) *work group support* – groups created based on the students' knowledge and combination of students interests, (5) *sufficient resources* – access to several types of building materials and informational resources (internet and books), and (6) *organized support* – volunteering to the project and building knowledge together in front of the project resulted in a shared vision, and support from the schools' administration provided the opportunity to implement the project three times.

Data collection and analysis

Data consisted of video recordings of all 23 groups of students working on the project. Data from the three classes are collected by means of 11 head-mounted action cameras and 12 video cameras on tripods facing the groups' table.

Data reduction was done according to the study's focus in two steps: (1) all teacher-student conversations that dealt with the topic of the project were transcribed, and (2) interactions where the audio was missing or unclear in part of the interaction were excluded from the study. It resulted in a total of 49 interactions. The interactions were all conducted during the first day of the project during the idea phase. The rest of the time was spent building the model and presenting it to the class. During the first implementation, the idea phase lasted the entire first day, but the time spent on this phase became less and less for each implementation, resulting in a decreasing number of interactions. Presented with preliminary analysis, the teachers both argued that this occurred because they became more secure about their own role in the project for each implementation and were able to guide the students faster in creating good and buildable ideas.

The conversations were analyzed with the use of conversation analysis (CA), a methodological approach to the study of interaction and social action. CA research aims to identify patterns of talk, and by doing so discover and make explicit the practices through which participants produce and understand conduct in conversations (Drew 2004). It builds on the premise that all talk is a kind of action situated within a specific context and designed with an specific attention to that context (Schegloff 1984).

Analysis was based on a detailed transcript according to Jefferson's (2004) manual for transcribing vocal conduct in talk-in-interaction, including detailed descriptions of turns and sequences, onset of simultaneous speech, and emphasis of talk. Descriptions of body orientation, gaze, and gestures are included in the transcriptions.

First, I conducted a *macro analysis* to identify phases and main activities that compose the overall structure appearing in the 49 interactions. Then, I conducted a *microanalysis* of the activities identified during the macro analysis, identifying conversational components within the overall structures that display how teachers respond to students' ideas, and how teachers' action may impact the students' creative abilities.

Results

The macro analysis revealed how teachers respond to students' ideas in two different ways, by showing (1) *display of preference*, and (2) *display of dis-preference*. Further, a micro analysis revealed how teachers displayed notions of preference.

The teachers display *preference* by (1a) encouraging the students to write down or draw their idea (25 of the 49 interactions), or by (1b) showing positive encouragement through verbal or non-verbal utterances (2 of the 49 interactions). Characterizing for both 1a and 1b is that when the teachers have acknowledged the idea as preferred, they do not open up for further dialogue, but turn away from the conversation. The teachers display *dis-preference* by (2a) ignoring the idea or undermining the idea with the use of irony or humor (6 of the 49 interactions), or by (2b) interrupting the students' discussion after detecting a problem with the idea and following up with questions and arguments to make the students realize the problematic aspect of the idea (16 of the 49 interactions). If the students succeed in providing an answer or a new/improved solution that is preferred by the teacher, the rest of the conversation follows the pattern of a preferred idea (1). If the students do not succeed in doing so, the rest of the conversation follows the pattern described in 2a.

The following presents the microanalysis of three extracts from the dataset which best represent the entire dataset and illustrate the different ways teachers respond to students' ideas. They also show how teachers' use of conversational practices to display preference or dis-preference determines how the interactions unfold and impact students' creative process.

That's a good idea – write it down

Extract 1 illustrates (1) display of preference. It illustrates how the teacher hears an idea, evaluates it as preferred and immediately encourages the students to write it down, before turning away from the conversation. T denotes the teacher and S1, S2 and S3 denote the students. Transcript conventions is presented in appendix A.

Extract 1. Display of preference.

1	T	((Stands beside the students' table. She folds her hands slightly and look
2		at S1 with her eyes wide open and eyebrows lifted))
3	S1–3	((Looks up on the teacher))
4	S1	Okay, we have found out that it is going to be like this- like this that can
5		transform carbon dioxide to oxygen. °That [squirts <very>-]°
6	S2	((Reaches out his hand and looks at the teacher))
7	S2	[That] thins out the new oxygen-
8	T	((Looks at S2, still with her hands slightly folded and nods ones while S2 is
9		talking))
10	T	((Smiles and leans over the table and moves the papers on the table around
11		with one hand while S2 is talking))
12	T	=But write it here' Very good?
13	T	((Points at the paper with one finger))
		(0.5)
14	T	Yes? Write down the idea here.
15	T	((Leaves the group))

The teacher initiates the interaction by addressing S1 to make an account of the groups' idea by gazing directly at him, while presenting a curious facial expression (line 1–2). The teacher's gaze functions as a sequence-initiating action which elicit a response from the student (see Stivers and Rossano 2010 for research about how gaze is used as a sequence-initiation action). S1 sees the gaze and recognizes the nomination, and takes the next turn with an acknowledging 'Okay,' in line 4. The other students recognize that S1 has been selected, and do not initiate a response.

In the dataset, there are various examples of similar sequence-initiating actions by the teacher. For example, the teacher enters the conversation with a simple utterance (Now' Look at this') a question (Yes?), or a *wh*-question (What have you decided for? or What is this?) followed by a rising intonation. However, the action is always followed up with the use of gaze to allocate the second turn in the sequence.

Students seem to have a shared expectation of which action is required once the teacher enters the group, since all students being nominated to take the second turn present the same type of response. As in extract 1, the student immediately responds to the teacher's request with an account of the groups' idea (line 4–5).

In line 5, there is a possible completion of the current turn unit (after ' . . . to oxygen.'), making a transition to a new speaker relevant, a transition relevance place (TRP) (see Sacks, Schegloff, and Jefferson 1974). However, S1 continues to speak without any apparent gap, which if present could indicate that the turn-constructional unit (TCU) was completed (see e.g. Goodwin and Heritage 1990; Wooffitt 2005), or without rushing to the next TCU to maintain his turn (see e.g. Sidnell 2010). This indicates that the teacher expects the student to produce an account of the groups' idea in the form of a story. The fact that no other student or the teacher intervenes with the telling after the TCU, also indicates that the story is recognizable as a story to the recipients (Sacks 1995). Telling a story often requires more than one TCU (Mandelbaum 2013), and, therefore provides the student with an opportunity to describe the idea in full.

When telling the story further (line 5), S1 talks with lower volume, indicating that he is insecure about what to say next. S2 notices S1's struggling and by taking the next turn by overlapping talk, he seeks the opportunity to initiate a repair of S1 account, by changing 'That squirts very-' to 'That thins out the oxygen-' (line 7). This repair also displays that S1's original account is in fact the groups' account, making it possible for S2 to intervene in the story. We may, therefore, see it as a way to display mutual orientation to an agreed version of an idea (see Edwards and Mercer 2013). Before S2 intervene in S1's telling, he reaches out his hand and looks at the teacher (line 6). Even though the teacher does not recognize this gesture, it indicates that the student sees the teacher as the one who decides who get to speak next. The students consider the teacher as the official addressee, as they look at the teacher while speaking and address the teacher when taking their turn to speak.

During S2's utterance, the teacher nods her head, which indicates an affiliation with the story. A nod is described as a continuer to the ongoing storytelling (see e.g. Goodwin 1986), and can serve as a preliminary indication of affiliation with the story (Mandelbaum 2013). In this case, however, the teacher interrupts the telling with an encouragement to write down the idea (line 12), emphasizing the encouragement by pointing at the place to write (line 13). She then follows up with an affiliative token, 'Very good', which provides an evaluative stance towards the idea. With this type of utterance, the teacher provides the students with insight into her stance toward their idea (Stivers 2008, 2013). When the students do not immediately write down the idea, the teacher initiates a repair of the previous utterance after a (0.5) gap (line 12–13). She reformulates the encouragement (line 14: 'Yes? Write down the idea here.'), to make sure that the students understand what to do. She then turns away from the conversation and leaves the group, granting no room for the students to reply to the previous turn or continue the conversation with the teacher. After the teacher turns away from the conversation, the students write down the idea and move on to the next idea.

In similar examples in the dataset, the students' further actions are determined by where in the idea process they are, whether they are expected to come up with more ideas or deciding on one idea. If the students are expected to come up with more ideas, the students write down the idea and move on to the next, without further developing the idea. If the students are expected to decide on one idea, the students write down the idea as the one 'preferred' idea without further developing the concepts of the idea. Further developing often occurs during the building of the model, but often in the form of looks and technical solutions.

But what if you run out on batteries?

Extract 2 illustrates (2) a display of dis-preference. The teacher hears an idea, evaluates it as dis-preferred and immediately tries to make the students themselves realize why the idea is flawed. When the students fail in providing the teacher with a preferred answer, the teacher uses humor to indicate that the idea is dis-preferred (2a).

Extract 2 follows the same pattern as extract 1 in the beginning, with the teacher nominating S1 to give an account of the groups' ideas in form of a story (line 1–7). However, in this extract the teacher detects a problem with one of the ideas, the car charged by batteries. The teacher interrupts the story by pointing out the problem ('How do you think you can get access to batteries?') (line 9). The utterance presents

Extract 2. Display of dis-preference.

1	T	((Approaches the group, puts both hands on the table and leans over slightly))
2	T	((Looks at S1))
3	T	Yes?
4	S1	Here's one that transport food = Here's a car that runs on (.) solar panel'
5		Here's a car that's charged by e:: e:: batteries' And here's a thing that e:
6		[heats water-
7	S1	((Points on the drawing))
8	T	((Bends down and sits down by the table)) ((Frowns her forehead))
9	T	[But ho-] How do you think you can get access to batteries?
10	T	((looks at S2))
11	S2	Yes'
12	S3	Yes?
13	S4	Solar panel? You just e::-.
14	S1	No. solar cells then'
15	T	((Looks at S1)) ((Nods))
16	S1	It takes up energy from e: sun' And: and that energy is being transported to
17		the batteries then'
18	T	But what if you run completely out of batteries? If this is going down to
19		collect it, = How long do you think it will take for that to collect it? = If it's
20		going all the way to the Earth and [pick up batteries?
21	S4	((stretches out his arms with palms facing up))
22	S4	[We does not run] out of batteries.
23	T	((Smiles and laughs while gazing at S4)) ((stands up and tries to walk away
24		from the group))

a competing action to the storytelling, and demonstrates dis-preference. The frown on the teachers' forehead (line 8) is a further indication of insecurity or dis-preference.

The teacher nominates S2 to answer the question by gazing directly at her (line 10). S2 takes the turn but does not have a good response to the question and answer 'Yes" with a rising intonation at the end, without continuing the turn (line 11). We then see the group working together to provide a good answer to the teacher in line 12–14. S3 notices how S2 is struggling and nominates herself to the next turn, and answers "Yes?" with a sharp rising intonation at the end. This can seem like a question or a token of insecurity, indicating a struggle to provide an answer. S4 nominates himself to take the next turn and suggest "solar panels" as a solution. S1 repeats the answer with a final rising intonation in the end, suggesting that this is the groups' final answer to the teacher's question.

The teacher gazes at S1 and gives an affirmative nod (line 15), which combined serves as a preliminary affiliation to the answer, and serves as a continuer for S1 to continue her answer (see Mandelbaum 2013). S1 takes the turn and develops her answer further by explaining how the solar panel works and provides energy to the batteries. This indicates that the students have not understood the problematic aspect of the idea, and the teacher initiates a repair of her question from line 9 with a reformulation in line 18, ('But what if you run completely out of batteries?'). She then points out what she thinks is the problematic aspect of the idea by focusing on the distance between the Earth and Mars. She does not open up for the students to provide an answer, but presents the preferred answer herself.

This could have ended the sequence, but S4 breaks out of the expected pattern of the teacher being the provider of speaking rights, and presents an argument that this is not

a problem because they will not run out of batteries (line 21–22). The teacher responds to the utterance with laughter and smiles at S4 (line 23), before moving away from the conversation. The teacher does not succeed in cuing the students to come up with a preferred answer, but uses laughter and humor to display dis-preference in a way that appears less problematic and harmless.

Other examples from the dataset show that when the teacher uses irony or humor to display dis-preference, the students either reject the idea without questions or they continue the discussion using the same arguments presented to the teacher, without being able to reach a conclusion or a common agreement. The discussion can last a long time, often because one of the students is determined to convince the rest of the group why this is a good idea, but the idea is always rejected in the end.

Turning a dis-preferred idea into a preferred idea

Extract 3 is a continuation of extract 2 and illustrates what happens if the students succeed in providing a preferred new or improved idea after the original idea was evaluated as dis-preferred (see 2b).

After making a display of dis-preference and after trying to turn away from the conversation, S2 initiates a new turn by presenting a new answer (line 25). Receiving tokens of disaffirmation is seen as a dis-preferred action for the students, and the student calling back the teacher with a new idea can be a way to repair the dis-preferred idea. The teacher returns to the group and presents a curious facial expression with her eyebrow lifted and eyes wide open (line 26–27). She immediately follows up with an affiliative token in line 29 ('smart"), with rising intonation at the end, indicating that the new idea is preferred.

At the same time as the teacher presents the affirmative token, S4 detects a problem with S2's idea, and by an overlapping talk she initiates a repair of the idea. The repair

Extract 3. Moving from a dis-preferred idea to a preferred idea.

25	S2	It- it- it- it cha:rges while it drives.
26	T	((Returns to the group)) ((Looks at S2 with eyebrows lifted and eyes wide
27		open))
28	S2	((Looks at the teacher))
29	T	[Smart']
30	S4	[Not like that.] We are having rechargeable batteries.
31	T	How exciting?
32	S4	Then there's just – that there is stored a lot like this, stored here as [(xxx)]
33	T	[Actually-]
34		Actually a possible problem that you are solving now? That is access to power
35		or electricity.
36	T	=Just write access to power or electricity. = That you see as
37		a problem.
38	T	((Points at the paper with one finger))
		(0.5)
39	T	Mm.
40	T	((Leaves the group))

indicates that S2's idea does not represent the groups' idea, and this is further evident when S4 returns to their previous idea of batteries. However, she uses S2's idea of recharging and includes it to the previous idea, by introducing rechargeable batteries. The teacher follows up with a new affiliative token 'How exciting', with a sharp rising intonation at the end (line 31), giving further indication of preference.

The affiliative token in line 31 is detected as a continuer by S4, and she continues her turn by telling the teacher more about the idea. The teacher, however, interrupts S4's account with overlapping talk, indicating that the teacher saw the affiliative token in line 31 as her final evaluative stance. The teacher attempts to lift the idea to a higher level according to the task, by pointing towards the problem this idea could help to solve (line 33–35). She quickly extends her turn after a possibly complete TCU has been produced in line 35, by encouraging the students to write down the idea, using both verbal utterance and gesture (line 36–38). This leaves no room for the students to take turns in the conversation, giving further indication that the teacher has given her final evaluative stance. The teacher, then, turns away from the conversation.

Discussion

The teachers' evaluative stance toward the idea determined how they controlled the conversation with the students. Entering the conversation, and throughout the conversation, the teachers positioned themselves as holding 'the speaking right power' (see Cazden 2001; Gardner 2013), by deciding who got to speak with the use of gaze and bodily orientation, and the students trying to provide a united account of their idea, hoping for a positive feedback. The interactions reflected a typical communication pattern in traditional teacher-controlled and teacher-fronted lessons (see e.g. Gardner 2013) following the pattern of an IRE-sequence, where the teacher *initiated* a first-position turn in the form of a request to the student, followed by a *response* from the student, before the teacher *evaluated* the respond (see McHoul 1978; Mehan 1979). Instead of really listening to, and exploring the students' ideas by considering alternative viewpoints and developing then further with 'dialogic and exploratory talk' (Alexander 2006; Mercer 2000), the teachers closed the conversation by indirectly or directly evaluated the ideas.

The analysis also showed that the students accepted the teacher as taking the evaluative stance. For example, when the idea was preferred by a teacher, the students accepted the idea as good and followed the teachers' further instructions. The teacher did not fully function as fellow collaborators and facilitators in exploring and developing ideas (Sawyer 2004; Scardamalia and Bereiter 2006). Taking an evaluative stance, the teacher also reflected the idea that there is one right answer, identified as an 'inhibiting practice' for creativity (Alencar 2002, in Kampylis, Berki, and Saariluoma 2009) and dialogue (Alexander 2006).

If the idea was preferred by a teacher, as seen in extract 1 and extract 3, the teacher gave preliminary indications of affiliation with the idea (nods, and tokens of affiliation), before encouraging the students to write down or draw the idea, using both verbal utterances and gestures. The display of preference was presented without delay and with tokens of affiliation, for example 'very good' pronounced with intensified form, which reflected previous research on the display of affiliative and preference action (Goodwin

and Heritage 1990; Pomerantz and Heritage 2013). Doing so, the teacher controlled the conversation with the students towards his/her own agenda of what a good idea was.

If the idea was dis-preferred by a teacher, as seen in extract 2, the teacher interrupted the student's account of the idea, by pointing out the problem. The teacher's interruptions demonstrated the teacher's power of being the provider of speakers right. The interruption in the form of a question provided the students with an opportunity to repair their idea according to the teacher's preference (see Goodwin and Heritage 1990; Pomerantz and Heritage 2013; Sidnell 2010). If the students failed in providing the teacher with a preferred answer, the teacher initiated a repair of the question, providing further opportunities for the students to come up with an affirmative answer. Asking questions and changing the question slightly to make the students realize why their idea was problematic, made the teacher's agenda more visible. This gave the students an easier task to come up with a preferred answer and reduced the teacher's risk of having to provide negative feedback. If the students were not able to come up with a preferred answer during the repair sequence, the teacher provided the dis-affirmative feedback masked in humor and irony. This defused the negative feedback, making it less harmful to give for the teacher and less harmful to receive for the students, which in turn was a way of minimizing conflict (Goodwin and Heritage 1990; Pomerantz 1984; Pomerantz and Heritage 2013).

Taking an evaluative stance towards students' ideas at this phase in the process seems to conflict with the general aim of the project and the teachers' goal of supporting the students' creativity. Controlling the conversation based on a teacher's evaluation of the students' idea could be seen as problematic related to the Four C-model of creativity (Beghetto and Kaufman 2007). Taking an evaluative stance seems to minimize the opportunity for the teacher to listen and explore the students' ideas, which was a premise for being able to help students in converting their mini-c ideas into little-c ideas (Beghetto 2007a; Beghetto and Kaufman 2007). This could have affected the students' creative process in a way that they did not see the point of taking the necessary risk related to expressing their creative thinking (Hathcock et al. 2015). The teachers also evaluated the ideas from their level of creative magnitude, that could risk the students' ideas as being devalued (James 2015). It also resulted in the teacher spending more time on the dis-preferred ideas than preferred ideas, missing out the opportunity for the students to further develop 'good' ideas together with a more competent teacher. Providing opportunity for students to make a repair of dis-preferred ideas could, however, also be seen as cuing the students within task constraints (see Beghetto 2007a). This seemed to work, because students often were able to provide an improved version of the idea. However, the idea was improved according to the teacher's preference, making it seem as students were trying to guess what the teacher wanted to hear (Black and Wiliam 2010).

The teachers' evaluative stance so early in the process could be a result of the need to complete the project in time. Completing and encouraging students to follow the 'right' idea and cuing them to write down or draw the idea, encouraged them to move on to the next phase of the project. By doing so, the students could provide a visible result of the process, and the teachers saw the phase as complete. The teachers seemed to have a product-oriented focus throughout the project, as they put more emphasis and time on the building and finishing of the model, rather than developing ideas, thought, and

arguments on a higher creative level. This indicates that the teachers focused more on the product aspect of creativity, than the process aspect of creativity (Rhodes 1961). The teachers' response when presented with the fact that they spent less and less time on the idea phase for each implementation (because of increasing self-confidence about what to do to make students create good ideas) also points to a product-oriented focus.

Conclusion and implications

Teachers display of preference towards students' ideas affects the interaction and limits further development. The idea phase ends with the display of preference where students are allowed to move on to the building phase of the project, or the idea is rejected after a display of dis-preference. If the teachers make more time to listen and understand the students' ideas, the quality of the feedback could be enhanced and students are supported in converting their mini-c creative ideas into little-c creative ideas. Ideas on a higher creative and scientific level.

Despite the aim of the project and the preparation preceding the project, this study has shown that the teachers struggle to function as fellow collaborators and facilitators through dialogues. This indicates that teachers need more training, and more explicit practice, in ways to promote students' creativity. It also shows that it is difficult to make time to support students' creativity within such project, where there are many students per teacher in the classroom. In a classroom context, it is important to see all students and follow up all groups, and this may have conflicted with the aim of focusing thoroughly on all ideas.

Through their actions and through conversation with the researcher, the teachers presented a product-oriented focus. Rushing the students towards the building phase reflects an underlying fear of not being able to complete the project in time. Together with the underlying time-constraint, the fear of not being able to present a finished product may be hard to swallow for teachers as well as students, putting further emphasis on the product aspect of the project.

The teachers did, however, volunteer and manage to make room in their busy schedule for a three-day project, plus time before the project started, which made it clear that they saw creativity as an important skill to integrate into science. The result from this study indicate, showever, that if we are to achieve the goals of the 21st century skills of developing students' creativity, we need to make change to the underlying school culture in the way we value and assess finished products and make more time to focus on the creative process and how students engage in the creative act. Teachers may need more explicit training in how to support students' creativity through dialogue, but to be able to implement it in their classrooms, there is a need for fewer students per teacher.

Disclosure statement

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References

Alencar, E. 2002. "Mastering Creativity for Education in the 21st Century." In Proceedings of the 13th biennial world conference of the world council for gifted and talented children, Istanbul, Turkey.

Alexander, R. J. 2006. *Towards Dialogic Teaching*. 3 ed. New York: Dialogos.

Amabile, T. M. 1998. *How to Kill Creativity*. Vol. 87. Boston, MA: Harvard Business School Publishing.

Andiliou, A., and P. K. Murphy. 2010. "Examining Variations among Researchers' and Teachers' Conceptualizations of Creativity: A Review and Synthesis of Contemporary Research." *Educational Research Review* 5 (3): 201–219. doi:10.1016/j.edurev.2010.07.003.

Applebee, A. N., J. A. Langer, M. Nystrand, and A. Gamoran. 2003. "Discussion-based Approaches to Developing Understanding: Classroom Instruction and Student Performance in Middle and High School English." *American Educational Research Journal* 40 (3): 685–730. doi:10.3102/00028312040003685.

Bandura, A., W. Freeman, and R. Lightsey. 1999. *Self-efficacy: The Exercise of Control*. New York: Springer.

Barbot, B., M. Besançon, and T. Lubart. 2015. "Creative Potential in Educational Settings: Its Nature, Measure, and Nurture." *Education 3–13* 43 (4): 371–381. doi:10.1080/03004279.2015.1020643.

Beghetto, R. A. 2007a. "Does Creativity Have a Place in Classroom Discussions? Prospective Teachers' Response Preferences." *Thinking Skills and Creativity* 2 (1): 1–9. doi:10.1016/j.tsc.2006.09.002.

Beghetto, R. A. 2007b. "Ideational Code-switching: Walking the Talk about Supporting Student Creativity in the Classroom." *Roeper Review* 29 (4): 265–270. doi:10.1080/02783190709554421.

Beghetto, R. A., and J. C. Kaufman. 2007. "Toward A Broader Conception of Creativity: A Case For" Mini-c" Creativity." *Psychology of Aesthetics, Creativity, and the Arts* 1 (2): 73. doi:10.1037/1931-3896.1.2.73.

Beghetto, R. A., and J. C. Kaufman. 2014. "Classroom Contexts for Creativity." *High Ability Studies* 25 (1): 53–69. doi:10.1080/13598139.2014.905247.

Black, P., and D. Wiliam. 2010. "Inside the Black Box: Raising Standards through Classroom Assessment." *Phi Delta Kappan* 92 (1): 81–90. doi:10.1177/003172171009200119.

Burnard, P., and J. White. 2008. "Creativity and Performativity: Counterpoints in British and Australian Education." *British Educational Research Journal* 34 (5): 667–682. doi:10.1080/01411920802224238.

Cazden, C. B. 2001. *Classroom Discourse: The Language of Teaching and Learning*. 2nd ed. Portsmouth: Heinemann.

Cole, D. G., H. L. Sugioka, and L. Yamagata-Lynch. 1999. "Supportive Classroom Environments for Creativity in Higher Education." *The Journal of Creative Behavior* 33 (4): 277–293. doi:10.1002/j.2162-6057.1999.tb01407.x.

Craft, A. 2005. *Creativity in Schools: Tensions and Dilemmas*. London, UK: Taylor and Francis.

Cremin, T., P. Burnard, and A. Craft. 2006. "Pedagogy and Possibility Thinking in the Early Years." *Thinking Skills and Creativity* 1 (2): 108–119. doi:10.1016/j.tsc.2006.07.001.

Cropley, A. J. 1997. "Fostering Creativity in the Classroom: General Principles." In *Creativity Research Handbook*, edited by M. A. Runco, 83–114. Vol. 1. Cresskill, NJ: Hampton Press.

Cropley, A. J. 2011. "Teaching Creativity." In *Encyclopedia of Creativity*, edited by M. A. Runco and S. R. Pritzker, 435–445. Vol. 2. London, UK: Elsevier.

Drew, P. 2004. "Conversation Analysis." In *Handbook of Language and Social Interaction*, edited by K. L. Fitch and R. E. Sanders, 71–102. Mahwah, NJ: Lawrence Erlbaum Associates.

Eckhoff, A. 2011. "Creativity in the Early Childhood Classroom: Perspectives of Preservice Teachers." *Journal of Early Childhood Teacher Education* 32 (3): 240–255. doi:10.1080/10901027.2011.594486.

Edwards, D., and N. Mercer. 2013. *Common Knowledge: The Development of Understanding in the Classroom*. New York, NY: Routledge.

Fleith, D. D. S. 2000. "Teacher and Student Perceptions of Creativity in the Classroom Environment." *Roeper Review* 22 (3): 148–153. doi:10.1080/02783190009554022.

Gardner, R. 2013. "Conversation Analysis in the Classroom." In *The Handbook of Conversation Analysis*, edited by J. Sidnell and T. Stivers, 593–611. West Sussex, UK: Blackwell Publishing

Goodwin, C. 1986. "Between and Within: Alternative Sequential Treatments of Continuers and Assessments." *Human Studies* 9 (2–3): 205–217. doi:10.1007/BF00148127.

Goodwin, C., and J. Heritage. 1990. "Conversation Analysis." *Annual Review of Anthropology* 19 (1): 283–307. doi:10.1146/annurev.an.19.100190.001435.
Gregory, E., M. Hardiman, J. Yarmolinskaya, L. Rinne, and C. Limb. 2013. "Building Creative Thinking in the Classroom: From Research to Practice." *International Journal of Educational Research* 62: 43–50. doi:10.1016/j.ijer.2013.06.003.
Hathcock, S. J., D. L. Dickerson, A. Eckhoff, and P. Katsioloudis. 2015. "Scaffolding for Creative Product Possibilities in a Design-based STEM Activity." *Research in Science Education* 45 (5): 727–748. doi:10.1007/s11165-014-9437-7.
Hu, W., and P. Adey. 2002. "A Scientific Creativity Test for Secondary School Students." *International Journal of Science Education* 24 (4): 389–403. doi:10.1080/09500690110098912.
James, M. A. 2015. "Managing the Classroom for Creativity." *Creative Education* 6 (10): 1032. doi:10.4236/ce.2015.610102.
Jefferson, G. 2004. "Glossary of Transcript Symbols with an Introduction." In *Conversation Analysis. Studies from the First Generation*, edited by G. H. Lerner, 13–31. Amsterdam, Netherlands: John Benjamins Publishing Company.
Kampylis, P., E. Berki, and P. Saariluoma. 2009. "In-service and Prospective Teachers' Conceptions of Creativity." *Thinking Skills and Creativity* 4 (1): 15–29. doi:10.1016/j.tsc.2008.10.001.
Lee, L. K. W., N. K. Goh, L. S. Chia, Y. K. Wan, and C. E. Lee. 2006. "Some Difficulties Encountered in Fostering Creativity in Science Education." International Science Education Conference, Singapore, November 22–24.
Lee, Y.-A. 2007. "Third Turn Position in Teacher Talk: Contingency and the Work of Teaching." *Journal of Pragmatics* 39 (6): 1204–1230. doi:10.1016/j.pragma.2006.11.003.
Lemke, J. L., and J. Green. 1990. "Talking Science: Language, Learning, and Values." Ablex Publishing Corporation. https://books.google.no/books?id=FkoPAQAAMAAJ
Lerner, G. H. 1995. "Turn Design and the Organization of Participation in Instructional Activities." *Discourse Processes* 19 (1): 111–131. doi:10.1080/01638539109544907.
Mandelbaum, J. 2013. "Storytelling in Conversation." In *The Handbook of Conversation Analysis*, edited by J. Sidnell and T. Stivers, 492–507. West Sussex, UK: Blackwell Publishing.
McHoul, A. 1978. "The Organization of Turns at Formal Talk in the Classroom." *Language in Society* 7 (2): 183–213. doi:10.1017/S0047404500005522.
McHoul, A. 1990. "The Organization of Repair in Classroom Talk." *Language in Society* 19 (3): 349–377. doi:10.1017/S004740450001455X.
Mehan, H. 1979. *Learning Lessons*. MA: Harvard University Press Cambridge.
Mercer, N. 2000. *Words and Minds: How We Use Language to Think Together*. London, UK: Routledge.
Newton, D. P. 2012. *Teaching for Understanding*. 2nd ed. London, UK: Routledge.
Plucker, J. A., R. A. Beghetto, and G. T. Dow. 2004. "Why Isn't Creativity More Important to Educational Psychologists? Potentials, Pitfalls, and Future Directions in Creativity Research." *Educational Psychologist* 39 (2): 83–96. doi:10.1207/s15326985ep3902_1.
Pomerantz, A. 1984. "Agreeing and Disagreeing with Assessments: Some Features of Preferred/disprefrerred Turn Shapes." In *Structures of Social Action*, edited by J. Atkinson and J. Heritage, 57–101. Cambridge, UK: Cambridge University Press.
Pomerantz, A., and J. Heritage. 2013. "Preference." In *The Handbook of Conversation Analysis*, edited by J. Sidnell and T. Stivers, 210–228. West Sussex, UK: Blackwell Publishing.
Raths, J. 2001. "Teachers' Beliefs and Teaching Beliefs." *Early Childhood Research and Practice* 3 (1).
Rejskind, G. 2000. "TAG Teachers: Only the Creative Need Apply." *Roeper Review* 22 (3): 153–157. doi:10.1080/02783190009554023.
Rhodes, M. 1961. "An Analysis of Creativity." *The Phi Delta Kappan* 42 (7): 305–310.
Runco, M. A. 2004. "Everyone Has a Creative Potential." In *Creativity: From Potential to Realization*, edited by R. J. Sternberg, E. L. Grigorenko, and J. L. Singer, 21–30, Washington DC: American Psychological Association.
Sacks, H., G. Jefferson, and E. Schegloff. 1995. *Lectures on Conversation* (One paperback vol, ed.). Oxford, UK: Blackwell Publishing.
Sacks, H., E. Schegloff, and G. Jefferson. 1974. "A Simplest Systematics for the Organization of Turn-taking in Conversation." *Language* 50 (4): 696–735. doi:10.1353/lan.1974.0010.

Sawyer, R. K. 2004. "Creative Teaching: Collaborative Discussion as Disciplined Improvisation." *Educational Researcher* 33 (2): 12–20. doi:10.3102/0013189X033002012.
Scardamalia, M., and C. Bereiter. 2006. "Knowledge Building." In *Cambridge Handbook of the Learning Sciences*, edited by R. K. Sawyer, 97–115. New York: Cambridge University Press.
Schegloff, E. 1984. "On Some Questions and Ambiguities in Conversation." In *Structures of Social Action*, edited by J. Atkinson and J. Heritage, 28–52, Cambridge: Cambridge Univ. Press.
Sidnell, J. 2010. *Conversation Analysis: An Introduction*. Malden, Mass: Wiley-Blackwell.
Sternberg, R. J., and T. I. Lubart. 1999. "The Concept of Creativity: Prospects and Paradigms." In *Handbook of Creativity*, edited by R. J. Sternberg, 3–15, New York: Cambridge University Press.
Sternberg, R. J., and E. L. Grigorenko. 2004. "Successful Intelligence in the Classroom." *Theory into Practice* 43 (4): 274–280. doi:10.1207/s15430421tip4304_5.
Sternberg, R. J., and W. M. Williams. 1996. *How to Develop Student Creativity*. Alexandria, VA: ASCD.
Stivers, T. 2008. "Stance, Alignment, and Affiliation during Storytelling: When Nodding Is a Token of Affiliation." *Research on Language and Social Interaction* 41 (1): 31–57. doi:10.1080/08351810701691123.
Stivers, T. 2013. "Sequence Organization." In *The Handbook of Conversation Analysis*, edited by J. Sidnell and T. Stivers, 191–209, West Sussex, UK: Blackwell Publishing .
Stivers, T., and F. Rossano. 2010. "Mobilizing Response." *Research on Language and Social Interaction* 43 (1): 3–31. doi:10.1080/08351810903471258.
UNESCO. 2013. "Twenty-First Century Skills." Accessed 3 March http://www.ibe.unesco.org/en/glossary-curriculum-terminology/t/twenty-first-century-skills
Wooffitt, R. 2005. *Conversation Analysis and Discourse Analysis: A Comparative and Critical Introduction*. London, UK: Sage.

Appendix A. Transcription conventions

(0.5)	Time gap, one-tenth of a second
(.)	Pause in talk, less than two-tenth of a second
[]	Marks overlapping talk
=	'Latching' between utterances
'	Slight rising intonation
?	Rising intonation, not necessarily a question
.	Falling or final intonation, not necessary the end of a sentence
,	'Continuing' intonation, not necessarily a close boundary
::	Stretching of the immediately preceding sound.
Word	Stress or emphasis of underlined item
°word°	Softer or quieter tone than otherwise
<word>	Slower speech rate than otherwise
>word<	Faster speech rate than otherwise
-	Cut-off or self-interruption in the prior word or sound
(xxx)	Inaudible talk
(())	Transcriber's comments and description of non-verbal activities

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