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# PhD Thesis

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# (Non)participation in the science classroom – A Longitudinal Study of Students' Participation and Identity-work in the Transition Process from primary to secondary school

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## Abstract

This thesis is based on four articles, which aim to investigate students' participation opportunities in science education. The thesis was carried out at the time where students go from the combined science subject, nature/technology, to three science subjects, biology, geography and physics/chemistry, a transition where, both nationally and internationally, there is a decline in students' interest and a change in their attitudes towards sciences. This thesis has focused on understanding what creates opportunities for participation and what prevents participation, and what significance this may have for students' identity work in science. The thesis' results are based on a longitudinal study that mainly took place in two schools, where I followed two classes throughout their year in sixth grade and the transition to seventh grade.

The first of the articles examines the possibilities of combining qualitative research with creative, visual and performative approaches to produce empirical material. The article is based on a systematic review that showed that only a few studies within science educational research used these creative methods. The article highlights the potential benefits of using creative approaches within educational research in STEM, but also looks at the limitations and challenges that may be present in using these creative approaches.

The second of the articles is based on ethnographic fieldwork and draws on empirical material from the period when the two school classes were in the sixth grade. From the observations it stood out that the student's participation was low; this included students being passive, quiet, and very little engaged in science teaching. The article examines what contributes to this low participation. The analysis shows that non-participation is produced through positions of exposure, being overlooked or being disciplined. Furthermore, the analysis indicates that these positions of non-participation are often difficult to negotiate, tend to remain stable over time and relate to social markers such as gender, race/ethnicity and social background.

The third article examines the transition from sixth to seventh grade and is based on four cases with four students and their experiences with science teaching and their ways of participating. Here we see how traditional classroom teaching excludes some students from participating, while group work creates some more active positions, but does not necessarily support the student in working with science-related competencies. We also see how performing as a good science student is about being able to say the right words and give the

right answers and how interest in science-related content is not contextualized, as no connection is created between the student and the content of the subject. In the article, we show how, in the transition, both continuity and changes occur in the students' experience of science teaching.

The last article analyzes the experiences of science teachers in seventh grade on the basis of interviews. We have investigated how the teachers act in relation to some structural and disciplinary factors and are subjugated to cultural notions that affect their relationships with the students. We can e.g. see how structures prevent science teachers from being active in creating different positions for students to occupy, how the teachers' ideas about students being involved in science-related content outside of school shaped some opportunities to be positively recognized in science education, how the risk of disciplining students into positions where they are not recognized as competent enough led teachers to organize a controlled science education, and how all of this together helps to shape positions where teachers are less responsible for creating opportunities for their students in science. The results point to a structure that seems stiff and does not support students in a meaningful relationship with science.

## Resume

Denne afhandling er baseret på fire artikler, som har til formål at undersøge elevers deltagelsesmuligheder i naturfagsundervisningen. Undersøgelsen er foretaget på det tidspunkt, hvor elever går fra at have haft natur/teknologi til at skulle have biologi, geografi og fysik/kemi. Det er tale om en overgang, hvor man både nationalt og internationalt ser, at der sker et fald blandt elevers interesse og en forandring i deres holdninger til naturfagene. Denne afhandling har haft fokus på at forstå, hvad der skaber mulighed for deltagelse, og hvad der forhindrer deltagelse, og hvad det kan have af betydning for eleveres identitetsarbejde i naturfagene. Afhandlingens resultater bygger på et longitudinalt studie, der hovedsageligt er foregået på to skoler, hvor jeg har fulgt to klasser igennem deres år i sjette klasse og i overgangen til syvende klasse.

Formålet med denne introduktion er at præsentere det overordnede formålet med afhandlingen, det landskab afhandlingen placerer sig i, mine metodiske valg og en diskussion samt de fire artikler. Tre af afhandlingens fire artikler tager forskellige perspektiver på det overordnede formål med afhandlingen. Den sidste af de fire artikler er et review med fokus på anvendelsen og mulighederne ved at bruge kreative tilgange til produktion af empirisk materiale.

Den første af artiklerne undersøger de muligheder, der er ved at kombinere kvalitativ forskning med at anvende kreative, visuelle og performeriske tilgange til at producere empirisk materiale. Artiklen tager afsæt i et systematisk review, der viste, at kun få studier inden for uddannelsesforskning i STEM-fagene gjorde brug af disse kreative metoder. Ved at bruge en tilgang kendt som the snowball approach blev litteratur fra andre forskningsområder, som anvendte disse metoder, gennemgået, og her blev der identificeret fire temaer: viden formidlet gennem artefakter, non-verbalt sprog, udfordring af magtpositioner og tid til at reflektere. Artiklen fremhæver de potentielle fordele ved at anvende disse kreative tilgange inden for uddannelsesforskning i STEM, men kigger også på begrænsningerne og udfordringerne, der kan være ved at bruge disse kreative tilgange.

Den anden af artiklerne er baseret på det etnografiske feltarbejde og trækker på empirisk materiale fra den periode, hvor de to skoleklasser gik i sjette klasse. Her fremstod det, hvordan elevernes deltagelse i naturfagsundervisningen var lav. Artiklen undersøger, hvad der er med til at skabe denne lave deltagelse. Analysen viser, at manglende deltagelse bliver produceret gennem positioner af eksponering, at blive overset eller at blive disciplineret.

Endvidere peger analysen på, at disse positioner ofte er svære forhandle og har en tendens til at forblive stabile over tid. Disse positioner af udeblivende deltagelse relaterer sig til sociale markører som køn, race/etnicitet og social baggrund.

Den tredje artikel undersøger overgangen fra sjette til syvende klasse, hvor elever går fra at være blevet undervist i natur/teknologi til at blive undervist i fysik/kemi, biologi og geografi. Artiklen bygger på fire cases, der går i dybden med fire elever og deres oplevelser med science-undervisningen og deres måder at deltage på. Her ser vi, hvordan traditionel klasseundervisning ekskluderer nogle elever fra at deltage, fordi deltagelse sker på en bestemt måde, mens gruppearbejde skaber nogle mere aktive positioner, men ikke nødvendigvis støtter eleven i at arbejde med science-relaterede kompetencer. Det bliver ligeledes tydeligt, i den måde eleverne fortolker det at være god i naturfagsundervisningen, men også deres måde at deltage i undervisningen, hvor det at performe god science-elev handler om at kunne sige de rigtige ord og give de rigtige svar. Samtidig ser vi, hvordan interesse for science-relateret indhold ikke bliver kontekstualiseret, da der ikke bliver skabt sammenhæng mellem eleven og faget og fagets indhold. I artiklen viser vi, hvordan der i overgangen både sker kontinuitet og forandringer i elevernes oplevelse af science-undervisningen. Kontinuiteten knytter sig bl.a. til den måde, eleverne forvalter skolekravene på, men også deres måder at deltage på. Forandringerne sker bl.a. ved, at eleverne i varieret grad begynder at agere anderledes inden for skolens rammer og forventninger.

Den sidste artikel analyserer på baggrund af interviews naturfagslæreres erfaringer med at undervise i 7. klasse, hvor eleverne går fra at have natur/teknologi til at blive undervist i de tre naturfag: Fysik/kemi, biologi og geografi. Vi har undersøgt, hvordan lærerne agerer i forhold til nogle strukturelle og disciplinære faktorer og er underlagt kulturelle forestillinger, der påvirker deres relationer til eleverne. Vi kan bl.a. se, hvordan strukturer forhindrer naturfagslærere i at være aktive i at skabe forskellige positioner, som eleverne kan indtage, hvordan lærernes idéer om elevernes involvering i naturfagsrelateret indhold uden for skolen formede nogle muligheder for at blive positivt anerkendt i naturfagsundervisningen, hvordan det, at elever kan blive opfattet som mindre kompetente af lærerne, skaber en mere kontrolleret naturfagsundervisning, og hvordan det hele til sammen skaber en undervisningsform, hvor lærere er mindre ansvarlige for at skabe muligheder for deres elever i naturfag. Resultaterne peger på en struktur, der virker stivnet og ikke understøtter eleverne i et meningsfuldt tilhørsforhold til naturvidenskab.

# Contents

# Introduction

## Navigating this thesis

This thesis, a culmination of extensive research, presents four significant articles. Two articles have already been accepted, while the others are submitted. Beyond these articles, I will introduce the overarching purpose of this thesis, its academic landscape, my chosen methodology, and a detailed discussion. This introduction lays the groundwork for the foundation of the articles and unites them in a discussion that can point to future implications in science education.

As it will appear, the results of this thesis are based on a longitudinal study that mainly takes place in two schools, where I have followed two classes throughout their year in sixth grade and the transition to seventh grade. The fact that the project took place in a dynamic field influenced the processes and purpose of this project. For one thing, is how I structured the thesis to progress; another is how it unfolded while I was in the field, where I had to interact with people who think, feel, say and act, and how all that changes, becomes challenged and negotiated in conjunction with other individuals and the environments. Based on these processes and interactions, this introduction aims to show the journey that has formed the four articles.

Three of the four articles in this thesis are rooted in the longitudinal study, each offering a unique perspective of the overall aim. In this introduction, I delve into the methodological choices and processes that have been significant in producing the empirical material for these three articles. The articles have a common theoretical approach, but each also adopts different theoretical approaches, which will be expounded upon in the respective articles. The final article is a review focusing on the application and potential of creative approaches in producing empirical material.

The introduction begins by focusing on the problem that the thesis is based on and the context in which it takes place. Next, I present the field where the project takes place and examine some existing knowledge. The presentation of relevant knowledge and my theoretical approach helped to sharpen the purpose of the project's investigation, and from this, three sub-questions were formulated. Next, my methodological choices and how they have supported and enabled the investigation of this thesis' purpose are presented. Finally, there is a discussion that goes across the three empirical articles. Besides that, there are methodological reflections and a conclusion.

## Framing the problem

As the sun rises, the undulating landscape comes into focus, with brownish-yellow tones gradually dispelling the darkness of the night. The peaceful country setting allows me to relax, feeling time slow down compared to the bustling city life of Copenhagen, where I spend my days as a PhD student. As I drive to one of the schools participating in my project on this autumn day, I watch as houses appear in the distance, transforming the undulating landscape into a small town. The silence is interrupted by the sounds of buses, cars, and distant voices formed by children of various ages as they head to the same destination as me. They are ready for another school day on this picturesque autumn morning.

It is my first day at one of the three schools that has agreed to participate in my project. I have come early in the morning to meet with the science teacher. We meet in the teacher's preparation room, where we get introduced and talk about how I would follow the class for the next 3 weeks. We briefly discuss the science subject and what they are currently working on. During the talk, the teacher singles out one of the students as particularly good—a student who has shown excellent skills in using scientific language. After our talk, we move towards the classroom, and here we are, met by the many voices and movements of students talking and fooling around.

Stepping into the classroom feels like entering a different world where relationships are formed, maintained, or dismissed. It is the students' everyday life, and they are eager to share their experiences after the weekend. One student quickly asks who I am and what my role is, but the teacher gently redirects the attention to the class, fostering a sense of inclusivity and engagement.

The teacher asks the students to calm down so that the class can start and then gives me the floor; I introduce myself and tell them who I am and what I will be doing at school. I tell them I am a researcher and ask them if they know what it is. One of the boys speaks and says that it is someone who can examine people's behaviour. I picked up the answer and led it to the fact that I am at the school to understand what it is like to be a sixth grader, with a particular focus on science. I tell them that since it has been many years ago for me, I have decided to visit them because they know best what it means to be a sixth-grade student.

After the presentation, we go to the school's science room. On the way down, I walk with two girls from the class. I ask them if they like having natural science and technology, to which Sonja replies, 'It is okay', and elaborates that she has liked it most when they do experiments.

However, the last time they did experiments was in fifth grade, and it was something with magnets. Alma adds that they have done various experiments with magnets.

We enter the class, and the teacher and the students quickly find their seats. The classroom has tables facing the lecture hall and a blackboard hanging behind it. As the class progresses, the teacher and students stay at the same spots they entered initially. Science teaching is organised by the teacher being in control of time and work, and the students follow this rhythm of receiving, working, and sharing. Several students seem more active or preoccupied with other non-science-related activities during the lesson. Even though it is my first time observing a science class, and nothing is certain, the many passive students reveal a bodily experience that gives a strong feeling that it is not the first time they have taken such positions. It is an experience that fosters curiosity and wonder on behalf of the students but also arouses a strong interest in investigating what creates these positions. After an hour and a half of teaching, the class ends. I notice students who have been mainly inactive slip out of class and prepare for the day's first break, ready to play ball or go for a walk – during which time they can activate their bodies and form relationships.

(Fieldnotes and reflections, 2021)

Despite being the first observation out of many, the impact of this day has remained with me. I could not let go of the students I had observed being quiet, passive, or not responding to the ongoing teaching, and at that time, I was left with a feeling that these were the conditions for some students to be science learners. I made similar observations subsequently, and I have used this empirical material set as an introduction to this thesis because it significantly influenced the project and the questions that followed.

Although this observation became significant, I did not encounter the field unknowingly. In recent decades, interest in science education has increased nationally and internationally as some competencies to solve global challenges, such as climate change, healthy conditions, and energy supplies, are developed and learned in science (Becker, 2024; Centers for Disease Control and Prevention, 2021). The focus has been on increasing the number of young people choosing an educational and career path in science (European Communities., 2007). From that perspective, science teaching has gained sustained attention as a place to inspire and teach students about the potential and relevance of science. Even though there has been noted an increase in students choosing a STEM (Science, technology, engineering, and mathematics) education, this seems to remain in some areas where others are still lacking, and issues related to diversity in STEM-related education continue to be a problem (European Schoolnet, 2023; The Education Hub, 2021). Similarly, it is not only about increasing the number of young people choosing an educational and career path in science but also strengthening children and young people to evolve an individual sense of science and to maintain a democratic voice in a world affected and formed by scientific challenges (Commission, 2023; Dawson, 2018; Nicolaisen et al., 2023).

From this increased focus, and as particularly relevant for this project, it has been found that there is a drop in students' attitudes towards science during secondary school. Although students identify science as relevant, they see less of an opportunity for themselves in science (Jenkins & Nelson, 2005; Osborne et al., 2003). Likewise, the British project ASPIRES explored hundreds of British students and their relationship to science and found that students think they learn interesting things in science, that their parents see science as necessary, and that scientists do essential work. However, across different ages, the students did not aspire to be scientists (Archer et al., 2013).

In tracing these limitations of students transforming science aspirations, the age group of 10–14 years is a critical period in picturing the pursuit of a career in science (DeWitt & Archer, 2015; Tai et al., 2006). Developing positive attitudes towards science is important as they influence and shape the aspirations of students to learn science; if challenged by less positive attitudes, there is a risk of a gap in academic achievement (Barmby et al., 2008; DeWitt & Archer, 2015). Similarly, when students express positive attitudes towards school science, it is not guaranteed that they will translate into aspirations for future science-related careers (DeWitt et al., 2014).

What stands out is that interest and positive attitudes are present, although, for some students, that does not make them aspire to follow a trajectory in science. These studies have shown that it is not only about interest but also whether students can see themselves as pursuing a career path to become a scientist. This contributes to moving the perspective beyond interest and exploring other aspects of what causes the shift in attitudes among students progressing from primary to secondary school.

In relation to what I have presented here, my project actually aimed to investigate the transition from sixth to seventh grade because there is a significant shift in science teaching at that time. Here, students move from a combined science subject to being introduced to multiple academically oriented science disciplines, namely biology, geography, and physics/chemistry. Therefore, I investigated the significance of the transition regarding students' participation and attitudes in sciences, focusing on inclusion and exclusion processes that can arise in the interaction between students, teachers, subjects, and across settings. This approach was also influenced by the challenges identified in the transition, such as the lack of coordination between the science teacher teams in sixth and seventh grades (Sølberg & Trolle, 2013).

My numerous observations of passive students sparked a sense of curiosity and wonder. I was intrigued by what factors contributed to the low participation in the class. I noticed that participation was particularly low during lectures, but also that it was less flexible and more defined during other activities such as group work. These reflections led me to revisit my aim. Based on the insight my observations had given me, I found it relevant to take a step back and to look more broadly at participation. What creates participation, and even more so, what does not? How might we better understand what low or absent participation is a response to?

As described in the literature, factors beyond a lack of interest contribute to the decline in interest. While decreased interest may be one explanation for why people lose interest in a particular subject or activity, that is not the whole picture. Based on that, I changed my aim to focus more broadly on participation. So, instead of functioning as a foreground for the project, the transition came to function as a background. I generated the following aim:

> This project explores students' participation in science classrooms, focusing on the processes that facilitate or prevent inclusion and exclusion to understand what that means for students in shaping science identities as they progress from sixth to seventh grade.

I will return to my aim after the theoretical chapter. I will unfold the aim after presenting the field from which this study was inspired, particularly the framework of science identity, and my epistemological approach. In the next chapter, I introduce the context of this study to settle the science from which this study has taken place.

## Context of study

As my study examines primary and secondary school students, this chapter provides an introduction to Danish public school (*Folkeskolen*). I provide a short and general presentation of the institution followed by a thorough presentation of the science subjects and how they are structured regarding Danish legislation.

In Denmark, the primary and lower secondary education system is unitary, meaning that students attend the same class from first to ninth grade. There may be exceptions, such as mixed classes during the transition from sixth to seventh grade, as some schools receive students from other schools that only go up to sixth grade. Likewise, there is a national curriculum ensuring that all students receive the same education (Børne- og Undervisningsministeret, 2023a).

*Folkeskolen* was founded in 1814, and all students were lawfully entitled to seven years of education (Ekholm et al., 2004). Since its establishment, the purpose has been to focus on educating and forming good citizens through teaching, which has varied in adapting to the surrounding society (Hermann, 2007). Today, there are 1066 registered *Folkeskoler* in Denmark (Børne- og Undervisningsministeriet, 2023). The goal of these schools is to prepare all students with the required knowledge and skills for their educational advancement, to foster curiosity for learning, and to cultivate Danish and other national and global cultures. Similarly, there is a focus on the importance of students engaging with nature – all to prepare each student for future education (Retsinformation, 2021). In addition, all schools follow a common goal along with standards of requirements for the subjects, the purpose of the subjects, and guidelines for school leadership and organisation. However, the responsibility to comply with these conditions is placed on the municipalities (Retsinformation, 2021). In Denmark, *Folkeskolen* is the most common form of schooling for children and young people (6–16 years of age), although other alternatives such as homeschooling or private schools are available given the fact that teaching is mandatory but school is not (Børne- og Undervisningsministeret, 2023a). In light of this, 80%–90% of all Danish children begin their schooling in *Folkeskolen* each year (Sievertsen, 2015). For children attending *Folkeskolen*, many years lay ahead in their developing of knowledge and competencies in the areas of:

> *Humanities:* Danish, English, Christian studies, history, and social studies;
>
> *Science:* mathematics, natural science/technology, geography, biology, and physics/chemistry; and

> *Practical/Creative*: physical education, music, visual arts, design, wood and metalwork, home economics, and food Science (Børne- og Undervisningsministeret, 2023c).

The Danish *Folkeskolen* includes one year of preschool (nursery class), first to ninth grades (primary and lower secondary school) and a one year of tenth grade. From first to ninth grades, the school is structured as a three-level system: elementary school (first to third grades), middle school (fourth to sixth grades), also known as primary school, and then lower secondary school (seventh to ninth grades) (Børne- og Undervisningsministeret, 2023a). Between each level, students encounter changes, particularly during the transition from sixth to seventh grade as the students move from the last year of middle school to the first year of lower secondary school. At this time, there are significant changes in settings, curriculum, and teaching practices (Styrelsen for Undervisning og Kvalitet, 2019).

| | **Level** | **Age** |
|---|---|---|
| **Preschool** | Nursery class | 6–7 years old |
| **Elementary school** | First to third grades | 7–9 years old |
| **Middle school** | Fourth to sixth grades | 10–12 years old |
| **Lower secondary school** | Seventh to ninth grades | 13–15/16 years old |

### The transition from the combined science subject to the more academically oriented science subjects

As mentioned, I followed the participants in this project as they progressed from sixth to seventh grade. This transition indicates the completion of their primary school time and the beginning of the three last years of *Folkeskolen* (lower secondary school). I will focus on changes linked to science teaching, although it is worth mentioning some of the more general adjustments span all school disciplines. Here, the students are introduced to some structural conditions as they are slowly introduced to the grading system they will face in eighth and ninth grades (Børne- og Undervisningsministeret, 2023b) and a change in setting (Danmarks Evalueringsinstitut (EVA), 2007). Conversely, students in lower secondary school will be evaluated differently from their time in primary school as they are being prepared for the final examinations in ninth grade (Danmarks Evalueringsinstitut (EVA), 2007). Concerning settings, students are often moved to another area of their school that covers their level (Danmarks Evalueringsinstitut (EVA), 2007). In this project, the students moved from one location to another as they progressed to seventh grade, their first year of lower secondary school. On some occasions, students are forced to go to other schools as they arrive from smaller countryside schools that end at sixth grade. Depending on the school, these changes sometimes generate new classes (Danmarks Evalueringsinstitut (EVA), 2007). This includes the students being unfamiliar with each other and having to start over in establishing relationships.

For the science subjects, the transition includes a primary shift in how students are taught science. Specifically, there is a move from the combined science subject (natural science and technology) into several more academically oriented school sciences (biology, geography, and physics/chemistry). Here, students are introduced to more focused science practices, knowledge, and methods regarding the habits and attitudes of the three disciplines (Retsinformation, 2020). This often involves new science teachers who are specialists in one or more of the three new science subjects, which, in combination with higher expectations, teaching driven by a more content-centred focus controlled by the science teachers, and the grading system occasionally, generates more fragmented relations between students and teachers (Speering & Rennie, 1996). Furthermore, modifications in time spent with science and the allocation (new science classes) change (Speering & Rennie, 1996). The participants in this project were introduced to more specialist rooms, such as the physics/chemistry classroom. Here, they encountered another classroom design that prompted other forms of behaviour, as access to materials (e.g., gas) and equipment (e.g., a burner) requires following specific rules to ensure the safety of teachers and students. Likewise, in this project, the transition involved a salient leap in hours spent with science as natural science and technology are structured as double lessons (one and a half hours) per week. In contrast, the three science subjects are structured as a double lesson in grade seven. Accordingly, the students move from a minimum of 60 hours of ‘natural science/technology’ in sixth grade to 60 hours each in ‘biology’, ‘physics/chemistry’ and ‘geography’ in seventh grade. However, common for all science subjects are the four main competencies: investigation, modelling, perspective, and communication, which the students develop over time and across the four disciplines. These competencies vary depending on the science discipline (Emu-redaktionen, 2023a, 2023b, 2023c, 2023d). Lastly, there is a focus on more inquiry-based teaching, which has been shown to increase motivation, interest in learning science, and positive attitudes towards science (Danmarks Evalueringsinstitut (EVA), 2021; Walan, 2016).

### The science examination

Even though this project does not focus on the science examination, I have included a short presentation as, in the interviews with the science teachers, it was a topic that took up space and thereby came to play a role in one of my papers.

Out of the seven subjects students will be tested on at the end of ninth grade, one of the five mandatory tests is the oral standard examination in physics/chemistry, biology, and geography. The last two examinations are drawn randomly; one of the three science subjects can be drawn individually as a written examination. The examination is project based, and the students have approximately two months to prepare before they draw their topic and before the final examination. During these two months, the students work on a problem related to an overall topic. All three science subjects must be presented because the examination is interdisciplinary. The groups have to use experiments and models and be able to present perspectives related to their project. The examination can be completed individually or in groups. It is a two-hour examination held by a dialogue where the students have to demonstrate the problem on which they have worked and the purpose of each of the three sciences, and exhibit their experiments or models (Børne- og Undervisningsministeret, 2021)

In this introduction the science subject in sixth grade is called the combined science subject, though this differ from article three where it is called N&T.

## Theoretical framework – *placing the study*

As presented in my research aim, I explored students' opportunities for participation and for them to work on a science identity during a time when science teaching is undergoing significant changes. Therefore, in this chapter I outline research and perspectives relevant to the purpose of my thesis. I have divided the chapter into two sections. I start by presenting research and reports focusing on the transition because of the variation in science teaching. Afterwards, I delve into the concept of science identity, which I have approached through three categorisations: (1) over time and across settings – identities as dynamic and fluent; (2) impacts on science identities – power, structure and social factors; and (3) science identities – social justice and equity.

### The transition from sixth to seventh grade

In my preliminary process of examining the literature about progressing from primary school to secondary school (grade six to seven), I became aware of Tandeep Kaur, Eilish McLoughlin, and Paul Grimes's review from 2022. They examined articles published between 1990 and 2020 focusing on this transition. In the following section, I provide a short overview of the findings from this review.

Kaur and colleagues (2022) presented limitations and affordances regarding the transition from primary to secondary school concerning mathematics and science. As my focus is on science, I have not looked at the studies that examined mathematics during the transition. The authors divided their review into three research questions looking at science during the transition related to what influences students' experiences, the implications of what influences the students, and the measures that have been used to support students progressing from primary to secondary science. The authors looked at three factors regarding what influences students: (1) student self-regulation factors relate to how students expect to enjoy secondary science based on their experiences with practical work in primary school. (2) School-related and academic factors indicate that while practical experiments and inquiry-based hands-on activities strengthen interest and engagement, science teaching in secondary school is often teacher centred and without many practical opportunities. (3) Social factors relate to how families play a crucial role in students' beliefs and achievement, although positive parental attitudes may not always translate to positive science aspirations for students, mainly if parents do not work in science-related fields (Kaur et al., 2022). Concerning the implications of students' experiences, the authors found that the decrease in science achievement resulted from a lack of general knowledge and parents. Conversely, the drop in interest is not a problem as no interest had been developed in the first place. Likewise, the authors found positive attitudes among students in secondary school as they were introduced to new learning practices. However, there is a decline in self-efficacy during transition, and positive aspirations might not drive students into a scientific path. Gendered patterns emerged in several of the included studies, such as girls showing lower science self-efficacy, interest, and aspirations compared with boys after transitioning to secondary school. Measures to support students during the transition and then facilitate small lessons that bridge units had positive outcomes for students' attitudes and teachers' confidence (Kaur et al., 2022).

In light of this review, it is indisputable that moving from primary school to secondary school entails challenges, although they might differ depending on positions and interests. However, none of the reviewed studies occurred in Denmark (Kaur et al., 2022). While there has been scarce research in Denmark, it is essential to note that other publications have highlighted the transition in this country. Publications such as reports and assessments have identified and illustrated limitations and affordances to science teaching in Denmark. Thus, many of these publications did not simply focus on the transition; rather, the authors took a more general perspective on science teaching.

Out of these publications, the Danish project Mathematics and Science in World Class (Danish title: *Matematik og Naturfag i Verdensklasse*) viewed and evaluated the transition from primary to secondary school. The project was carried out in 2000–2007 and focused on mathematics and science in primary and lower secondary, high school, and the transition between these two institutions (Knudsen, 2000). The project aimed (1) to increase interest in mathematics and science, (2) to focus on mathematic and scientific literacy, and (3) to encourage young people to enter technical or scientific courses of higher education (Knudsen, 2000). It is not my intention to review the project as; rather, I will present the highlight from the project's assessment of the transition – 'Now we understand how it all works! - an evaluation of the transition project: "From natural science and technology in 6$^{th}$ grade to geography, biology and physics/chemistry in 7$^{th}$ grade" [Danish title: *Nu forstår vi, hvordan det hele fungerer! - en evaluering af overgangprojektet: "Fra natur/teknik i 6. klasse til geografi, biologi og fysik/kemi i 7. Klasse"*]. Here, the assessment pointed out that a knowledge base linked to a standard didactic science classroom should be established at each school, encompassing natural science and technology and the three science subjects. In that regard, combined science subjects serve as a general methodological introduction to the field of science. Furthermore, continuing education of science teachers to keep them updated on scientific developments is needed (Jacobsen, 2004). Lastly, the author emphasised that bilingual students were challenged as they did not have the same understanding of the interplay between nature and culture as Danish students. Based on that, (Jacobsen, 2004) suggested that we work on providing space for bilingual students instead of thinking that they lack something.

Other publications have also reported challenges between the science teachers' teams, such as coordinating or sharing information between primary and lower secondary science teachers or across the three science disciplines (Sølberg & Trolle, 2013), or have focused on single science disciplines to strengthen the continuity between educational institutions (primary/lower secondary school to high school to university) by focusing less on conceptual knowledge and instead working with scientific competencies in physics and chemistry (Poulsen, 2002).

Subsequent reports in Denmark have also documented different challenges due to STEM-related education referring to problems such as a drop in primary school students' interest in science and the significance of gender in understanding these challenges (Hald et al., 2020; Jørgensen et al., 2019; Teknologipagten, 2020). There has been relatively limited research about the transition between primary and lower secondary school in Denmark. However, other research publications have shed light on transition-related challenges in Denmark. Among such studies, I will highlight the work by Henriette Tolstrup Holmegaard (2013), Andrea Fransiska Møller Gregersen (2021), and Katia Bill Nielsen (2021).

I am aware that these studies take place at the university level and promote other environments and settings and, therefore, are not comparable. However, they can be used as inspiration for understanding the meanings of transitioning to new settings. Holmegaard (2013) examined the transition from upper secondary school to higher education in STEM. Out of the findings, she, among other things, showed that some students struggled to match their expectations of STEM in higher education, considering their thoughts of what they identified as an attractive identity. Consequently, some students decided not to pursue STEM-related studies after upper secondary school. Similarly, Gregersen (2021) investigated students who encountered a first-year study programme. She found that students' identity work intersects with decoding expectations and navigating and negotiating their identities in the settings. Gregersen (2021) stated that this is not a straightforward process, as subtle exclusion mechanisms operate unconsciously and influence these processes of identity work. Furthermore, Nielsen (2021) focused on the transition between bachelor's and master's programmes. The traditions and possibilities of the programmes formed these transitions. One aspect she pointed out is how the culture of the programmes influenced students' choices of career paths to what is emphasised and valued within the established culture. Furthermore, Nielsen (2021) showed that students negotiated their future career paths over time due to the culture.

These studies have demonstrated how students negotiate their identities to expectations and settings and how these negotiations might be challenging as they encounter the cultural practices of STEM education, particularly when looking at transitions in their science education. I found the authors' focus on identities as an ongoing process of negotiation influenced by culture and expectations in science to be exciting and essential to understand the transition that students experience when moving from the combined science subject to several more academically oriented school science subjects. The studies show the strengthening of exploring identity among students during transitions and how that presents an opportunity to comprehend students' experiences and attitudes towards science over time. It also allows us to gain a better understanding of the intricate interplay of factors that shape students identities as science learners as identity work is not a linear process but dynamic, constantly evolving, and changing, as it reflect the complexity of individuals' experiences and emotions. Inspired by these studies, I also drew on the possibilities of using identity as a lens to understand the transition.

This view led me to examine the research on identities in science.

## Science identities

Before I outline perspectives on science identity, I would like to briefly point to the work of Glen Aikenhead and Olugbemiro Jegede (1999) and identity theory. In early studies, scholars introduced how groups of students have experienced alienation from the culture of science (James & Smith, 1985; Sidlik & Piburn, 1993). In the 1990s, Aikenhead and Jegede (Aikenhead & Jegede, 1999) approached this problem and showed that groups of science learners experience a discrepancy between the culture of school science and the learners' life-world. They demonstrated how alienation is a product of the process of assimilating into the scientific culture, requiring science learners to submit themselves to specific science practices, ways of thinking, values, and ideas of what science is and is not, which might conflict with the learners' personal life experiences and perspectives. It is an approach that functions as a social mechanism where only a more minor group fits the expectations and aligns well with those expectations of who they are. This focus of students not feeling they fit the culture of science has continued to be a primary factor in understanding why science only embraces a minor group of students e.g. by using identity as a lens to approach and understand these challenges.

Before continuing to outline perspectives on science identity, I find it relevant to highlight a more general focus on the literature that has served as a platform for how the concept of identity is used in science education research.

Of these theories (which I will return too), a common focus is that identity is not something inherent and unchangeable, as stated by essentialists (Gelman, 2003). Instead, identities are seen as something formed via interactions. Therefore, to be someone requires the presence and participation of other individuals (Gee, 2000; Gee, 2014; Gergen, 1997). As described by Kenneth Gergen (1997, p. 239), there is no such idea of a 'true self'[1] that predetermines one identity because identities are experienced fluently and constructed and shaped through processes of negations that take place in culturally recognised practices and repertoires (Hasse, 2008; Holland et al., 2001; Tonso, 1999). Hence, individuals seek stability as a way to create meaning in a complex world (Giddens, 2000). Thus, it is possible to investigate this stability by approaching identities as transformed by interactions and environment. How are identities formed, and what does it mean for the individuals? What is enabled, and what is not? Likewise, as pointed out by Foucault (1982) these processes that shape individuals to see themselves and to interact with the world they encounter are formed by practices of power that transform individuals to see themselves through a particular lens. In that sense, individuals are formed by various mechanisms that are far from neutral. Out of these practices, biology can be viewed as a firmly embedded tool in our society that can be used to explain individual behaviour, like associating females with assumptions of being nice, polite, quiet, and passive (West & Zimmerman, 1987) and associating males with reason and rationality (Pavco-Giaccia et al., 2019). This is also why identities are viewed and described as an outcome of exclusion (Stormhøj, 1999). Hence, by shifting from the perspective of identity as something that is fixed to something that is constructed, we can see that identity is something we perform rather than something we are (Butler, 1993). In that sense, identities can be destabilised when interacting with others (Tan, 2017). I will get back to these

[1] Translated from the Danish *sandt selv*.

perspectives and reflections in the chapter on theoretical approaches. For now, I will turn my focus to the concept of science identity.

In their seminal paper, Heidi Carlone and Angela Johnson (2007) presented their conceptualisation of a science identity concerning the intersection of three dimensions: competence, performance, and recognition. Each dimension refers to segments of a science identity: competencies entail having scientific knowledge and understanding science content. Recognition focuses on seeing oneself as belonging in science as well as being recognised by others as belonging in science. Finally, performances refer to students' ability to engage actively and to apply this knowledge in practical settings within science, such as using appropriate terminology or laboratory equipment (Carlone & Johnson, 2007). The authors showed how one can demonstrate performance without sufficient competence and vice versa. Likewise, it is possible to possess competence and to perform correctly without being recognised or acknowledging oneself as a science person (Carlone & Johnson, 2007). From that perspective, the model can be viewed as dynamic: it is possible to explore different combinations of a science identity. Hence, identity is dynamic, constructed, and changeable.

Since that study, the framework on science identity has grown to become an intensely analytical tool – a quick search on Google Scholar showed that the article has been cited 2,270 times – used by many researchers in science education to embrace the complexity of being a science learner. In addition, the setting of science is approached as a dynamic and cultural practice that interacts with various learners in changeable and vigorous ways. Hence, the concept is based on a group of students who have already decided to pursue a study in science at the university. Then, as argued by Hazari and colleagues (2010) the dimension of an element as interest may be less salient to the construction of a science identity because the group of participants had already chosen science. These authors added interest as a fourth component to the framework on science identity to capture whether high-school students had a desire or curiosity "to think about and understand physics" (p. 982).

Including 'interest' as a fourth component provides the opportunity to assess motivation and engagement beyond the other dimension of science identity. For the researchers, the component provided a way to understand what influenced the students' decision to pursue physics-related careers. In that sense, constructing a science identity entails both external and internal factors. External factors refer to social expectations, cultural norms, and support systems. In contrast, internal factors (self-perceptions) include beliefs, attitudes, and motivation, all of which impact the possibility of students shaping a science identity. In adding a fourth component, these authors could explore the interplay of external and internal factors that might influence students' attitudes and aspirations in and towards the field of physics (Hazari et al., 2010).

As mentioned previously, there has been an increase in research in science education applying science identity to understand affordances and limitations in and towards science. In their review, Anna Danielsson and colleagues (2023) examined this expansion of studying identity in science. Based on their review, they categorised the findings into three groups: (A) macro-studies within a psychological tradition, (B) macro-studies within a sociological tradition, and (C) micro-studies within an interpretive tradition. They divided group C into two sub-categories as this group was the most extensive. Studies from the two first groups mainly concerned more prominent statements and conditions, while studies from the last group were qualitative and primarily explored science identity in smaller groups (Danielsson et al., 2023). In addition, they found it critical that methodological homogeneity emerged among the studies revealed by group C. The researchers did not clarify how they used science identity as an analytical tool, reducing the potential for continuity (Danielsson et al., 2023).

While I find it worth keeping the results from that review in mind, I argue that the group C studies have significant meaning for the field of science education. In some countries, the use of science identity towards some areas of science education is still relatively new, including primary and lower secondary schools in Denmark. Together with this project, the SCOPE[2] project is the first study in a Danish context to explore science identity in primary and lower secondary schools (Pedersen, 2023). Much of the cited research is from the United States, which shows notable cultural differences compared with Denmark.

Nevertheless, there is no doubt that science identity has gained a position in science education. In the following section, I delve into the concept of science identity in science education, exploring and focusing on students' experiences. Although my focus is on students, I am aware of the growing field of researchers examining science teachers' experiences and challenges within science, exploring their construction of a science identity (for inspiration see: Avraamidou, 2014, 2016; Gale & Parker, 2014; Richmond & Wray,

[2]SCOPE investigates the development of science capital among Danish children and young people over time to better understand how the resources and prerequisites of different children and young people interact with their recognition in STEM fields and their sense of belonging.

2023; Varelas et al., 2023). It is not my intention to follow up on this area. Rather, I have narrowed my focus to primary and lower secondary school. However, research on science identity in education spans from preschool (Kane, 2012) to high school (Aschbacher et al., 2010; Chapman & Feldman, 2017) university (Holmegaard et al., 2014; Madsen & Malm, 2023).

In my analysis of the scientific literature, which forms the basis for this thesis, I have classified the articles into three thematic categories: (1) over time and across settings – identities as dynamic and fluent; (2) impacts on science identities – power, structure and social factors; and (3) science identities – social justice and equity.

### Over time and across settings – identities as dynamic and fluent

In the first of the categories, I explore the factors of time and setting concerning science identities. Because identities are negotiable, different learning situations might offer other opportunities for students to participate and engage in science practices. In that sense, the focus is to examine identities over time to gain knowledge regarding changes, limitations, and affordances within science education and to understand how students' identities work as they progress through science practices. In this chapter, I deal with the advantages of time and variation.

The ASPIRES project in an example of a large-scale endeavour that followed students over time (Archer et al., 2013; Archer, 2023; Archer et al., 2020). Here, the researchers followed students to track their science and career aspirations over time as an outcome of participation and the possibilities to relate oneself to science. They employed a theoretical approach to science identities by drawing on Bourdieu's theory of practices. In addition, the research group developed the concept of science capital, which includes four dimensions, and explored why some students might have low science capital (Archer, Dawson, et al., 2015). The project's timeframe provided a position to explore whether changes appeared and what forced these variations, such as the possibilities to engage with science activities outside of school, students' attitudes to science, and social factors such as family background. Similarly, other researchers have taken a longitudinal approach to understand and make sense of students' experiences with school science. For example, Carlone and colleagues, (2014) examined the role of identity in understanding ways of participation in science classes over time by tracking the trajectories of three students (grades 4–6). As science teaching changes, the ways of celebrating and recognising legitimate participation in science classes transform. In addition, the students' attitudes towards science change, and they become less interested in science (Carlone et al., 2014). From other studies following students over time, insights into how structures of gender, race, and class enable and shape participation and engagement, particularly for girls (Barton et al., 2008; Carlone, Johnson, et al., 2015). These long-term studies have provided insight into understanding how gender performances for girls changed into less celebrated performances (Carlone, Johnson, et al., 2015) and how creating hybrid spaces for urban middle school girls over time can support interest and engagement in science (Barton et al., 2008). Both studies showed how structures and what students are offered in science influence their identity work. In addition, there has been a focus on out-of-school activities (Calabrese Barton, 2013; Gonsalves et al., 2013; Gonsalves & Rahm, 2023; Tan & Barton, 2020; Wade-Jaimes et al., 2022; Wade-Jaimes et al., 2021). Despite the difference between these studies and my project, I find these studies to be relevant as they have shown the potential gained when the settings for learning science are modified and organised differently from the science received in school.

What I gained from these studies is that by organising learning environments in other ways, participation changes. In addition, by making space to disrupt science presentations that might be experienced as exclusionary, educators create new ways to access science practices, including everyday experiences; support and inspire students to see themselves as belonging in science; and offer alternatives for participation and to engage with science. Furthermore, the studies have shown that identities are negotiable and destabilised.

Lastly, studies have revealed that marginalised groups face systemic issues such as stereotypes, lack of representation, and unequal access to resources and opportunities (Archer et al., 2023; Ibourk et al., 2022). From the time perspective, such challenges might inevitably impede the development of a science identity. This leads me to the categorisation.

### Impacts on science identities – power, structure and social factors

The critical point from the literature on science identities is that students' identity work in science is an interplay between individual agency and the impact of social structures (Carlone, 2012). Likewise, social factors such as gender, race, and class intertwine with the students' possibilities in science (Archer & Francis, 2006; Rainey et al., 2018). Research has suggested that science teaching is far from neutral; rather, it is formed from cultural, social, and structural factors (Archer et al., 2012).

Likewise, historical events such as colonisation have formed institutions such as the schools on whiteness (Seiler & Kwamboka, 2023). In addition, the culture of science draws on the masculine (Harding, 1998), which in Western cultures is viewed as elite, specialised, and objective (Aikenhead, 1996; Lemke, 1990). This focus has also led to a science culture of masculine ideals and discourses, which promotes the performance of White and middle-class science learners (Carlone, Huffling, et al., 2015; Wade-Jaimes et al., 2022). From that perspective, I see students' identity work in science as a complex interplay among various mechanisms that interact to create possibilities for recognition. As Avraamidou (2020) stated in her seminal paper, these recognition practices are far from neutral. She argued that the processes of recognising oneself and being recognised as science learners intertwine with layers of power that intersect with the norms and practices in science (Avraamidou, 2019). In research, such challenges to recognition practices are explored mainly regarding issues of race, gender, class, and science culture. Here, race or ethnicity, gender, and class consciously or unconsciously create and produce advantages and disadvantages regarding students' opportunities to participate in science (Archer et al., 2019; Brickhouse et al., 2000; Brickhouse & Potter, 2001; Godec, 2018; Wade-Jaimes & Schwartz, 2019). Scholars have shown the importance of considering how identities such as race, gender, and class intersect with science teaching and influence access, participation, and achievement in scientific settings. Other research has demonstrated how places can be gendered and how dominant gender norms and expectations dictate students' experiences and attitudes towards science (Archer et al., 2016; Dawson, 2020). Although the setting differs from the science classroom, we can learn how students react to their surroundings from these studies. The studies have shown that norms, expectations, and ideologies predefine places. For example, Wade-Jaimes and Scwartz (2019) found that African-American girls were positioned as outsiders in science because they did perform what could be recognised as science leaners.

Furthermore, how students experience science settings holds significant value for their participation, and how students participate is crucial for developing a science identity. Researchers have explored how students navigate, negotiate, and resist dominant cultural norms and practices within science teaching (Carlone, 2004). Students actively engage in scientific activities to gain a broader sense of a scientist's identity. Moreover, how students perceive these perceptions impacts their construction of a scientist's identity as well as attitudes and engagement with science. Another important aspect is how students experience stereotypes of science as boring, masculine, filled with lab experiments, hard and brainy, or needy (Archer et al., 2010).

## Science identities – social justice and equity

In the last of my categories, I focus on research in science education that has highlighted the variations that can play a role in changing some of the issues I described in the two other categories. To make such changes, we must know that students come from different backgrounds and encounter the world differently. However, the way science is structured only welcomes a few groups of students while excluding many students because they are not recognised to fit within science or, in many cases, do not recognise themselves as science learners. To do so, a deconstruction of traditional learning practices must be replaced by focusing on equity or social justice in science education. As Barton (1998) showed, it is about increasing participation in equity and social justice, considering the experiences and perspectives of marginalised communities.

Likewise, Barton and Tan (Barton & Tan, 2010) focused on the opportunities for students to develop agency and identity in science as that would entail their cultural backgrounds, interests, and experiences to promote a deeper engagement and motivation so that students are recognised and valued for whom they are. Like Carlone and colleagues (2011) focused on the opportunities for students' voices, agency, and participation to be included in creating more inclusive and equitable learning experiences for all students. Furthermore, they stated that instead of focusing on traditional knowledge and skill-based outcomes, other factors such as classroom culture, interactions, and participation should be considered in assessing equity in science education. Seeking to create more inclusive practices has the potential to address and disrupt traditional structures in science education that promote inequities like challenging power and privilege (Rodriguez & Morrison, 2019). Likewise, it is about confronting stereotypes to create a broader diversity, visibility, and representation, particularly for issues related to race and gender, for students to participate and follow academic and professional trajectories in STEM (Brown et al., 2017; Conner & Danielson, 2016).

Creating these inclusive and equitable learning environments is an ongoing process, not a checklist and/or a to-do list. Collaboration among policymakers, educators, teachers, and researchers is required to work towards equity of treatment and social justice for all students in science education.

## Theoretical approach

In this thesis, I aim to understand students' possibilities for participating in science by exploring processes that facilitate or prevent inclusion and exclusion so that students can shape a science identity. As presented in the previous chapter, identities are constructed, fluent, and negotiated over time and across settings regarding conditions and expectations in the culture of science. Like some of the aforementioned studies, I followed students over time to explore their experiences of their science teaching and the social context of these experiences. This methodological approach allowed me to be a part of the students' everyday school life and to understand how they learned to see themselves in the social contexts with which they interacted (Roth & Tobin, 2007). I will return to this later as I present my methodological framework for understanding the processes of inclusion and exclusion. First, I introduce my epistemological approach to understand what is included and supported and what is excluded and neglected in relation to students' possibilities to participate. Therefore, I needed a framework that could help me embrace inclusion and exclusion processes to approach the way students navigate in their science teaching.

Hence, as participation, a central notion in this thesis, has been extensively explored by Lave and Wenger (Lave & Wenger, 1991; Wenger, 1999), I draw on positioning theory in this thesis. In their framework, participation is intricately linked to the social learning process in specific contexts. However, this thesis conceptualises participation differently, drawing upon positioning theory. This choice fosters a more dynamic conceptualisation, wherein positions are fluid and evolving, in contrast to the more static notions of legitimate or peripheral participation proposed by Lave and Wenger (Lave & Wenger, 1991; Wenger, 1999). By applying positioning theory, this thesis aims to embrace a dynamic conceptualisation of participation that acknowledges the fluidity of position and sees participation as continuously negotiated between students, teachers and the classroom setting.

Based on that, I will explain my use of positioning theory (Davies & Harré, 1990) to understand the various actions that take place over time and in different settings; these scholars showed that identities are not fixed products; rather, they are negotiated through social practices. Their theory shows how positions are constructed and reconstructed through the social practices that individuals join. It is a dialectical and dynamic process, as the individual positions themselves and is positioned by others. In that sense, the individual is not a defined product; instead, they are given the possibility to negotiate their identity (Davies & Harré, 1990). In working with identities as fluent and shaped by negotiation processes, individuals can be seen as moving in and out of positions shaped by what is offered, recognised, obtained, and neglected through social practices (Holmegaard & Johannsen, 2023). I have used the concept of positioning to explore how subject positions are shaped in the science classroom and what legitimatises these positions as they influence how students recognise themselves in science and how their teachers and peers recognise these positions.

From the perspective of positioning theory, positions are created and activated during interactions with others. Although an individual can refuse the positions put forward, they still have to deal with them and the environment in which they play out (Davies & Harré, 1990). This means that relationships are not neutral; rather, they are influenced by various dynamics, such as implicit expectations, structures, and power relations (Avraamidou, 2020). Therefore, if someone rejects a position, it does not necessarily mean it will disappear. The rejected position can reappear, as peers and teachers might reproduce it. Additionally, the positions offered in teaching may conflict with an expectation that the students cannot or do not want to meet. Although freedom is associated with positioning, structures and power relations can limit what is possible (Davies & Harré, 1990). The fact that some positions reappear results from discursive practices that presuppose what can be recognised – in other words, the right way to participate in science.

Through this lens, I embarked on a exploration of science teaching. This approach allowed me to uncover the positions that are made possible in science and what shapes and constitutes them. Equally intriguing was the opportunity to delve into what is rejected, excluded, or overlooked, as these occurrences are shaped by what is legitimised and influenced.

Besides the use of positioning theory, this thesis is similarly formed from feminist theories, particularly the work of Judith Butler. Her research enables us to question our assumptions about what we take for granted and then assumes that it cannot be done differently or performed in other ways. According to Butler (1990), gender is performative rather than inherent in individuals. I extend this concept beyond gender to account for other actions by following Carlone and Johnson's (2007) conceptualisation of performance. In short, Butler's notion of performativity is about a confrontation with the fact that there should be an inherent and natural link between being masculine and man and being feminine and woman.

In Butler's (1990) work, gender is not a biological product of our physical bodies. Instead, gender, both biological and social, is a construct of discursive and culturally ingrained practices. Gender is enacted through actions that adhere to discursive practices of acts, gestures, and enactments, either female or male. Butler perceived gender and other identities as constructed and performed, not fixed and determined products of our biological bodies. In this context, actions are gendered and can be interpreted as masculine or feminine based on their nature. Moreover, masculinity and femininity are embodied practices of how to perform man and woman. Butler underscored that these actions are repeated, and this repetition validates the actions. This perspective offers a sense of liberation, where gender is not an innate characteristic but a product of our actions.

Butler (1990) delved into how social conventions project something as natural as if it were preordained. Therefore, it is through individual actions that gender is actualised, and how men and women conform to the expectations of their gender roles helps perpetuate masculinity and femininity. By approaching gender as constructed and performed, based on expected behaviours considered natural for men and women, we can challenge these ideas and rewrite them. Such an approach also involves being aware that gender changes over time and, in many ways, is experienced differently depending on age (Staunæs, 2004). In this thesis, the participants are still children, indicating that they might experience gender differently.

Using the concept of performativity, it becomes possible to examine what actions are linked to the positions and, perhaps even more importantly, whether these actions are repeated and defined by factors legitimising how to participate in science teaching. I only used and discussed the concept of performativity in article two, although I used the term through the lens of Carlone and John's model of science identity (Carlone & Johnson, 2007). These ideas form the concept of performativity and have greatly influenced my perspective as a researcher and how I engage with the field. I view identities as always in the formation process but as subjugated to larger structures that can create stability and challenges for identity work. Because I observe science teaching, I am interested in exploring this phenomenon. Besides, Butler's work also offers an opportunity to discuss ways to alleviate the burden of repetition and stability.

As a last perspective, I would point to the concept of intersectionality introduced in 1989 by law professor Kimberley Crenshaw from the University of Columbia. Crenshaw (1989) used the concept to show how different systems of power create discrimination and inequality for Black women. She focused on ways that sexuality, race, and gender intertwine with being a Black woman. The concept provides access to understanding that oppression is experienced differently depending on a person's social identity. This means that if measures focus only on gender, then exclusion will only be seen through one axis, thus creating challenges for those who will experience exclusion on several axes.

The concept has opened up a lens through which I can approach my research project, with the understanding that how we interact with the world and how individuals are met by their surroundings are far from universal and straightforward.

## Returning to the aim

Based on the influential literature and the theoretical framework, I will return to my aim. As shown numerous researchers have explored students' opportunities to engage and participate in science and have found that who are recognised and he ways science is taught is far from neutral. Similar, we see how, identities are not fixed; rather, they are constantly negotiated and influenced by the environment that surrounds the individual. This dynamic process occurs in relation to various structural, cultural, and historical factors that shape the surroundings and how these surroundings are not neutral but rather carry their own biases and power.

In that sense, it is revealed how practices of recognition shape what and who is recognised, which creates processes of exclusion and inclusion in science teaching (Holmegaard & Johannsen, 2023). Then what becomes available vis-à-vis in science results from these recognition practices, although,  these recognition practices (to recognise oneself as a science learner and to be recognised by others) are shaped by complex layers of power like systemic biases in educational institutions (Avraamidou, 2020). These layers of power intersect with students' backgrounds, scientific settings, and relations with peers and science teachers, and, in particular, marginalised groups encounter challenges in being recognised as legitimate science learners. Such processes convey feelings of exclusion and impede the formation of a science identity (Avraamidou, 2020). Consequently, these recognition practices produce and reproduce disparities among students' possibilities in science. This has been uncovered and illustrated in the last decades of research in science education. Researchers form the influential literature have explored how these disparities emerge by understanding what students are offered in science and for whom these possibilities are sensible and experienced as accessible due to students' participation opportunities (Archer, 2017; Olitsky et al., 2010; Ryu, 2013). In addition to these studies, the work of elucidate students' identity work in science has had a significant contribution to understanding the affordances and limitations for students' participation in science teaching. It is important to highlight that the attempt is not to fix the students, but rather to understand how science teaching is structured to explore the culture of science as a culture that shapes and recognise different kinds of expectations that students have to navigate and negotiate and how these expectations have little to do with science (Carlone, 2023).

Within this complexity, I return to my aim. As stated in the introduction of this thesis, I examined students' participation in science teaching. Specifically, I explored the factors contributing to inclusion and exclusion in this setting and how these factors impact students' identity work in science. This endeavour involved three research questions:

1. How do gender, ethnicity, and class intersect with students' ability to participate in science?
2. What challenges and opportunities emerge during the transition for students' identity work in science?
3. What recognition practices enable student participation concerning a meaningful belonging to science?

I have produced three articles to answer these questions. The articles are not chronological; rather, each article has a different perspective related to the overall aim. Each article includes a discussion of the results and further implications for research. At the end of this thesis, I provide a section for future directions. One of my four articles is methodological. I produced this article because my participants were young people, and I considered whether there were other ways to involve them without relying too much on language. This approach would allow for different ways of expressing knowledge and potentially open up new ways of conversation beyond just asking and answering questions. Next, I provide a brief introduction to the articles' formation to help readers better understand how they relate to the project.

## The four articles

### Overview

The table below presents an overview of the four articles included in this thesis.

| | |
|---|---|
| **Article one** | |
| Title | Art-based methods in science education research: A systematic review of their prevalence and an analysis of their potential in addressing complex questions |
| Purpose | (1) To offer a systematic review of the extent to which art-based research methods have gained ground within science education research; (2) to analyse the kind of knowledge that is produced by applying art-based research methods and thus the potential of these methods for science education research |
| Journal | *Nordic Studies in Science Education* |
| Status | Published |
| Co-author | Henriette Holmegaard |
| **Article two** | |
| Title | Unveiling the production of non-participation in the primary school science classroom |
| Purpose | To investigate: (a) what kinds of non-participation are performed and shaped in science classes; (b) whether there are some of these performances of non-participation more dominant than others; and (c) how non-participation is constrained or supported through intersections of social categories such as gender, race, ethnicity or class |
| Journal | *Cultural Studies of Science Education* |
| Status | Accepted, and in the final state for being published |
| Co-author | Henriette Holmegaard |
| **Article three** | |
| Title | Transition from 6th grade to 7th grade – transformation of science identities over time – change or stability in relation to science |
| Purpose | To explore which possibilities students are offered in school science for developing a sense of science and thus a science identity over time as the science setting changes from sixth grade to seventh grade |
| Journal | |
| Status | Submitted |
| Co-author | Lars Ulriksen |
| **Article four** | |
| Title | Repeated, essentialised and reproduced at the transition: Lower secondary school science teachers' practices of recognition and positioning |
| Purpose | To investigate: At a time when new science subjects are introduced in lower secondary school, how do science teachers describe their science teaching, and how do they recognise and position their students as science learners? |

| | |
|---|---|
| Journal | |
| Status | Submitted |
| Co-author | Bjørn Friis Johannsen |

### **Article one:** Art-based methods in science education research: A systematic review of their prevalence and an analysis of their potential in addressing complex questions

This article emerged from a curiosity to understand and explore other ways of meeting children and young people when they participate in research projects within science education research. The article identified that within other research traditions, it had been shown how drawing on performative, creative and visual elements can allow one to express oneself in other ways but also set the framework for meeting research participants in other ways. This led to a systematic review examining literature within science education research that uses visual, creative and performative elements as research methods. The systematic review found that only a few studies used art-based methods as a methodological approach. Based on that, the snowball approach was used to examine the identified literature that had inspired the article and from where a thematic analysis was done. Here, four themes were identified: knowledge made available through artefacts, non-verbal language, more balanced power positions, and time to reflect. This analysis highlights the advantages of incorporating art-based approaches in science education research and explores their potential benefits. Additionally, it considers the significance of these methods for research and identifies the limitations and challenges of using these creative approaches.

### Article two: Unveiling the production of non-participation in the primary school science classroom

This article draws on ethnographic fieldwork in two sixth-grade classes, where it emerged that the students' participation was low; this included students being passive, quiet, and very little engaged in science teaching. Based on other studies that have conceptualised non-participation, this article examines how non-participation is shaped in primary school science. To investigate this, positioning theory has been used in combination with Butler's concept of performativity, and the article's analysis points to three forms of non-participation: 1. through exposure, 2. through being overlooked and 3. through being disciplined. Applying theoretical concepts of performativity and positioning allowed for a deeper understanding of how non-participation is produced and maintained in different practices. It became evident that non-participation was often a result of rigid positions that are challenging to negotiate and, therefore, tend to remain stable over time. Similarly, these positions of non-participation interfere with intersections of gender, race/ethnicity and social background.

### **Article three:** Transition from sixth to seventh grade: Transformation of science identities over time—change or stability concerning science

This article examines the transition from sixth to seventh grade, where students move from being taught in a combined science subject to being taught in physics/chemistry, biology and geography. By combining positioning theory to the concept of science identity with Hazari's addition of interest, as well as Nuthall's three socio-cultural systems, the public system, the semi-private system, the private and the internal system, that take place in a classroom, we have explored what changes and what does not during the transition. The article is based on four in-depth cases of four students' experiences with science teaching and their ways of participating and performing in science. Here, we see how plenum silences, while group work creates more active positions but does not necessarily support the student in working with science-related content. At the same time, we see how interest is not redeemed, as there, to a lesser extent, is created a link between the student and the subject and the content. Likewise, competencies are interpreted in a way that has very little to do with science, and performing in class, therefore, has very little to do with science, apart from being able to use scientific terminology. The students' ways of orienting themselves based on the three systems took different directions, such as drifting them away from science. It could also appear as more isolated behaviour, although interest in science would still be pursued in that case. Likewise, some students begin to navigate regarding exams and grades. Within this, we see how there is both change and continuity among the students during the transition. Continuity is linked, among other things, to how they managed the school expectations and performed in class. It does not seem like there has been a significant change here. In reverse, change is merely reflected in how students move and behave in relation to the school's framework and expectations and their level of interest in the individual science subjects.

### **Article four:** Repeated, essentialised, and reproduced at the transition: Lower secondary school science teachers' practices of recognition and Positioning

This article examines the experiences and perceptions of science teachers in teaching science in seventh grade, where the students become acquainted with the three academic science disciplines of geography, physics/chemistry and biology after having the combined science subject. Using Collins' domains-of-power framework and positioning theory, we have investigated the teachers' experiences of teaching science to understand what it means for the teachers' way of teaching and students' participation opportunities and how to be recognised in science. Here, we saw how the teachers act in relation to some structural and disciplinary factors and are subjugated to cultural notions that impact their relations with students. In the structural domain, we see that structures prevent science teachers from being active in creating different positions for students to take up during teaching activities. From the cultural domain, ideas like students being involved with science-related content outside school shaped some possibilities for being positively recognised in science teaching. The disciplinary domain captured the risk of disciplining students to positions where they are recognised as not competent enough, which for teachers made them organise a controlled science teaching. In the last domain, we see how the domains interconnect and shape positions where teachers are less responsible for creating possibilities for their students in science. The findings point to a congealed structure that does not support students' recognition of meaningful belonging in science.

## Methodological approach

My project's core focus is comprehending the factors that facilitate participation or not and its profound significance for students' identity work in science. I took a longitudinal approach combined with qualitative methods such as ethnographic fieldwork, interviews, and workshops to understand the interaction between individuals and their surroundings in the science classroom and the possibilities and limitations of participation and identity work. By utilising various methods, I could approach the issues from different perspectives and gain a more comprehensive understanding of the topic. Similar it allowed me to adopt an open approach to gain insights into students' experiences and assumptions with science. This helped me understand the students' everyday routines and why they behaved the way they do. Ultimately, I gained a deeper understanding of the participants' behaviours and actions. Overall, the chosen methodology provided a comprehensive understanding of the dynamics that create opportunities and those that hinder them while allowing for a nuanced exploration of participants' actions and words.

### Overview of the empirical material

Over one and a half years, I followed students through sixth grade and halfway through seventh grade. I divided this time into three periods.

| **Period** | **Methods** |
|---|---|
| Period one, 2021–2022<br>*Fall/winter* | • Workshops with science teachers at all three school schools<br>• Three weeks of ethnographic fieldwork at all three schools<br>• Interviews with students (N = 13) |
| Period two, 2022<br>*Spring* | • Observations of the combined science subject, three times at schools X and Y and two times at school Z<br>• Workshops with the students at the three schools<br>• Interviews with the science teacher in grade six (N = 3) |
| Period three, 2022<br>*Fall* | • Three weeks of observations at school X and four at school Y<br>• Interviews with students (N = 12)<br>• Interviews with the science teachers in grade seven (N = 7) |

### The field

My project involved three schools. I contacted the schools by either using my network, asking if any might be interested in participating in a project that focused on the transition from sixth to seventh grade, with a focus on participation opportunities in the sciences, or I called the school to ask if they would be interested. It was important for me to find schools interested in participating based on being well informed about the purpose and structure of the project. Therefore, I held a workshop where they could say no afterwards. I will explain the format of the workshop later. All three schools where I held the workshop agreed to participate. Of the three schools, two are in the countryside, and one is in the suburbs. Although the primary analysis in this thesis is based only on the material from two of the schools, the third school is what Flybjerg refers to as an atypical case (Flyvbjerg, 2006). This school has experienced a drop in the number of students: they only have half the number of students as a standard school class in Denmark, and the majority of the students are minority students. This information was first conveyed when I came to hold the workshops. Based on that, I decided to invite a school more. Thus, I kept collaborating with the third school, although I only visited it while the students were in sixth grade, as I learned during my time that the problems the school faced differed from the aim of my project.

I produced the empirical material used in this thesis at the two other schools – one countryside school (school Y) and one suburban school (school X). The schools are similar on an institutional level but differ geographically, as the suburban school is located close to other educational institutions. Of the two schools, one is situated in an area with high income and wealth and average potential for growth and job creation. The other school is located in an area with low income, wealth, growth, and job creation. The rating scale used for comparison includes five categories: very low, low, average, high, and very high (Jakobsen et al., 2023)

## The ethnographic fieldwork

> I felt excited and well prepared as I headed for my first day in the field. I had thoroughly studied the theory and methodology to be as ready as possible. However, I had not prepared for the overwhelming flood of emotions, expressions, and feelings that occur in an institution such as a school. In other words, I had forgotten what it meant to be a student; to be a child in an educational institution; to encounter an institution like the *Folkeskolen* with all its disappointments, joys, irritations, and surprises (Reflections).

My fieldwork at the involved schools was where I produced much of my empirical material, just as it formed the background for my later interviews and workshops with the students. I visited the involved schools over one and a half years, divided into the three periods, as illustrated above.

During the first period, I spent three weeks at each school. I participated in all the different activities that were taking place at the schools and formed the daily school lives of the students. This included formal teaching, where I observed science teaching as well as other school subjects to the extent it was possible and meaningful. It also included informal activities during breaks such as ball games and conversations. My intention during this first period of the fieldwork was to keep my focus broad to get to the know the field and the students.

During the second period, I took a more focused approach as I narrowed in on science teaching, my key focus. Thus, I only visited the schools to observe the combined science subject. I did this three times at schools X and Y and two times at school Z.

During the third period, I continued to focus on science teaching. I visited school X for three weeks, where I only followed the students when they had one of the three science subjects. I visited school Y over four weeks as the class and students I had previously followed had been divided into three new classes. This meant that to follow all of the participating students, I now had three classes to follow instead of one. Thus, I spent more hours here than at school X, as I often walked from one biology lesson with one class to another later lesson with another class on the same day. At both of the schools I planned my visits so that I could spend breaks before and after the lessons with the students. This allowed me to have informal conversations with them about the lessons, their current interests, and what had happened since I had last visited them. These conversations were meaningful in keeping up with how the life for the participants changes due to age, interests, and aspirations.

During my time at the schools, I also participated in less traditional activities such as school days that were structured differently. For example, I went on a one-day trip to a science arrangement.

My approach to the ethnographic fieldwork was inspired by participant observation (Musante, 2015). I gained insights into everyday school life by taking up active and participatory positions. Therefore, I planned the first period of my ethnographic fieldwork to include other subjects and activities, as I was interested in the broader picture of students' everyday school life (Hammersley & Atkinson, 2007). In particular, while the science subjects might appear to be isolated on the school schedule, the role of a science learner is entangled with what else is going on at the school.

### Building relations with the students

During the fieldwork, my aim was to establish relations with the students that could allow me to gain insight into their everyday school lives and what they were interested in or what occupied them (Konopinski, 2014). Therefore, I avoided taking on a position as co-teacher or otherwise being authoritarian in my approach to the students. Accordingly, I worked to ensure that the students understood that I did not pass on what I saw or heard to their teachers. I explained to the students that I would only do so if there were situations that required it, and that I would inform them or ask them before passing on any information. This only happened once, as one student shared with me her experience of being bullied. I asked her if I could talk with her teacher about this specific situation, and she agreed.

There were many situations where the students asked for help; in such instances, I instructed them to ask their teacher or classmates. However, this also prompted some questions, where the students asked if I could not figure out the subject. This happened during a mathematics lesson where I, after encouraging them to ask each other, told them that mathematics was not my strongest skill. To this, one of the students asked if I did not have to be good at mathematics to be a researcher, to which I replied that it depended on what type of researcher you wanted to be. To that, the student replied that she then also wanted to be a researcher.

However, there were also times when I was challenged in my position and ended up helping the students. I experienced these situations as variations in my position as a researcher in ways where boundaries became more fluid as I encountered the students differently from when I first met them. I experienced how the boundaries between informal conversations and not being involved in the students' school tasks became blurred, and it happened that I discussed academic content with them

Although I developed strong relations over time, I experienced that in the beginning, the students needed to observe me with distance and maybe even test my credibility to figure out what kind of person I was. As they experienced that, I did not judge or scold them; I slowly got invited to their spaces beyond rules and regulations and teacher authority and slowly drifted into the rhythm of school. The time I spent with the students turned into hours of informal conversations – it turned into dodgeball, football, cheese (a ball game), and tag. I played Uno or Twister and watched YouTube videos about gaming. I was trotting around, hiding from the yard guard, fishing mobile phones from the locked cupboard, and being scolded for not cleaning up after ball games in the hall. My position among the student became evident when I returned to one of the schools in seventh grade and a new student in one of the classes seemed hesitant towards my position. This was noted by another student who said, *'Don't worry, she doesn't gossip'*. This comment illustrates the trust I managed to build with the students, who over time came to accept my role as a non-teacher and someone who would not go straight to the teacher to tell on them.

The ethnographic fieldwork established a unique snapshot of school life and helped me develop relations with the students, which supported my interviews and explorations of the students' participation in science. Furthermore, my observations of science teaching provided an awareness of what enabled participation within different contexts, teachers, and practices.

### Fieldnotes

I produced and conducted fieldnotes during my ethnographic fieldwork. By producing, I refer to situations where I was involved or presented, such as when I made my observations or interacted with the participants. By conducting, I refer to materials existing with or without my presence in the form of teaching materials. Fieldnotes comprise written notes; pictures; sketches; recordings; and other materials like things the students gave me, such as drawings or a bracelet one student made for me. I have saved and archived everything.

Hence, my primary source of empirical material consists of descriptive fieldnotes recorded either on paper or on a computer, depending on the situation (Emerson et al., 2011). If the students worked on their computers, I would also use my computer. However, most of my recordings from the field are paper notes or, as described by Emerson and colleagues (2011), 'jottings', as much information had to be written down quickly. I transferred the jottings into a document on the computer on the same day to avoid my notes transforming to 'cooling notes' (Sanjek, 2019).

During the fieldwork, I used my phone to take pictures and, in a few cases, to take notes. However, I was attentive to where and when I used my phone, as phones were not allowed during classes, and I did not want to create unnecessary attention. However, the pictures I took have served as a tool to remember and elicit situations from days when I was overwhelmed with information and visual impressions. In addition, I used the pictures to recall situations.

Sometimes, I would make recordings on my phone when I walked to the bus or train after a school day. I used these recordings to reflect upon the day or to remember ideas that arrived on breaks when it was often difficult to take notes as I could be in the middle of a game, like playing cards.

### Reflections of positionality, power, and trustworthiness

During the production of my empirical material, I continually reflected on the positions I took up or was assigned during the fieldwork, observations, interviews, and workshops. Developing relations with research participants is not a neutral process; it interferes with social categories, power dynamics, and the ongoing negotiations of these positions (Spangler, 2023). Therefore, I as a researcher had to reflect on my own background and biases and what this means for the positions I took on and was ascribed (Hasse, 1995). Such reflections are important as power, privilege, and biases emerge from the very same system we try to question (Madison, 2012).

In particular, as a well-educated White woman from a middle-class home, I am in a more powerful and privileged position than many of the students with whom I conducted the fieldwork. Likewise, I am formed by interests, assumptions, and experiences that shaped the interactions and relations that I developed with the participants, and which would be different from how other would approach the field and the participants (Agar, 1996). Similarly, there was also an age difference that created an asymmetric power relation, as I at any given time could take on a position of authority.

Of such relations, I experienced particularly how some of the minority boys kept a certain distance from me. However, some of these relations also changed over time based on other activities. For example, when one of the minority boys learned that I was good at ping-pong, this transformed our relations, and he started to ask if I would join their game during the breaks. During these games, different conversations occurred spontaneously. This seemed to be a more comfortable way for him to talk and interact with me, compared with the more direct and personal conversations I would often have with the girls. In article two, I wrote how this might be an outcome of gendered patterns in how to be a 'girl' just as ping-pong can be seen as an artefact that negotiates the power relations (Hoppe & Holmegaard, 2022).

I saw my position as temporal. I captured snapshots of the students' and teachers' everyday school life, which I scribbled down as notes. Even though these snapshots might seem locked as they become attached to the paper as words, sentences, or descriptions, they are not, nor are they universal, as the empirical material I produced is situated and socially constructed (Berger & Luckmann, 1972). Therefore, I did not aim to make broad generalisations; rather, I carefully considered the empirical material and the directions it revealed. Given this focus, I applied an ethnographic approach, in combination with interviews and workshops, to produce the empirical material. With such an approach, one can explore what is *taken for granted* instead of only describing what is observed (Baumbusch, 2011).

## Ethical considerations

The participants in this project, including the schools, teachers, and students, participated voluntarily. I have anonymised all of the participants and I have followed the ethical guidelines from the Danish Data Protection Authority (Datatilsynet) regarding good research practice.

I was in contact with the teachers before I started producing the empirical material. I started the first day at each of the schools by introducing the project and the purpose of myself being at the school. I explained that I would not teach or act as a co-teacher, but that I was visiting them to learn about being a sixth-grade student. Afterwards, the students could ask questions. Moreover, a document of consent was sent to the students' parents, providing them with information about the project and contact information if questions arose or if the student wished to withdraw from the project at a later point.

As described above, my relations with the students developed over time, as they got to know me and began to trust me. My relations with the students also brought up numerous ethical considerations, as in the situation where a student shared her experience of being bullied. Another situation that illustrates the ethical challenges that were part of my fieldwork was my encounter with a girl who I early on experienced as somewhat an outsider to the class community. From the very first day of my fieldwork, she began to seek my attention. This, among other things, became evident as she began choosing a place close to me during the lessons, whenever that was possible, or offered me a spot next to her. After the first few days, she began to approach me during the breaks where she wanted to play ball or cards with me. She began to want to follow me around and go to the same places as I went.

As I observed her over time, I experienced her as a somewhat lonely girl, and my initial perception that she was not always included in the class community only became more evident. In this social context, I was all of a sudden there, a weird kind of adult, neither a classmate nor a teacher. The relation became one that I had to balance so that I could engage in different activities and build relations with other students. I found this task to be challenging both methodologically and ethically. How could I also make time for other students without dismissing her completely? I felt my empathic self being torn, as I could see that she was having a hard time. Therefore, I had many considerations about how to balance this relation. I ended up talking to her, explaining that I had to talk to all of the students and that I would sometimes play with other students, not always her. Despite my preparation and considerations, my words still affected her. Situations like these are challenging, and I am still not sure what was the right thing to do.

During my time at the school, I tried to remain open about my work, like not being secret about my notes and using creative methods to challenge power relations (as elaborated in article one). I did not invite the participants to be part of the analytical process in the form of interpreting the empirical material (Baumbusch, 2011). This approach was a result of the project's ethical framework promising anonymity to schools and the participants. However, that has meant that I have been in a more powerful position as I performed the analytical work without involving the participants

## Interviews

As part of the empirical material, I produced semi-structured interviews (Kvale, 1994) with students and science teachers. In all the interviews with students, I used creative activities (Hoppe & Holmegaard, 2022). Even though the interview followed a guide with questions and sub-questions, I allowed space for detours, which meant that the interviews took different forms, but I would still get through all of the questions. I interviewed the same students in both sixth and seventh grades. I only interviewed the science teachers once as it is different teachers in the combined science subject and each of the three science subjects. In this section, I will explain the process of selecting participants and the structure of the interviews.

I interviewed 13 students, seven students at school X and six at school Y. In the original plan, I had decided to interview six students at each of the two schools. However, I ended up interviewing seven students at school X as I found myself in a difficult position of having to choose between two students, both of whom were worth following, so I ended up asking both of them if they wanted to participate and they both said yes. The students were asked during the second weekend of the fieldwork, as that gave me time to get to know the students and to be a part of their everyday school life.

I asked the students if they would like to interviewed in person at their school. I endeavoured to create a space where I told them about the interview and what it entailed, but that they could say no if they did not want to participate. I am aware that as an adult, it is an asymmetric relation, and the students might find it difficult to say no. On the other hand, I experienced that the students I asked found it cool to be asked. Thus, out of the 13 students, one hesitated, but after considering participation, the student said yes. Conversely, I also experienced students asking why they were not interviewed. This happened despite my presentation on the first day, where I informed the students that I would be conducting interviews with some of them. Even though I wished to speak to each of them, I told them that was impossible as I had to follow certain rules similar to those they also had to follow at their school. These students were those who, during the ethnographic fieldwork, often took contact and told me about their thoughts and everyday life, so I responded by explaining that the questions I was going to ask their classmates were similar to the conversations we had already had during the last weeks. This seemed to be expected by the students, expressed by smiles and bodily self-confidence. It was interesting to notice this difference because it points to an important factor about how we, as researchers, must be attentive to which voices we provide space. As already described, I experienced how some students approached the space and expressed themselves differently. This might result from resources and recognition, which we need to be aware of as some students might be overlooked.

After deciding which students to interview, I followed these students more closely. I produced all interviews at the students' school in a quiet place to avoid interruptions and to provide a safe space to talk. The interviews were recorded and then transcribed. I began each interview by explaining the purpose of the project to the participants. I also reminded them about the importance of anonymisation and sought their permission to record the interview. I emphasised that there were no right or wrong answers to the questions, as I was interested in their personal thoughts and experiences. I informed the students that if they disclosed anything that needed to be reported to a teacher or another responsible individual, I would inform them first before taking any action.

### Selecting participants for interviews

I used four criteria to select students for the interview to create a maximum variation of the empirical material (Flyvbjerg, 2006). The first two criteria focused on diversity regarding gender and ethnicity to provide a representation of a typical Danish school class. The other two criteria identified ways of participation and the time students spend with each other during classes and during breaks. I observed involvement across all school subjects, particularly in the science classes. In total, I asked six boys and seven girls, of which four were minority students. As mentioned, the two other criteria are based on my observations. The first concerns how participation was shaped and varied across different practices. During lectures, there were two types of participation: active and passive. Active participation involved students raising their hands to share something with the class; here, I noted how and what they shared. Furthermore, there were also times when students were cold-called to participate. This form was active but not self-chosen. Aside from lectures, I also observed participation during activities such as group work, including experiments or seatwork. Here, I looked at how the students participated and what their participation entailed. On the other hand, passive participation involved students who sat still while looking outside the window or were busy with non-related science activities such as chatting, surfing the Internet, or 'playing' with materials in the classroom. Lastly, I observed whom the students played or hung out with during breaks, and whom they chose as workmates during worksheets when teachers did not assign groups. In total, these factors helped me gain diversity in the students I chose, so I had students representing different ways of participating and different interests, desires, and wishes.

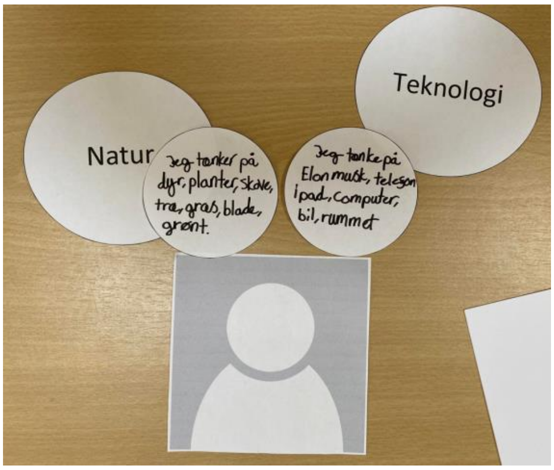
### Interviews in sixth grade

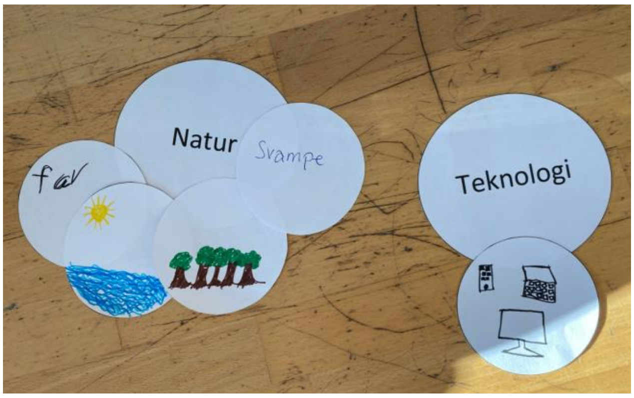
As mentioned, I planned to produce the interviews in sixth grade at the end of the fieldwork to provide a more informal and relaxed interview as I, at that point, would have spent time with the students. When the interviews were held, we had shared experiences from teaching and breaks, so I could easily follow the students' narratives. As described in the chapter on positionality, my position as someone familiar enabled a more casual and familiar interview, as there were things they did not have to unfold, like something about a teacher or classmate. For the interview, I brought pencils and paper and asked the students if they wanted to draw while they were interviewed.

Concerning the project's aim, the purpose of the interview was to learn about the students' experiences with the combined subject and to get a better overall impression of the students.

Based on that, the interview guide comprises seven parts: (1) introduction to the interview and the project; (2) life outside school (family, home, everyday life, members, pets, and activities) and spare time (hobbies and friends); (3) nature and technology (thoughts about nature and technology in general); (4) school and the combined science subject; (e) school subjects they dislike/like, class culture and teachers, and especially their experiences with the combined natural science/technology subject; (5) links between the science subject and other school subjects; and (6) dreams and the future (thoughts about seventh grade and science and what they might want to do after ending school); (7) if there was something they would like to add or if they had something they would like to ask me.

Around midway in the interview, I introduced an association activity. This was done to talk more generally about nature and technology before talking about the combined science subject (natural science and technology). I asked the students to draw or write what they thought of when they heard the word nature; some drew/wrote landscapes and talked about nature as a peaceful place, and others drew/wrote animals, but also people such as family members or the science teacher. For technology, the students drew/wrote about mobile phones, computers, robots, or other people.




## Interviews in seventh grade

During my second round of interviews with seventh-grade students, two students had moved to other schools since my previous interviews, one from School X and the other from School Y. Furthermore, one student did not want to be interviewed again, stating that he had already shared all the information he deemed relevant. As a researcher, it is imperative that I respect the wishes of the participants. Therefore, I thanked the student for his participation and expressed my thankfulness for the information he had provided. To address the gaps created by the absences and withdrawals, I interviewed two new students, one from each of the aforementioned schools.

The seventh-grade interviews were held before or after I observed the students. I structured the interviews into 10 parts: (1) introduction to the interview and the project; (2) how have things been since last time?; (3) school in more general terms, like how they experienced being a seventh-grade student; (4) how they experienced the transition between the science subjects; (5) I asked about all three of the science subjects, including what they liked/disliked, what it meant to be good, etc.; (6) biology; (7) geography and physics/chemistry; (8) the links between the three science subjects and the other school subjects; (9) did they still have the same dreams as the last we spoke or if they had changed; and (10) if there was something they would like to add or if they had something they would ask me about.

For each part where we talked about one of the three science subjects, they made a drawing where they portrayed themselves in the subject. The first drawing is from physics/chemistry and the second is from biology.


I also asked the students to describe what genre of movie each of the three science subjects would be. One student described physics/chemistry as an action movie:

> Rebekka: There's just a lot going on in Physics and Chemistry, and you always have to be on your toes, and it's very exciting and stuff like that, and I feel like it's very much an action film. Umm…

Another said about biology:

> Emil: Ummmmmmm……. It would probably be a bit like an Animal Kingdom drama film, a bit like The Lion King.

About geography, one student said about the following:

> Thomas: It had to be something with the continents all of a sudden, something with them moving, or something.
>
> I: And what happens when they move?
>
> Thomas: So much chaos.

As a last thing, I also asked the students what they thought of when they heard words such as reflection, curiosity, and learning. I did this because the teachers often used these words in ways that made me wonder whether the students understood them.

### Science teacher interviews

I produced 10 interviews with science teachers. Three of these were with teachers who taught the combined science subject. The other seven interviews were with teachers who taught one or more of the three science subjects (physics/chemistry, biology, and geography). I interviewed one teacher at school Z (science teacher in the combined subject), three at school X (one science teacher in the combined subject and two who taught one or more of the three science subjects), and six at school Y (one science teacher in the combined subject and five who taught one or more of the three science subjects). I interviewed the three science teachers who taught the combined science subject during the spring of 2022, and the seven remaining teachers during the autumn of 2022. I planned the interviews so that they fit with the teachers' schedules.

The interview guide comprised seven themes: First, I introduced the project. Second, I asked them to describe how they became a science teacher. Third, I asked them questions with a more general view of science teaching, such as what they thought science offered in contrast to other school subjects. Fourth, I asked them about their own teaching, such as if there were any topics they found difficult to engage the students in or if they experienced groups of students fitting well into the subject they taught. Five, I asked about teaching materials. Six, I asked about the opportunities to do stuff with students, such as doing school competitions or spaces to share challenges with colleagues. Lastly, I asked them if they could predict the future, would they think that the science subjects would have the same meaning as the one they had described, or would it be different?

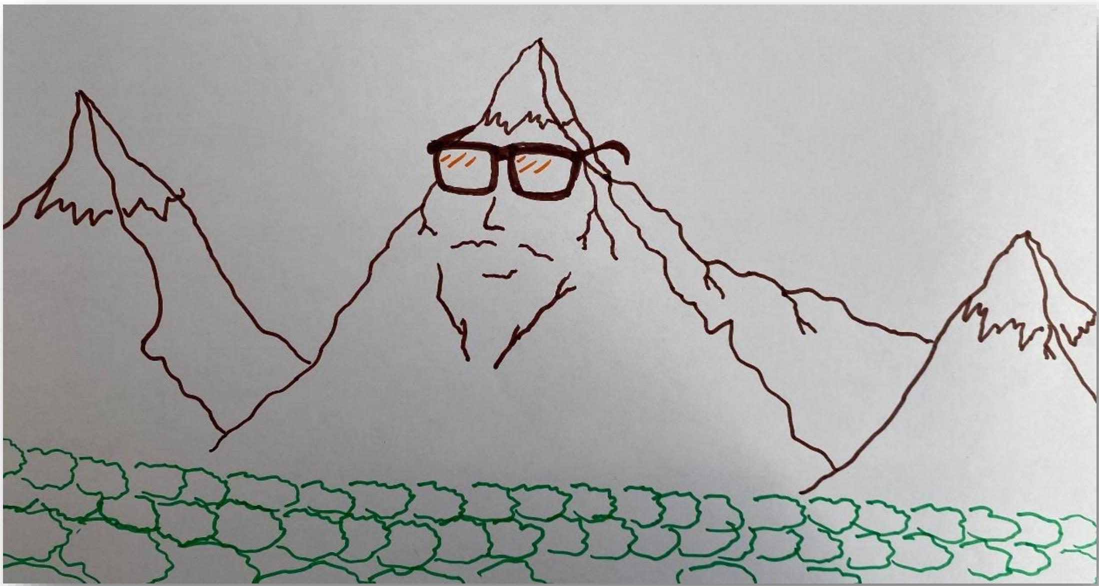
## Workshops

As a third method, I used workshops. I facilitated workshops at all three schools, where I held one workshop for the teachers and one for the students. At two of the schools, teachers who I did not interview attended the workshop. One of these schools was school Z. In the other school, it was uncertain who would be teaching the students in seventh grade, so it made sense for everyone to participate in the workshop. Below, I will explain the purpose of the two workshops.

### The science teacher workshop

The purpose of the teachers' workshop was to introduce the teachers to the project and to start a conversation about their experiences in teaching science. The workshops were divided into four periods. First, I introduced the teachers to the project, followed by questions focusing on their thoughts on the project. Second, I asked the teachers to share why they had chosen to be a science teacher. This was followed by an activity where I asked the teachers to draw themselves as they saw themselves as science teachers. Afterwards, the teachers explained their drawings, and then I asked them to draw themselves based on how their students might see them. This task caused laughs among the teachers as they realised that they might have two very different views. We talked about the differences and similarities between the two drawings. One of the things that stood out from the drawing exercise was how some of the teachers experienced themselves as being enthusiastic and engaged in their science teaching (drawing one), but when they had to imagine the students' view, they had to admit that there was probably a lot of standing at the blackboard and talking and explaining things (drawing two).

*Drawing one*



*Drawing two*

In the third part, I provided the teachers with post-its and asked them to write down what they have experienced as a challenge about maintaining students focused in their teaching. We categorised the answers into groups and subgroups, which we discussed. Finally, I introduced the teachers to the research field in which my project is situated and to some international results showing why some students might align with science while others feel alienated.

## Student workshop

This workshop was held as a result of my work with the methodological paper and was not actually incorporated into my empirical production plan. Hence, the work with the paper inspired me to facilitate a workshop for the students where they could express their thoughts about their science teaching in sixth grade in more creative ways.

I had four different tasks planned for the workshops with the students, and I tried to make space for alternative ways of expression, relying less on spoken language and conventional writing. So, the four activities were inspired by and designed to provide other possibilities for the students to express how they have experienced their science teaching. I had planned to have as few rules as possible for the activities, so when the students asked if they were allowed or if it was okay if they did this, I responded that it was up to them as there were no right or wrong ways to do it. I brought lots of paper for the tasks, and for activity four, I also brought newspapers.

In the first activity, I asked the students to portray themselves in science. As a guide, I said that they could draw things they liked or disliked about science. For the second activity, I told them we would pretend that the politicians had decided to remove science from their schedule. Based on that, they were allowed to write a letter to the minister of education to explain why they saw it as either a good or bad idea. For the third activity, I told them to imagine they were participating in a national competition to write a poem about science. For the last activity, I asked them to visualise that the science subject they had in sixth grade would be something that students in fifth grade could chose, but it was no longer mandatory. Based on that premise, they had to make a commercial for the science subject to get the students to choose it. For this activity, the students could use newspapers and magazines. However, during this activity, some students asked if they could use other materials, which I gave them space to do, and they went outside to pick material such as flowers and leaves.



The drawing I have added is from the first activity. The drawings that the students made were both interesting in relation to my interviews and observations, and it also made me choose to do the activity again with the seventh-grade students I interviewed. I found that the drawings provided time for reflection and opened up the conversation in another way. Through the drawings, the students took control of the conversation instead of just answering the questions that I asked.

## Analysing the empirical material

In each of my articles, I describe my analytical approach and briefly explain how I accessed my empirical material. To elaborate further, I will provide a brief overview of how I approached my empirical material.

As a researcher who follows the ethnographic tradition, I approached my empirical analysis as a continuous, evolving process that unfolds both within and outside of my fieldwork (Emerson et al., 2011). The approach I adopted in my fieldwork involved openness and flexibility. I consciously avoided restricting myself to any particular focus or agenda, preferring instead to remain receptive to a variety of situations as they arise. This approach enabled me to explore and investigate the experiences and interactions of the students in a more nuanced and comprehensive manner. By being adaptable and responsive to the ever-changing dynamics of the field, I gained a deeper understanding of the complex relationships that exist between the students and their environment.

Through my approach, I gained insights into many different problems, even those not related to science. However, what stood out the most for science teaching were the ways in which the students participated. Their participation became a central focus for the students' selections, and it also sharpened my view, which is the basis of articles two and three.

In the analysis phase that followed the empirical production, I employed a thematic analysis strategy (Clarke et al., 2015). This approach is particularly evident in articles three and four, which are structured around themes. The empirical material from the field served to support, develop, and challenge these themes. This process led to a further refinement in article three, which focuses on four specific cases. The thematic approach allowed me to identify differences and similarities, thereby enabling me to address the research question more effectively.

My analyses are characterised by a dynamic movement between the whole and the fragment (Søndergaard, 2006), a process often described as iterative–deductive (O'Reilly, 2012). This approach views analysis not as a linear, isolated task, but rather as a continuous process that occurs both during and after empirical production. It also involves a constant interplay between the empirical material and theoretical interests, allowing me to explore various avenues in my research. In particular, the application of positioning theory served as a valuable tool in understanding the observed material in relation to the students' actions and inactions.

# Article I: Art-based research methods in science education research: A systematic review of their prevalence and an analysis of their potentials in addressing complex questions

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# Art-based research methods in science education research: A systematic review of their prevalence and an analysis of their potentials in addressing complex questions

**Abstract**

*In this paper, we explore the potentials of applying art-based **research** methods in science education research. **Art-based methods are a range of qualitative methods that draw on performative, creative, and visual elements and thus propose innovative ways to produce knowledge in research.** The paper is based on a systematic review of the literature on applying art as research methods in science education research. The review shows that only a few studies within science education use art-based methods as a methodological approach. Additionally, the literature identified through a snowball approach was thematically analysed. Four themes were identified: knowledge made available through artefacts, non-verbal language, more balanced power and positions, and time to reflect. The analysis outlines the strengths embedded within applying art-based methods and the potentials that they present to science education research. The implications for research and limitations of art-based methods are discussed.*

## INTRODUCTION

Science education research is by nature cross-disciplinary in that it draws on epistemologies from both science and education. Thus, different epistemologies influence science education research

(Duschl, 2008; Kelly et al., 2012). It was during what has been labelled the cultural turn in the early 1980s that the idea of the science researcher engaging in objective, norm- and value-neutral science was first contested (Tobin, 2015).

Inspired by the social sciences and humanities, qualitative methodological methods eventually gained a more established position within science education (Devetak et al., 2010), and today they include various methods, for example semi-structured interviews (Ulriksen & Nejrup, 2021), timeline interviews (Malm, 2021), longitudinal interviews (Holmegaard, 2020), and so-called 'think-aloud' interviews (Bowen, 1994). With a growing interest in social life across different cultural contexts, anthropological approaches, like critical ethnographic fieldwork (Calabrese Barton, 2001) and comparative ethnography (Carlone et al., 2011), eventually gained ground. Recently, qualitative studies have proved to be valuable in examining the complex interplay of power, knowledge, and participation on the one hand and the meeting with science disciplines and cultures on the other (Avraamidou, 2019; Gonsalves, 2020). For example, studies using science identities as a theoretical lens have explored how different forms of participation are available, celebrated, and supported as well as excluded, ignored, or alienated across different science contexts (for example: Calabrese Barton, 1998; Carlone, 2004; Due, 2014; Godec, 2017; Ryder et al., 2015).

Methods are not a neutral instrument, but they allow for certain forms of knowledge production (Denzin, 2012). Thus, to approach challenges related, for example, to social justice, it becomes crucial to investigate methods that do not limit themselves to reproducing hegemonic discourses but find new ways to unbox new insights. By following this thread of thinking, we will argue that novel and alternative qualitative methods can enable a nuanced and comprehensive understanding of such complex research challenges to be unpacked. This is our starting point in this paper.

Methods drawing on art have found their way into research areas such as anthropology (Worth & Adair, 1972), psychology (Vick, 2003), health research (Fraser & Al Sayah, 2011), and education (Prosser, 2007). In these areas, techniques drawing on art are used as a tool in qualitative methods and often support existing methods, such as interviews.

Therefore, our aim in this paper is twofold. Firstly, we offer a systematic review of the extent to which art-based research methods have gained ground within science education research. Secondly, we aim to analyse the kind of knowledge that is produced by applying art-based research methods and thus the potentials of these methods for science education research. The scope of the paper is to expand the ways in which future science education research engages in complex socio-political challenges, such as equity, diversity, and social justice (Rodriguez & Morrison, 2019).

## ART-BASED RESEARCH METHODS

Art-based methods cover almost 30 different approaches (Leavy, 2017), and, given the expanding field of applying art in research, there might be even more (Knowles & Cole, 2008). Proposing one single unified definition that embraces these artistic techniques is not easy as they originate from different academic fields, in which they have been used for different purposes. However, all the research approaches that have art at their centre use art as a way to engage participants and thus enable research to produce knowledge in new ways. Therefore, in this paper, we will apply *art-based research methods* as an overall concept for creative, visual, and performative methods that encompass methods such as drawing (Bagnoli, 2009), using Lego (Gauntlett & Holzwarth, 2006), and making stories or poems (Eshun & Madge, 2012). It is beyond of the scope of this paper to introduce each one of these methods (for an overview see Knowles & Cole, 2008), though, to give the reader an idea of art-based methods, two short examples are provided.

Danielsson and Berge's (2020) research is an example of a study based on video diaries. Here, the research participants record themselves and are offered a freer space in which to share their narratives. The method allows participants to take on more ownership in sharing an unprompted, reflective monologue by controlling elements such as time, place, and subject. It replaces question and answer dialogue, which many interview methods involve, but it requires the participants to be able to express themselves in monologue format.

Another example is the use of music as a method to investigate the everyday lives of young people in their transition to adulthood. Here, young people are invited to bring with them to the interview a piece of music that they associate with a significant event or experience. Using music offers a space where strong emotions and memories are shared and worked as a way to link past, present, and future in the young people's narratives (Ravn & Østergaard, 2018).

## METHODS

To investigate the extent to which art-based methods have gained ground within science education research, we 1) conducted a systematic literature review, which is presented in the first part of the results section; and 2) undertook an additional analysis of key pieces of literature on art-based methods, not only within science education research but more generally. These pieces were identified through a snowball approach (Lindvig & Ulriksen, 2019). The analysis is presented in the second part of the results section. The focus in the analysis was on exploring the unexploited potentials for applying art-based methods in science education research.

This paper has a clear focus on research methods. As a consequence, pieces of literature that apply art in science practices, for example science teaching, to enhance student learning are left out as they differ in the aim and purpose of producing knowledge entailed in research.

### A systematic literature review

To conduct the review, we used the databases Web of Science and SCOPUS to search for peer-reviewed, international publications in the area of science education and science education research that used creative, visual, and performative techniques to produce data. We based the search on the following keywords: **science education research** and **art-based methods* OR visual* OR creative* OR performative***. We used these terms because they occur frequently in the key literature identified through the snowball approach (see below). We searched the period between 2000 and 2021 and selected only studies in English.

The search in Web of Science resulted in 39 articles, and the search in SCOPUS revealed 83 articles. In SCOPUS, the term 'art-based methods' was not a possible keyword. As a result, we decided to separate art-based methods into methods and art. In total, 122 publications were identified by the search. All of these were read to ensure that they met the following two criteria: 1) entailing art-based methods; and 2) applied as a research method.

The publications that did not meet the criteria were omitted. The excluded articles were all pieces in which the keywords occurred but in which art was not used with a methodological purpose in the research.

### The snowball approach

To explore unused potentials for science education research embedded in art-based methods, an additional review was undertaken, namely the snowball approach. The first step in the snowball approach was to identify key pieces of literature. Here, the paper by Bagnoli (2009) and the handbook by Knowles and Cole (2008) were identified as they have both been well cited by studies using creative qualitative methods drawing on arts and thus have gained an inevitable position. The second step was to identify relevant studies in the two pieces' reference lists in which researchers applied art-based research methods as part of their methodological approach. The third step involved reviewing the articles to understand how art-based research methods were used. To systematize the review, we performed a thematic analysis of all the materials that we found (Clarke et al., 2015), with a focus on the potentials that these methods offer. As a result, four themes appeared: 1) the use of artefacts as a medium between the researcher and the participants; 2) how the use of art-based methods allows for non-verbal language; 3) contests of the mechanism of power between the researcher and the participants; and 4) how the use of these methods increases the time for reflection. In the results section, each theme is presented, and the potentials embedded in art-based methods, as well as the advantages of implementing them in science education research, are investigated.

## RESULTS

This section is divided into two parts. We present first the results of the systematic literature review and then the results of the thematic analysis based on the snowball approach.

### The systematic literature review

Of the 83 publications found in SCOPUS, two appeared twice, and five of the 39 articles found in Web of Science had already shown up in SCOPUS. That left us with 116 publications identified through the two searches. All the papers were read to ensure that they met the two criteria of drawing on art-based research methods and applying the methods within science education research.

A group of publications did not draw on art-based research methods. In particular, the use of 'science education research' as a search term resulted in publications (29) focusing on teaching in respect of tools or skills with which to improve teachers' teaching or students' opportunities to learn or teach. However, as the focus in this paper was on investigating the application of art-based methods *within research*, studies using art-based methods in science practices were not included in this review.

Another group of publications was identified through the keywords 'creative', 'visual', and 'performative', though without any of them being related to a particular methodological research approach. Examples cover making representations to enhance students' skills in visualizing different subjects (Moore & Waters, 2002), the keyword performative resulted in papers on how people perform in different situations (Clement, 2004), and the word 'visual' produced papers on visualizing and visual representations, for example to enhance students' skills in visualizing different subjects (Moore & Waters, 2002).

Of the 122 publications identified from the two databases, only three contained empirical data produced from what we have defined as art-based research methods. Below, a short description of the three publications is provided.

Neumann (2014) explored students' associations, emotions, and risk perceptions of radiation using drawings, interviews, and a 'trend study' (a statistical technique to identify overlaps between future behaviours by understanding past ones) before and after the tragic events in Fukushima in 2011. The study showed that learning about radiation was mostly associated with negative emotions. To support more nuanced learning, the research group suggested that science teachers must scaffold learning to include the positive aspects of nuclear power.

Akın and Uzuntiryaki-Kondakci (2018) focused on novice and experienced chemistry teachers when teaching about reaction rates and chemical equilibrium topics to understand interactions among the components of pedagogical content knowledge (PCK). Akın adopted a qualitative multiple-case design study utilizing methods as a card-sorting activity, a Content Representation (CoRe) tool, semi-structured interviews, observation of instruction, and field notes. The card-sorting activity was carried out before an instruction to elicit the teachers' purpose and goals of teaching chemistry. Akın designed 12 cards describing different scenarios related to chemistry teaching. The teachers were asked to sort the cards into three categories (representative, not representative, and unsure) and to explain how these scenarios related to their own chemistry teaching. This activity helped to provide an understanding of the difference between what teachers think about their teaching and how they teach.

Fachrunnisa and colleagues (2020) examined the reinforcement of creativity as a learning skill to meet and overcome future challenges in society. The qualitative study explored 25 pre-service biology teachers' reflections on their own creativity and the use of creativity in teaching biology. The student teachers participated in a model strategy, teaching the visible thinking approach integrated with the biology context within three learning cycles. Using a reflective essay instrument allowed the participants to reflective on their experience and encouragement with four indicators of creativity (fluency, flexibility, elaboration, and originality). The results of the project showed that the participants' reflections centred on emersion, misunderstanding, and refraining ideas when reflecting on creative thinking skills and processes. Based on this knowledge, the project developed a three-step strategy that can be used to work with creativity in biology.

The systematic literature review showed that, despite qualitative methods being widely applied in science education research, art-based research methods have not yet gained ground. However, while art-based methods have rarely been used in science education research, creative approaches in schools are far from being a new phenomenon. Science teachers use creative tools in their classes to make space for different learning processes. Here, visualizing teaching materials offer a range of benefits to support teaching in science classes (Pederen, 2018). With qualitative methods being widely applied in science education research and art-based activities being used in science teaching, we will show in this paper that there is an unexploited potential for bringing art-based research methods into science education research. Therefore, this paper focuses solely on the potential for using art-based methods in science education research to support qualitative methods.

## THE POTENTIAL FOR APPLYING ART-BASED RESEARCH METHODS IN SCIENCE EDUCATION RESEARCH

Based on the key studies identified through the snowball approach, in this section, we present a thematic analysis of the knowledge potential produced by applying art-based methods. Firstly, the analysis investigates how art-based research methods allow for other forms of communication. Secondly, the use of artefacts opens up new forms of expression and participant engagement in research. Thirdly, we explore how art-based methods negotiate the mechanisms of power between the researcher and the participants. Finally, we consider how these methods create more time for reflection in the meeting between the researcher and the participants. The limitations of art-based methods are discussed at the end of the section. The section is organized in respect of these four overarching themes, which we label: 1) non-verbal language, 2) power and positions, 3) knowledge through artefacts, and 4) time for reflections. Although the four themes overlap, we deal with them separately so that a deeper analysis of their respective strengths can be undertaken.

### Non-verbal language

Most methods, such as interviews, observations, and surveys, rely on oral or written language and on the ability to narrate situations and experiences. This, for example, is the case of qualitative interviews. In observations, the focus is on actions and accounts as they unfold in everyday contexts, in which, again, the use of written language in field notes plays a significant role (Hammersley & Atkinson, 2007). However, oral and written accounts are only some of various ways in which the participants involved in empirical work can express themselves as expressions draw on a repertoire of and interplay between various sensory relations, such as colours, sounds, smells, and shapes. Using art-based methods, the researcher can engage and activate a broader spectrum of expressions, gaining novel insights into how the world is presented to the research participants (McNiff, 2008). One example is the use of collage as a way of understanding ethnic identities among young people from different backgrounds based on how they see themselves and how they think others see them (Awan, 2007). Using this method, the participants are given a blank surface, often a sheet of paper and various materials in the forms of newspapers, photos, or other sources often connected to a theme. The idea is to let the participants place the materials on the surface in ways that define or link them or remind the participants of the theme. The participants choose what to add to the collage and where to place it depending on the story that they want to tell. This involvement is based on emotions and feelings and how the pictures, images, and other sources elicit emotions and feelings about how the participants interpret and perceive them. It is a process that has the strength to elicit meanings that might be hard to verbalize because of social norms (Marcu, 2015). It provides the participants with the opportunity to construct their own interpretations of the research aim. They select which pictures to use in creating the collage, and it is their interpretations of the pictures and what the pictures evoke in them that matter.

It is worth paying attention to these various elements that extend beyond oral and written language because they challenge the barriers and constraints related to language skills, such as cognitive abilities and native language (Polkinghorne, 2005). The vulnerability of language requires the abilities to recognize, remember, and pronounce with confidence when speaking and writing (Brooks et al., 2020). Such challenges are overcome by utilizing the potential of art-based methods to move beyond language skills and barriers by expressing wordless understandings of the world.

When applying art-based methods, other forms of expression, narratives, and perspectives are allowed that make language less central (Dodman, 2003). This, however, does not mean that language is irrelevant as many art-based methods act as a platform for creating a dialogue between the researcher and the participants. However, instead of setting the scene for the empirical production, language acts as a support in explaining the artefact, for example a drawing or a photo.

Moreover, art-based methods have the potential to access what is described as wordless knowledge (Patton, 2020). Wordless knowledge emphasizes a more tacit knowledge embedded in the body and as a consequence challenges the idea of knowledge as something that can be reduced to rationality and language (Eisner, 2008). The consequence of approaching knowledge as something exceeding words and numbers thus calls for novel and innovative ways of generating new knowledge (Chaplin, 1994). As Eisner stated: 'knowing is a multiple state of affairs, not a singular one' (Eisner, 2008, p. 5).

This supports the argument that different methods are suitable for producing different forms of knowledge both to understand various research questions and to engage a diversity of research participants. Art-based methods allow for expressions that exceed oral and written language, and, as a result, such methods present the potential for destabilizing the categories produced through language that have become natural and instead allow for new and critical ways of thinking. An example is a study in which artwork made by students investigated how oppressive conditions became familiar within education in postcolonial Hawaii (Kaomea, 2003). Another such example is the study by Nielsen, who explored drawings produced by girls and boys. These drawings were used as a platform for investigating the cultural differences between the ways in which boys and girls expressed themselves (Nielsen, 1996). These examples of making everyday perceptions understandable highlight the importance of allowing space for novel methods that support creative expression.

Such creative methods have the advantage that they enable abstract notions to enter into sounds, drawings, pictures, or movements, where they may unlock different understandings of a phenomenon (Bruselius-Jensen & Danielsen, 2018; Pless & Katznelson, 2018). Bruselius and Danielsen explained that they concern not exclusively what is shared but also how it is shared: the pauses, the rhythm, and the tone indicate how the participants prefer to represent themselves (Bruselius-Jensen & Danielsen, 2018). This approach offers another way of encountering research.

Inviting participants to use artefacts bridges the gap between language and experience with other forms of communication based on embodied presentational forms. The performance of bodily expressions when interacting with environments such as other persons or materials is not always expressed in words but sometimes articulated through other senses, which can be expressed through art-based methods. This provides an alternative for understanding how participants respond to their social worlds in a more physical and personal form. Working with art provides a space in which to connect with memories and perceptions and to evoke our emotions and capacity to feel; as Eisner pointed out, art helps us to 'discover our own interior landscape' (Eisner, 2008, p. 11).

By reducing our use of spoken words, we might liberate new opportunities to share narratives that may have been overlooked in the preference for language. Using art-based methods enables participants to express themselves through these non-verbal forms, presuming another kind of participation by them. An artefact is not only an object in the world; it also mediates the dialectical relationship between external and internal interpretations of our senses. By reducing the interruption of oral and written language, an approach like drawing a self-portrait offers participants the lenses through which to see their lives differently (Bagnoli, 2009). This became visible in a study on children's understanding of health in their lives (Wetton & McWhirter, 1998). Children were provided with a picture of a figure with smiling white teeth, but, based on a presentation of mouth hygiene, they drew figures with black and sharp teeth. This depiction illustrated a mixture of playfulness, ideas, and interpretation created by the possibilities of drawing. Instead of asking children about the health effects of sugar, the participants were allowed to communicate using non-verbal skills. Conversely, language needs a meaningful connection with the spoken word; contents of drawings are detached from these linguistic practices. Drawings overcome the limitations of language by moving between the known and the unknown. Nielsen, in her work with students, showed how the visualization of abstract topics, such as the future, is made more accessible through drawings. Depicting their future allows students to discuss different future selves (Nielsen, 2021).

This distinctive opportunity provided by drawing creates a space for participants to obtain ownership because the artefact becomes visible and physical in a different way from spoken words. The researchers hand over the task for the participants to complete without defining or determining how the artefact is produced or dictating the process. Dictation means the designing process whereby the participant draws the drawing. Moving beyond language, there is an unexplored potential to encounter the research field and to meet one's participants under conditions that frame a less power-laden relationship and that allow access to the obvious and unnoticed in everyday life.

## Knowledge accessed through artefacts

The main point of art-based methods is the use of artefacts, that is, objects placed between the researcher and the participants. Artefacts can be anything from Lego designs to drawings or music. As a medium, the artefact invites both the researcher and the participant to adopt other perspectives and positions. The artefact may trigger forgotten memories and access other layers of consciousness (Harper, 2002). It allows different and new insights to be accessed through a bodily interaction with the artefact involving holding, seeing, and creating, which the authors argued 'leads to a deeper and more reflective engagement' (Gauntlett & Holzwarth, 2006, p. 89).

Using artefacts is a way to activate memories through something concrete. Materials and objects surround us in the world, and they are often embedded with certain meanings or, as Skeggs stated, 'certain tastes'(Skeggs, 2004). These meanings might be difficult to research through language, and they may have acquired a simplified understanding that is less recognizable. The use of artefacts opens a new entry point to understanding these meanings or tastes. Examples of using drawings as an entry point to understand how certain stereotypes become institutionalized give knowledge to the consciousness that forms our minds and being in the world.

We can see this in the 'draw-a-scientist' test by (Chambers, 1983). Chambers provided a very powerful idea of what stereotypical images of a scientist involve and what they exclude. Moreover, a study like this shows how powerful stereotypical images can be and how static they are, yet they develop over time. When working with artefacts, in this case drawings, the researcher obtains access to this world of details, through which the visibility of the symbols is displayed. The drawings show how symbols are so cultivated in respect of certain stereotypes that they become natural to our perceptions of the world. This, moreover, highlights how our interacting with our surroundings is based on images, which can be achieved by utilizing art-based methods.

However, it is not only the artefact itself that is interesting but also the processes through which the artefact is produced, what is represented, and which different needs and styles this involves (Bagnoli, 2009). The artefact becomes a transfer for understanding participants' visual preferences and how they interact with their choices and the framing and considerations that they make when creating the artefact (Warren, 2005). Creating an artefact or a performance has the potential to move the participants and the researcher away from their everyday behaviour to indulge in a deeper reflection on the process that creates the product. It is not only about the product and the process of designing the artefact, like deciding what to take pictures of and what to erase from or add to a drawing. What one suddenly remembers draws more attention to the creation and how the participants may wish to represent themselves.

At the same time, the artefact has the strength of defamiliarization (Shklovsky, 1917), a concept created in the field of art, which is a way of slowing down our perceptions to recognize what has become stale in our everyday lives (Mannay, 2015). In this case, the defamiliarization is the artefact requiring the participant and researcher to slow down (Mannay, 2010), allowing them to acquire new perspectives and different views. As a result, it can be the unseen or forgotten elements of the everyday life lived by the participants that are made visible (Pless & Katznelson, 2018). In other cases, the artefact might act as a go-between for material in which sensitive topics are more easily expressed because the participant may feel less pressured (Heath et al., 2009; Prosser & Loxley, 2008). The strengths of these methods often lead to their use with vulnerable groups, such as the homeless (Packard, 2008) or the sick (Fraser & Al Sayah, 2011; Frith & Harcourt, 2007; Frost & Smith, 2003). However, these methods have also provided a whole new entry point in studies in which children and young people participate in research because they allow creativity to be used as a way of telling.

Moreover, by including such artefacts in research, the researcher gains access to meanings and interpretations though other materials, objects, and sensory support. These methods provide access to bodily knowledge, understanding the body as being a central aspect of individuals' emotions, opinions, intelligence, and experience (Merleau-Ponty, 1982). Thus, placing artefacts at the centre of the investigation is a way of enabling new ways of sharing narratives and experiences to emerge. Inviting an artefact into the research field emphasizes and reinforces the power of non-linguistic elements to count as legitimate ways of expressing and interpreting. This engagement opens up a new form of narrating something because the narratives are transformed into other forms, such as drawings and collages, clay models, poems, and so on. Everything from seeing and feeling to performing may emerge from the artefact, generating new questions, connections, and meanings. This promotes other ways of sharing narratives. When we consider our senses as something legitimate with which to interpret our world, we gain a more diverse spectrum of knowledge on how to encounter science.

## Power and positions

This theme examines the possibilities that art-based methods offer to disrupt power relations when producing qualitative empirical material. The mechanism of power is related to the positions that we encounter as both researchers and participants and the way in which these positions interact with and exert an impact on research.

Art-based methods offer a shared space where control over what is undertaken and how is negotiated by the participants (Awan & Gauntlett, 2011; Mannay, 2015). The researcher is the one who leads and controls the pace of the interaction, while the participants are those whose responses are challenged. However, it becomes possible to open up other forms of conversations that are characterized less by a one-way dialogue. This also acts as a critique of qualitative interviews that are dominated by asymmetric power relations, with the researcher often being in control (Kvale, 2002). By using art-based methods, such asymmetric power relations are redefined because the power moves between the two parties. Adriansen showed how timeline interviews can provide a platform for sharing what she labelled 'analytical power', which enables a position from which key experiences and events are selected and presented by the participant (Adriansen, 2012). Thus, involving an artefact has an impact on the way in which power is shared because the production of an artefact creates a new position from which participants can produce and communicate knowledge relating to them in new ways.

One example of what such a shared space can look like and how the participants can engage in the production of data is provided by studies in which the latter are encouraged to select or take their own photos (Hubbard, 1994). This, for example, is the case of the research by Staunæs (2004), who studied race, ethnicity, and gender in relation to school life in a seventh-grade class and, among other methods, used snapshots as a way of eliciting the participants' perceptions of their school lives. Another example is Rasmussen (1999) work with children aged eight to 12, aiming to understand the possibilities of using cameras to obtain insights into children's lives outside school. In both studies, the participants were asked to take pictures of their everyday lives and were encouraged to talk about them. When meeting the researcher, they were invited to describe how they had composed the photos and what they aimed to capture by taking them. The photos were thus used as a platform for gaining a more detailed and concrete understanding of the young people's lives from their own perspective as a way to uncover the unknown (Packard, 2008). This invites one to acquire an awareness of places, things, or objects that might seem irrelevant but are significant to the participant. By means of the researcher sharing analytic power with the participants, the latter are provided with a position from which they can share their points of view and decide what is important to them and what matters in their current situation. The aim is to generate a more balanced relationship in which the co-construction of interpretations becomes a shared activity for both the researcher and the participant. As Rasmussen (1999) stated, there is the physical experience (how the world is seen from a height of 1.30 cm) and the mental experience (how a 12-year-old person meets the social world). This shows the opportunities that give the participants greater control over producing data, which is less controlled by the researcher.

In conclusion, by using art-based methods, such as a camera, possibilities are opened up to achieve a position in which the participants become an '"expert" on their own worlds' (Leitch, 2008). Regardless of the choice of art-based methods, the participant maintains a position in which negotiating control over the act of creating is possible. This increases the level of engagement and establishes a more equal relationship between the two parties (Prosser & Loxley, 2008).

By giving more control to the participants, we create a space in which they can enjoy more control. We see this in action research as well – the idea of creating a temporal free space, or at least a freer space, is sought (Thingstrup, 2015). In both approaches, the aim is to provide a platform for the participants to interpret and solve the research task for a while, without interruption by the researcher.

## Gaining more time for reflection

When working with art-based methods, it becomes significant to consider the dimension of time: time to reflect, time to engage with the artefact, and time to embrace a slower pace. Often, when we talk, we respond immediately because it is polite but also because silence in a conversation is experienced as discomforting (Newman, 1982). Talking is a flow of exchanges, a way of responding verbally and non-verbally to others, which makes the conditions for reflexivity less favourable. Art-based methods allow for a different type of interaction, creating a space that allows time for reflection. When working with an artefact, participants need time to create or build what is in their mind, which prompts slowness (Gauntlett & Holzwarth, 2006). Stories told with artefacts need time for the participants to reflect on the task, transforming the reflective process by moving it from an internal to an external process (Gauntlett & Holzwarth, 2006; Ingram, 2011). The experience of reflecting is present when creating something. The participant needs to imagine the artefact and then create it. This entails a double reflexivity that is bound to both process and product and is both physical and sensible to the participant as well as the researcher (Rasmussen, 1999). Depending on which art-based method is being used, the understanding of slowness has the power to extend the time spent on research. The researcher can, for example, provide the participants with an opportunity to create without the researcher's presence (Mannay, 2010), which extends time because it is not located in a single concrete situation.

Of course, other ways of using art-based methods are temporal, but that does not change the space for reflexivity. The reflexivity that emerges from the artefact used by the participants responds and establishes a new dimension.

## DISCUSSION AND CONCLUDING REMARKS

Methods are not neutral but offer researchers a certain set of lenses through which to approach the world. For science education research to unpack and approach novel and complex socio-political challenges, such as equity, diversity, and social justice, and to exceed the reproduction of existing power and knowledge structures, in this paper, we argue that it is crucial to develop and apply new qualitative methods to support alternative, nuanced, and comprehensive forms of knowledge.

Art-based qualitative methods have gained ground in related research areas, such as education, in which they have proven to be vital in gaining insights that more widespread methods, such as surveys and interviews, struggle to capture (Brooks et al., 2020). Based on a systematic literature review, we showed how art-based research methods have gained limited ground within science education research with a few identified studies. The scope of the paper was to investigate the kind of knowledge that is produced by applying art-based research methods and thus the unexploited potential that these methods offer science education.

As shown, art-based methods come from different research fields based on different epistemologies depending on their methodological approach and theoretical grounding. As such, it is not in the scope of this paper to generalize art-based methods as one homogeneous research paradigm set by a certain epistemology but rather to seek how these various methods might support and provide space for new forms of knowledge to emerge in science education research. Based on studies applying art-based methods identified through a snowball approach, we carried out a thematic analysis. As a result, four themes were identified: knowledge through artefacts, language, power and positions, and time to reflect.

We showed how working with artefacts encourages new ways of meeting participants by providing a space in which to share experiences by moving the attention from the participants to the artefact. This reveals new insights into how participants interpret the world and allows for a greater level of engagement because linguistic skills and language are less of a barrier. However, there needs to be awareness of the participants' prerequisites for and experiences with engaging in art-based methods. We suggest that researchers applying art-based methods pay particular attention to the participants' creative abilities and preferences. These include practical experiences when forming, drawing, listening to, or picturing that provide some participants with the ability to engage in and interpret art-based methods because they have been exposed to art in their lives, while other participants may feel more alienated. When analysing the artefacts applied in and produced through the data, it is thus crucial not only to include the product itself but also to analyse its creation.

In the paper, we showed how oral and written accounts are only some ways in which participants involved in empirical work can express themselves. Art-based methods offer a platform for moving beyond the limitations embedded in language, such as cognitive and linguistic abilities, as well as the ability to recognize, remember, and formulate oneself. Moreover, art-based methods can engage participants with speaking and writing disabilities, and the methods are particularly relevant for children, who lack huge language repertoires. Furthermore, art-based methods have the potential to engage groups that might not be used to finding words for experiences that are not commonly recognized or shared, as is the case with marginalized groups in STEM (Siry & Gorges, 2020). However, a relevant objection here concerns whether art-based methods actually extend beyond language. For example, Laclau and Mouffe (1987) argued that linguistic and non-linguistic elements alike establish meaning through discourse and therefore all objects are socially constructed, being articulated in different positions in which they acquire meaning. This highlights the understanding that we access the world through language and therefore never escape it. In this case, it is crucial to pay attention to how the participants construct the art-based objects and how they make meaning out of them but more importantly how the researcher understands art-based objects. Here, the transparency of the analytical approach becomes vital for the reader in following the steps taken in interpreting the participants' engagement in the methods and the artefacts that they are presented with and produce. The analytic approach to art-based methods has not been the scope of this paper, yet we believe a fruitful next step could be to discuss how art is analysed or not through language.

The analysis showed how time to reflect becomes key when working with art-based methods. In interactions with research participants, there is a flow of non-verbal and verbal recognition, prompts, and responses that seems natural; as a consequence, long breaks are considered impolite. Art-based methods, by contrast, create the space and time for reflection. However, it could be contested whether more time provides better or more authentic insights into the research question. Our point is not that more time to reflect produces a truer version of the analysis. Instead, we argue that time to reflect is often lacking in tight and compact methods in which carefully planned themes or questions provide limited room for participants to construct their own narratives.

In the analysis, we showed how art-based methods support and contribute to challenging power, imbalances, and inequalities by enabling positions in which the participants have more influence on the production of data. Even though art-based methods address these unequal relations between the researcher and the participants in new ways, they do not fully escape these unequal positions. While they unlock new forms of entering and understanding these positions and thus reduce the inequalities in the methodological process, art-based researchers must still be attentive to asymmetric power relations when producing and analysing data and when choosing which art-based methods to use.

A final concern regarding art-based methods is the extent to which there is a discrepancy in putting such methods forward to science teachers, science students, or scientists. We have shown how these methods can be applied to a range of different research aims and participants as well as demonstrating the potential that these methods bring to science education research. However, we suggest that science education researchers start cautiously in selecting activities such as using photos and drawings that might be familiar to the participants. Introducing methods that are outside the comfort zone will emphasize that the researchers guarantee to create a safe and inclusive space where it is clear to the participants what their roles are expected to be (Feuerstein, 1988). It is our experience that this does not apply only to art-based methods.

In conclusion, we have shown that innovative art-based research methods can unlock new insights into science education research and that they have great potential for expanding the already-established repertoire of qualitative methods.

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# Article II: Unveiling the production of non-participation in the primary school science classroom

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ORIGINAL PAPER

# Unveiling the production of non-participation in the primary school science classroom

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## Abstract

This paper originates from experiences of low participation in science teaching in primary school during ethnographic fieldwork. Focusing on these observations and inspired by other studies conceptualising non-participation, this paper examines how non-participation is shaped and produced in primary school science. Drawing on ethnographic fieldwork and interviews with students in year six (12 years old), three forms of non-participation are analysed as well as the various forms and shapes they take, namely non-participation: 1. through exposure; 2. through being overlooked; and 3. through being disciplined. Using the theoretical concepts of performativity and positionality, the paper analyses how the production of non-participation emerges as rigid positions, hard to negotiate and thus quite stable over time, as well as interfering with intersections of gender, race/ethnicity and social background. At the end of the paper, we discuss how the positions' displays of stability serve as barriers to students' ability to form identities as science learners in different contexts and over time, and we argue that teachers play an important role in disrupting these positions. Moreover, we point towards future research to continue the work on conceptualising non-participation, and we suggest that there is potential in combining research on emotions and affect with understanding how non-participation is formed and shaped not only inside the classroom but also in other science settings outside school.

**Keywords** Science identities · Primary school · Non-participation · Positions · Ethnographic fieldwork

We begin this paper with an episode from the ethnographic fieldwork, which was conducted in a primary school science class (with 11-year-old children). During a science lesson, the light suddenly went out (because the sensors had not registered any movement for some time). Consequently, the teacher waved her arms in the air to turn the light on again. One of the children turned towards the ethnographer and explained: '*it is because we are very quiet [in science class]*'. This, together with observations of silence, quietness and passivity in science teaching, raised our awareness of how these practices are produced, in contrast with contemporary ideas of school science as being inquiry based

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(Chu, Reynolds, Tavares, Notari and Lee 2021), student centred with student impact on their learning (Demirci 2017) authentically (Braund and Reiss 2006) and justice-oriented science teaching (Calabrese Barton and Tan 2020). In her seminal paper, Lucy Avraamidou (2020) argued that people come to see themselves in science and come to be recognised as science persons through layers of power dynamics that intersect with the norms and practices in science teaching. Linking participation and the construction of identities in science, she asks:

> What science? Whose science? Is everyone welcome to science? How might science (non)participation look like? How might science (non)participation feel? How might we understand the politics of science (non)participation? Can we imagine alternative and infinite ways of being/becoming a science person? (p. 324)

Avraamidou links (non)participation to equity (‘*whose science*’) when discussing how participation follows patterns of power dynamics. Becoming and being a science person is not equally accessible for all children, and following Avraamidou’s line of thinking, (non) participation is a result of ongoing recognition practices in the classroom that involve who is recognised as someone aligning with the subtle norms, values and ideas of what science is and how it should be performed in the classroom, and those who is not—while acknowledging that these negotiation practices are continuously shaped. In this paper, we have sought to understand empirically how non-participation is produced and the shapes that it takes in primary school science classes.

Only a few studies within science education research have applied the concept of non-participation, and one such study by Karlyn Adams-Wiggins, Michelle Myers and Julia Dancis (2020) investigated group work with a focus on the role of peers in creating and legitimising non-participation in primary classroom interactions. They found that children in low-status positions risked being associated with ‘*marginal non-participation*’ (p. 431), in which non-participation was perceived as a personal trait (rather than a temporal position), which made the negotiation of status hierarchies difficult. They showed that such hierarchies were reproduced and legitimised by applying disciplinary norms—that is, by positioning someone as not aligning with expected disciplinary behaviour. Conceptually, they approached non-participation with Wenger’s focus on marginal non-participation with a link to power and on ‘*how status hierarchies shape opportunities for participation and thereby also shape opportunities for identification with science as a discipline*’ (p. 428).

Another study on non-participation by Emily Dawson (2018) applied a Bourdieusian lens by investigating the ‘*patterns of advantage and disadvantage through who can and cannot participate*’ (p. 775) in terms of becoming a part of science communication practices. Dawson linked non-participation to processes of exclusion, and she argued that non-participation often risks being associated with the participants’ lack of possession of the right values, knowledge and attitudes and is thus connected to deficits. In conclusion, she showed how patterns of participation were narrow and preserved for participants not only by restricting access but also by misrepresenting their voices.

While non-participation has not been widely applied as a concept within science education, several studies have sought to understand participation in relation to learning situations within science by drawing inspiration from Jean Lave and Etienne Wenger (Lave and Wenger 1991; Wenger 1999) and by linking participation and learning to the creation of identities. One such example is Heidi Carlone, who explored how specific learner identities are promoted and supported in physics classroom settings (Carlone 2004). For Carlone, learner identities develop when new positions are made available and taken up by the learner. However, such positions can be unavailable, not achievable or restricted to some participants, and not all participants might be interested, in or feel comfortable with, inhabiting that position. Carlone links patterns of participation with power structures and recognition practices of who can take up what kinds of positions, and to gain recognition as science learners, some students might need to submit themselves to practices they do not feel align with who they are, whereas others might not feel they have to compromise themselves to gain recognition.

In line with Carlone (2004) and Avraamidou (2020), we have been inspired to approach non-participation as a matter of identity. Closely tied to the recognition practices at stake in the classroom are, on the one hand, the interplay with power—who you are matters for learning science, as pointed out by Carlone (2004) and Dawson (2018)—and social hierarchies—as pointed out by Adams-Wiggins and colleagues (2020). On the other hand, so too is the meeting of science disciplines and cultures, as pointed out by Angela Calabrese Barton (2013), that determine which students are recognised and which ones recognise themselves as science learners. It is with this complexity in mind that we explore non-participation. To do so, we ask the following questions: (a) What kinds of non-participation are performed and shaped in science classes?; and (b) are some of these performances of non-participation more dominant than others?; and (c) how is non-participation constrained or supported through intersections of social categories such as gender, race, ethnicity or class.

We add to existing studies by examining how non-participation is produced in the primary school science classroom and investigating the dynamic interplay among school-based science, teachers and students. We strive to understand how the production of non-participation in science influences how students come to learn and see themselves as science learners.

## Theoretical background

A common thread in the studies presented in the introduction is how power interplays with recognition practices and comes to shape positions of non-participation. It is within this field that we seek to understand non-participation in primary schools, and to do so, we use the theoretical concept of positioning as proposed by Bronwyn Davies and Rom Harré (1990). They conceptualise identities as ongoing and negotiated through social practices, which means that positions are fluent and changeable in relation to the practices presented in different contexts. We approach non-participation through the lens of positioning-theory to explore the mechanisms within the science classroom that shape these positions. Besides the concept of positioning, we also use the concept of performance developed by Judith Butler (1990). These two theoretical concepts are used in combination in this paper because of their strength to examine non-participation as an ongoing negotiation and renegotiation among the participants.

### Positioning

In this paper, we strive to understand how positions of non-participation become available and produced during science in the sixth grade (children age 11–12). Davies and Harré (1990) state that subject positions are made available through social practices, as multiple and complex 'openings' invite subjects to take on positions, and 'closings' refer to where attempts are rejected and not recognised. In this study, we focus on these practices of recognition and rejection to understand the production of positions that are shaped through the interactions occurring during science teaching positions that for some students might provide access to restricted forms of participation and engagement while for others opens they open up opportunities for participation. By using the concept of positioning, we explore the twofold process of being positioned and the positioning of others and how positioning appears and entails significant meaning for recognition and for what that recognition is gained.

*The positions we obtain are not necessarily coherent, as we can be positioned in contradictory ways through different contexts or even within the same interaction entailing different forms of meaning* (Holmegaard and Johannsen 2023, p. 117). We are interested in the positions offered to students in relation to the production of non-participation, so as to understand whether these performances of non-participation ultimately manifest themselves in stable or temporary positions, which influence students' opportunities to see themselves as science learners as well as developing science identities.

As positions are shaped by, and emerge in, social practices in which individuals participate, individuals are constituted and reconstituted in relation to various discourses (Davies and Harré 1990). As individuals move in and out of discursive practices, the idea of who they are and who they wish to become is an ongoing process of negotiation that involves *recognising,* both recognising themselves and being recognised by significant others. A lack of recognition minimises the individual's sense of self and hinders the development of a sense of belonging in meaningful ways (Davies and Harré 1990, p. 48), particularly as identities in this understanding are more dynamic than describing different sides of a person, offering lenses through which to see the subtle inclusion and exclusion practices at stake in social practices and who one is allowed to become through the social practices in which one participates.

Using positioning as a theoretical lens, we approach science classes as practices of negotiation about who and what kind of participation gain recognition, and whether it is meaningful for the students' to perform that participation.

Thus, we focus on the non-available routes for students to become recognised as learners in science classes, and we examine scenarios in which attempts to take up such positions and actively participate in the science classroom are continuously restricted, rejected and not recognised by peers and teachers, ultimately resulting in passivity, making the students take on positions as spectators rather than learners.

The positions allow students not only to come to see themselves in certain ways but also to see the world through the perspective of the position held (Davies and Harré 1990), being recognised as someone contributing with valuable inputs to science classes, and thus allowing the world to be seen as science-associated. As we will unfold next, we see the axis of power entangled with ideas of who is recognised within science settings and who is not. Science participation is thus shaped by many years of forming ideas of what science participation looks like, who and what belong and who and what do not (Carlone 2004). These ideas are continuously (re)produced and find novel and subtle routes of manifestation. In understanding the production of non-participation, we strive to transcend these well-established norms of engagement, often associated with ideal, exemplary students naturally inclined towards science (Carlone 2023). Our focus shifts to the subtle performances that evade attention and the forces that shape, and possibly sustain, their recurrence. Thus, from being interested in the privileged, ideal students that naturally feel a fit with science we explore the performances that go unnoticed with an attention on what shapes and might even keep reproducing them.

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## Performativity and power

In conjunction with the concept of positioning, we employ Butler's notion of 'performativity' (Butler 1990) to comprehend the performances enabled and facilitated by positions emerging in the science class. This allows us to explore the background of the potential discomfort and undesirability experienced by certain students when engaging in these performances, which are shaped by cultural and historical ideas and expectations, embodying expectations that may be unsuitable or exclusionary for specific students to adopt them. Through the lens of performativity, we approach positions as situated performances as they are an outcome of relations shaped by science teaching and do not belong to the individual (Butler 1990).

According to Butler's ideas, gender is a performative expression woven into discursive practices, encompassing a spectrum of acts, gestures and enactments that constitute the ongoing 'doing' of gender. The embodiment of masculinity and femininity is manifested in these actions, and Butler underscores how the repetition of such acts serves to legitimise them (Butler 1990, p. 191). As such, gender is not inherently predetermined but rather a dynamic construct actively shaped by our actions—a continuous process of 'doing' rather than a fixed aspect of who we are.

The performances of masculinity and femininity are then entangled with practices of recognition (to recognise and to be recognised) as recognition refers to 'readings' of correct or expected actions. As Archer and colleagues showed in a study on gendered performativity during a museum visit, boys often conformed to traditional masculine norms while interacting with science by asserting their competence and dominance when engaging with science activities (Archer, Dawson, Seakins, DeWitt, Godec and Whitby 2016). By applying a Butlerian lens, they identified two main forms of masculinity and a less common performance enacted by the boys during the museum visit: *laddishness*, *muscular intellect* and *translocational masculinity*. The researcher then explored masculinity in relation to identity and engagement and the influence of others as well as the boys' performances of masculinity for who could and could not do science identity (p. 443). In the analysis, they showed how social norms and stereotypes around masculinity influenced the boys' experiences at the museum by addressing the pressure among boys to conform to traditional gender norms when encountering science and how that influences interest and participation (Archer, Dawson, Seakins, DeWitt, Godec and Whitby 2016).

In this paper, we use the concept of performance for two main reasons. The first is to examine positions of non-participation as performance. This allows us to explore practices in science classes and the limitations and affordances of these practices in relation to accepted and rejected performances. Which performances are allowed and what kind of recognition do these performances gain from teachers and peer students? Second, we use this concept to see whether non-participation is gendered by, for example, drawing on ideas of masculinity or femininity and the embodied practices of these performances.

Performance as a concept offers a lens for delving into subtle ways of performing such as non-verbally and without explicit embodied practices. We use the concept to see the science classroom as a micro-cultural context where positions are taken up, recognised, rejected, negotiated and reproduced. Performance thus creates a form of logical truth undermining others' ways of participating to arrive and be recognised, while maintaining positions of non-participation instead of challenging them.

Using performance is a way of localising the production and reproduction of non-participation. As (Butler 1990, p. 45) mentions, the continuous repetition of actions is what creates ideas of a natural sort of being like, for example, some students being naturally unengaged. Performance involves ongoing acts of negotiation, although in some situations, negotiation might be difficult or absent because of dominating ideas such as who belongs in science and can recognise themselves and be recognised as a science person. This might create 'locked' and stable positions from which students can be interpreted as unmotivated, uninterested in or ignorant of science. Thus, we do not only focus on gender. Over the last few decades, *intersectionality* (Crenshaw 1997; Crenshaw 2013) has proved crucial in understanding students' access to, and participation within, science. The intersection of social categories such as social background, race and ethnicity, and geography also intersects with recognition practices. A range of studies has pointed out how minority students tend to feel a disconnection between themselves, their background, values, interest and language in relation to becoming a science learner (Brown 2004).

# Method

## Context of study

The public school in Denmark (*folkeskolen*) is the most common school institution and 80–90 per cent of all children (aged 6) begin their schooling in a public school (Sievertsen 2015). The remaining 10–20 per cent use other alternatives such as home-schooling or private schools. Public schools is a nine-year mandatory education, which covers both primary (grades 1–6) and lower secondary (grades 7–9) schools (emu-redaktionen 2023).

In low-population areas, some countryside schools end at grade six, which means that the students move to bigger schools in the area to finish grades 7–9. The Danish folkeskolen are similar to primary and lower secondary schools in the UK or primary and middle schools in the USA. In this article, we will focus on the last year of pri-mary school, i.e. grade six (ages 11/12).

We focus on sixth grade science classes (ages 11–12) in Denmark, where children are presented with the combined science subject called *natural science and technology*, which includes elements from technology, biology, geography, physics and chemistry in one united subject. Patterns of participation in the sixth grade can, therefore, be crucial for entering future science subjects in the seventh grade (biology, geography and physics/chemistry) and for future educational choices.

We use data produced in two Danish public schools. One of the schools is a country-side school, and the other one is a suburban school; both schools include classes from the non-mandatory nursery school (6 years old) to ninth grade (16 years old). While public schools comply with the national learning plans, the teachers do not follow a strict day-to-day learning plan, but both the school and its teachers have the opportunity to decide how best to organise their teaching to meet the plan, and how much time to spend on each topic as long as ministry plans are met. However due to limited preparation time, the teachers often feel restricted in their planning. In addition, the schools can decide on areas that they will emphasise, and one of the schools has prioritised an emphasis on science that is greater than that required by the government (Undervisningsministeriet 2008).

## Natural science and technology

The subject of science in primary school is, as previously mentioned, interdisciplinary and encompasses elements from nature, technology, biology, geography and chemistry and physics (emu-redaktionen 2023). In the sixth grade, where this study is situated, science is normally structured as a double lesson (1 h and 30 min), and it is the only time the students meet science during the week. Some schools are challenged in finding teachers that can cover science in the sixth grade, which might force the schools to allocate teachers without science backgrounds (Hyllested 2017).

The students follow the combined science subject from grade one to six, and in grade seven, they are introduced to three new science subjects: chemistry/physics, geography and biology. The combined science subject is a three-step process divided between grades one and two, grades three and four and grades five and six and during these transitions the content and purpose change (Børne- og Undervisningsministeriet 2008). Hence, four competences, namely investigation, modelling, perspective and communication, remain consistent over time.

In the subject of combined science, students are required to develop the four science competencies. These competencies includes that students' acquiring knowledge and skills about important phenomena and contexts, as well as developing thoughts, language and concepts related to nature and technology that are applicable to everyday life. According to legislation, it is expected, and extremely beneficial, that the combined science teaching is to be based on students' own experiences, as this strengthens their practical skills, creativity and ability to collaborate (Børne- og Undervisningsministeriet 2008). Furthermore, science teaching should maintain students' interest and enjoyment in science, while also helping them to connect science to the world around them. By the end of grade six, students should be capable of designing experiments using hypotheses, creating simple models, relating the subject to the world and current events and communicating about nature and technology (Børne- og Undervisningsministeriet 2008).

## Ethnographic fieldwork

During the ethnographic fieldwork, the first author participated in science classes; other school subjects were followed as well, and there were breaks to gain insight into the everyday life of the school. Using ethnographic fieldwork as a method provides access to awareness of 'actions and accounts […] in everyday contexts' (Hammersley and Atkinson 2007). As previously mentioned, a science class is normally structured as a double lesson (1 h and 30 min) although this is only a small part of the students' school life. A more general understanding of school life was, therefore, explored to better understand the practices of science but especially to gain access to the 'everyday contexts' of school that surrounds the science class. The ethnographic approach provided a lens through which to explore these different contexts and how they influenced science practices, as well as the possibilities for developing science-based identities.

The ethnographic fieldwork took place over two periods, with a total of 18 h of science class observations. In the first period of fieldwork, the focus was on forms of participation throughout the classroom. However, to narrow the focus and allow for closer observations, we selected 13 participants to follow as a foreground. This enabled a closer look at the forms of participation that might be invisible at first glance but entailed more subtle

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and sometimes non-verbal forms of interaction. Ways of participating were noted in the selection of focus students. Each of the classes was mapped in relation to who the students played/hung out with during the breaks but also who they worked with in class. This were done to ensure that a broader degree of variation in the class was represented.

Note taking is key to ethnographic fieldwork. In this project, the notes were reflective and descriptive (Bogdan and Biklen 1982) and contained interactions (student–student and student–teacher), ways of participating (how they appeared), activities (both science and non-science activities) and science practices (how the science class was structured). Depending on the situation, notes were captured by writing on paper or on a computer, taking pictures and texting or recording on a phone. In situations where the students worked at a computer, notes were taken at that computer. Other situations made it difficult to make descriptive notes, such as during social activities (playing games in breaks) or when students were doing experiments. In such cases, jotting notes (Emerson, Fretz and Shaw 2011) were jotted down and transcribed into descriptive notes as soon as possible. Recordings were used as a reflective device to make notes of thoughts after the school day, and pictures were another way of remembering specific situations. The various sources of the notes where combined into written notes after the fieldwork.

Taking notes risks creating an asymmetric power relation between the researcher and the participants; it is, therefore, crucial to reflect upon the position that one enters as a researcher. The positioning of the researcher has been identified as essential because *'it is important to not dismiss power dynamics that exist between the researcher and participants'* (Wade-Jaimes, King and Schwartz 2021, p. 858). To develop relationships of respect, trust and acceptance, these authors argues that we, as researchers, have to have accountability to be aware of inequalities embedded in structures of culture, history and practices. These power dynamics need to be considered by the researcher, especially in relation to gender, race, class and age, among other elements. With this in mind, we have emphasised the careful explanation and demonstration that the researcher is not a co-teacher and that the experiences from the activities of teachers and children both inside and outside of the class would not be shared with the teachers. At the beginning of the fieldwork, some students were hesitant in the presence of the ethnographer, but eventually the students engaged in activities that were not allowed in school despite the ethnographer being present (like using their phone in breaks despite it being collected by the teaching at the beginning of the day or hanging out inside the school area when the students were supposed to be outside).

## Interviews with students

In the interview stage, 13 young people were selected to be interviewed (see Table 1) based on four criteria to create maximum variation in the data (Flyvbjerg 2011): diversity of gender, of ethnicity, of ways of participating in science classes, and of how the students spend time both in and outside of school. The interviews were carried out in the final week of the fieldwork by applying a semi-structured approach (Kvale 1994). The students were asked to participate in person, and it was carefully explained to them what an interview was; consent forms were returned with parents' signature (Kampmann, Rasmussen and Warming 2017) in accordance with national rules (Datatilsynet). The interviews were structured around the following themes: school (school subjects dis/liked, class culture and teachers), life outside of school (family life and spare time activities), experiences with science

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**Table 1** Participant' self-reported background information

| | Gender | Race | Social class[a] | Data source |
|---|---|---|---|---|
| Amir | Boy | Middle eastern background | Working class | Interviews and observations |
| Emil | Boy | Danish | Working class | Interviews and observations |
| Frederik | Boy | Mixed: Danish and Asian | Middle class | Interviews and observations |
| Josephine | Girl | Danish | Upper class | Interviews and observations |
| Kian | Boy | Mixed: Danish and African | Lower middle class | Interviews and observations |
| Maria | Girl | Danish | Working class | Interviews and observations |
| Mathilde | Girl | Danish | Working class | Interviews and observations |
| Neela | Girl | Asian | Middle class | Interviews and observations |
| Nicolas | Boy | Danish | Working class | Interviews and observations |
| Rebekka | Girl | Danish | Middle class | Interviews and observations |
| Sara | Girl | Danish | Middle class | Interviews and observations |
| Sophia | Girl | Danish | Upper class | Interviews and observations |
| Tobias | Boy | Danish | Middle class | Interviews and observations |
| Jane | Girl | Danish | Not known | Observations |
| Ronja | Girl | Danish | Not known | Observations |
| Amalie | Girl | Danish | Not known | Observations |
| Liam | Boy | Danish | Not known | Observations |
| Louise | Girl | Danish | Not known | Observations |
| Elena | Girl | Danish | Not known | Observations |

The participants listed are the ones either interviewed or participants in the examples applied in the analysis of the ethnographic fieldwork

[a]Based on the participants' description of their families (in particular their parents' employment, educational background and income), we have divided socio-economic classification into being working class middle class and upper class (though we acknowledge that a thorough classification of social class would entail a more nuanced measurement). Categorisations are based on the highest recorded parental occupation

classes (what is dis/liked about science, teaching practices and learning science) and their thoughts about the future.

The interviews took place at the schools in a quiet place to avoid interruptions and to provide a safe space to talk. All of the interviews were recorded and later transcribed. A creative activity was completed during the interviews; the activity included drawings of what the students associated with nature and technology, which allowed the students to express knowledge through a medium other than language and in particular allowed a dialogue in which language did not set the scene (Hoppe and Holmegaard 2022).

## Positionality, power and trustworthiness

Studies have shown the cruciality of being reflective of the positions we as researchers take up, especially as qualitative researchers (Spangler 2023) using (critical) ethnography (Powell 2022). As pointed out by Madison (2012), reflecting on our positionality allows *'us to acknowledge our own power, privilege, and biases just as we are denouncing the power structures that surround our subjects'* (p. 8).

As an example, the first author often met and approached the students through informal conversations during the school day, which in many ways provided a lot of the research data, but in doing so she also implicitly expected them to find such conversations meaningful. Through the fieldwork, the positions enabled during such conversations were often taken up by girls, and the relations almost have a character of the first author being a *'big sister'*. This unfolded differently with some of the boys who were more careful and pensive as well as seeming less interested in these conversations. Relations developed during fieldwork are far from neutral as our interests, motivations and positionality influence these relationships (Powell 2022). Serval of the girls easily applied these conversations while the boys rejected them, or even more importantly experienced them as less accessible. As a woman, the first author found that developing relations with some of the boys was challenged by the expectations in organising the conversations. These social norms of 'doing' conversing applied to some of the girls, which the first author, through the conversation, took for granted, but like the girls the first author is also subjected to these cultural ideas of doing girl/woman (West and Zimmerman 1987), and therefore implicitly maintain or reproduce them in the meeting with the girls. These biases necessitated more flexibility in developing relations and somehow going beyond the 'traditional' transformation of a conversation such as focusing less on conversing and instead doing activities such as playing games to build relations.

It is important to highlight the fact that the relations are not static but are fluent and shaped differently as gender, ethnicity, age, class, etc., form the them (Baumbusch 2011). Moreover, these descriptions are not monolithic and ascriptive presentations but changed, challenged and reproduced through the process of ongoing negotiations and thus the relations with the students changed over time and across spaces (Spangler 2023). Developing these relations has been of meaningful significance to this project where the focus has been on creating spaces for the students' *voices,* particularly students who rarely talked during science classes, so allowing voices to be expressed through other settings helped the process of creating truth and loyalty among the students. Furthermore, it reduced the power relations by providing spaces where students had control over the situation.

This was also applied in the interviews, which included an active, creative element to disrupt the sometimes intense focus on questions and answers. We ensured that questions allowed room for each young interviewee's experiences, and for example, the first part of the interview was structured around their life outside school to invite each interviewee as a whole person and not only a science person into the interview (Powell 2022). To gain such knowledgeable insight into the science teaching and the mechanism structuring practices of positions, acts and 'truths' needed to be based on the students' experiences and knowledge. For this purpose, data in this paper come from fieldwork and interviews.

In addition, teacher interviews was added (thus, they are not used in this article) as an extra layer to the students' experiences to ensure their perspectives were included particularly on some of the situations from the observations to achieve credibility (Baumbusch 2011). We have no intention of pointing to the teacher as the sole producer of non-participation, however, as we are aware that they have reduced autonomy in organising teaching (see, for example, Wade-Jaimes and Schwartz 2019), as we see teachers as agents of change influencing the students chances of being science learners. Due to the character of the study, sharing data with students was not ethically responsible, as the students had reduced agency in making changes in their participation opportunities. While at the end of the project we will present the results to the teachers involved, we did not invite them into the analytic process as is the tradition within some ethnographic studies (see, for example, Baumbusch 2011). One reason for this was that we wanted to take the student perspective in this study; another was that we risked challenging student anonymity in doing so as teachers might combine specific student interviews with fieldnotes. Instead, we have a collaboration with a teacher education institution and work on transforming our research into teaching material seeking to give back to the field, which is also called *the transformative power of research by* (Baumbusch 2011).

## Analytical approach

To dig deeper into the production of non-participation, we were inspired by the steps suggested by Virginia Braun and Victoria Clarke's theoretical thematic analysis (Braun and Clarke 2006).

The number of experiences from the ethnographical fieldwork where students were quiet, passive or discounted during the science teaching, and the fact that many of these situations were explicitly teaching practices, established the interest in understanding these situations. In this process, we became aware of what Stacy Olitsky has described as *'frontstage'* and *'backstage'* performances in classroom practices inspired by Goffman's concepts of backstage and frontstage (Olitsky 2007). In our data, frontstage teaching is where the teacher is the one who controls the teaching, presents content, leads the class discussions and decides who should speak and who should not, and when to move on to the next point on the agenda. During frontstage teaching, activities might take place synchronically backstage, and Olitsky writes that the majority of productive learning takes place backstage, including '*the rehearsing of lines, the making and arranging of the props, and practicing a stage fight*' (p. 213). She states that these practices is formed of a rehearsing stage not ready to be shared on the frontstage, risking *'the judgmental eye of a critical audience*' (p. 213), and that performing unrehearsed practices for a critical audience and with social distance from the teacher is nevertheless the practice adopted in many classrooms. In our article, the utilisation of frontstage and backstage are viewed from the students' perspective in exploring what the stages offer or how they might restrict students' chances of taking up positions of learner identities in science as well as the production of such positions.

In our coding of non-participation, we thus:

1. noticed subtle performances that eluded the attention of students who were quiet, passive or somehow seemed disconnected in relation to the ongoing participation;
2. applied Olitsky's distinction of *'frontstage'* and *'backstage'* performances to categories the context of these performances;
3. noticed instances that occurred ahead of these performances (we asked ourselves what seemed to lead to these instances). Here, we applied our theoretical concepts of positioning and performativity to explore how non-participation seemed to be produced by diving into practices of recognition emerging in the science teaching;
4. also sought to understand how forms of masculinity and femininity infiltrated these positions as well as the intersection with social categories.
5. constructed, as a result themes that we found characterised the production of non-participation in science classes. Based on the construction of these themes, the first author returned to the data to see whether they were consistent across different situations.

Working with the themes was thus a stage of moving back and forth between empirical data and theoretical concepts. This moving back and forth between theory and empirical data is described by O'Reilly as an inductive–deductive approach and illustrates the work of the ethnographic analysis (O'reilly 2012). This revisiting of the data led to some adjustments in the initial themes leading to the three main groupings identified as exposure, overlooked and disciplined. We also revisited the literature to read more about how non-participation is theorised. Our focus narrowed towards an understanding of the production of non-participation.

It is important to say that the students might have acted in different and sometimes contradictory ways and were not limited to one position as they might have moved through several positions during a science class. Therefore, the themes are not to be seen as static or fixed but are used to understand the production of non-participation.

## Analysis

To understand the variance in non-participation, we moved back and forth between our empirical data and theoretical concepts to gain an understanding of the production of non-participation.

In the empirical data, different kinds of performance emerged during the science classes. These performances entailed signs of discomfort (e.g. hesitation or insecurity, avoiding or being avoided by the teacher or peers), resistance (e.g. boredom, humour or doing non-related science things such as gaming), but also a lack of meaning (students zoning out or students approaching the first author during the ethnographic fieldwork and saying ‘please stay and help, we don’t understand it’). To understand these performances, we focus on the process that led to them.

The analysis is divided into two parts. The first part is a description of our initial coding, which showed a science teaching dominated by frontstage performances, and the second part explores how non-participation is produced with these practices of either front- or backstage performances. Three themes in the second part address forms of non-participation as well as the various shapes that they take. The first theme presents how non-participation emerges from positions of exposure. The second theme shows how being overlooked becomes an accepted position, as it creates fewer interruptions. The last theme focuses on being disciplined, and how it produces non-participation. At the beginning of each theme, a theoretical conceptualisation of exposure, being overlooked and disciplined is provided. These themes are not disconnected categories, but we deal with them separately to provide a deeper analysis of their respective strengths to show how the production of non-participation can be undertaken. The analysis draws on edited excerpts from the field notes and interviews.

## The context of science teaching

To set the scene for the analysis, a general description of the structure of an everyday science class at the two schools is provided. The teaching at the two schools was not identical, and there were variations in content forms and teaching material; however, the national and cultural context that the teaching was situated in provides some overall practices that will serve as a background for understanding some of the common structuring elements.

Everyday science classes often entailed moving from the students’ primary classroom to one of the school’s science rooms. Students would be placed at tables in front of the teacher’s desk in surroundings that contained science materials such as laboratory equipment, liquids and stuffed animals. Students often entered the room in small groups with the classmates with whom they would normally hang out during breaks and, if possible, they would sit together during the class as well, which is different from all other teaching taking place in the classroom with fixed seats assigned by the teacher. For the teachers, beginning a science class would require connecting their computer to the whiteboard system. After this settling in and setting up, the instruction would begin.

The teacher would start by introducing a new subject or following up on an existing theme. Often this would be followed by small conversations that would either concern the phenomenon and how it appears outside the school context or by going through the more theoretical side of the phenomenon. This was often followed by the class practice of taking turns to read aloud from text material. The teacher would select a student to read, and after a while, the teacher would select a new student to take over. This reading constituted a practice during which the teacher could ask questions to the class based on the section read. These conversations had two forms: informal and formal. The informal conversations often allowed for the sharing of experiences or non-related school experiences (e.g. what kinds of food the students like or dislike during a theme about food waste). The formal conversations, however, enabled content-specific conversations. The informal conversations seemed more appealing to the students and often entailed broader participation in class.

After the introduction, worksheets would often be handed out. Tasks would be solved at the computer or on a sheet of paper, in groups or individually. These tasks ranged from mathematical calculations to drawing models based on the text. In cases where the students did experiments, this consisted of following manuals or demonstrating scientific ‘laws’ or phenomena; however, experiments were not common.

While the students completed the worksheets, the teacher had less of a sense of what was happening in the class and often took a guided position to make sure the students did their tasks correctly; this practice gave value to students’ skills in following instructions. Although these situations might appeal to more dialogue-based interactions, they often unfolded as situations in which the teacher structured the process of the task to avoid results that were unexpected or based on time pressure. An example of this was a teacher who encouraged a group of two students to reflect on how they would show their experiment; both students were hesitant to enter the conversation, so the teacher explained how they could do it. After working on the tasks, the teacher would summarise the work. This was generally done as a joint practice in which the students contributed with their answers, but if no one contributed, the teacher would choose a student to share results.

Some students thrived during these practices and their participation often led to recognition from the teacher as well as from peers. It became clear to the ethnographer, however, that these science class practices seemed to be reserved for only a relatively small group of students, while most of the class only interacted with the teacher to a limited extent and with peers only when doing group work. This often entailed these students becoming less actively engaged in the course content. Applying Olitsky’s ideas of frontstage and backstage teaching, a standard science teaching in our observations would look like this (see Fig. 1):

As we will show in the analysis below, frontstage teacher-led activities did not mean that backstage activities such as chatting with peers or working on non-related science-activities did not take place. Our focus in the analyses below is, therefore, on investigating how non-participation were shaped in both front- and backstage teaching situations; however, as frontstage teacher-led teaching predominates, this will be the dominant focus in the following analysis.

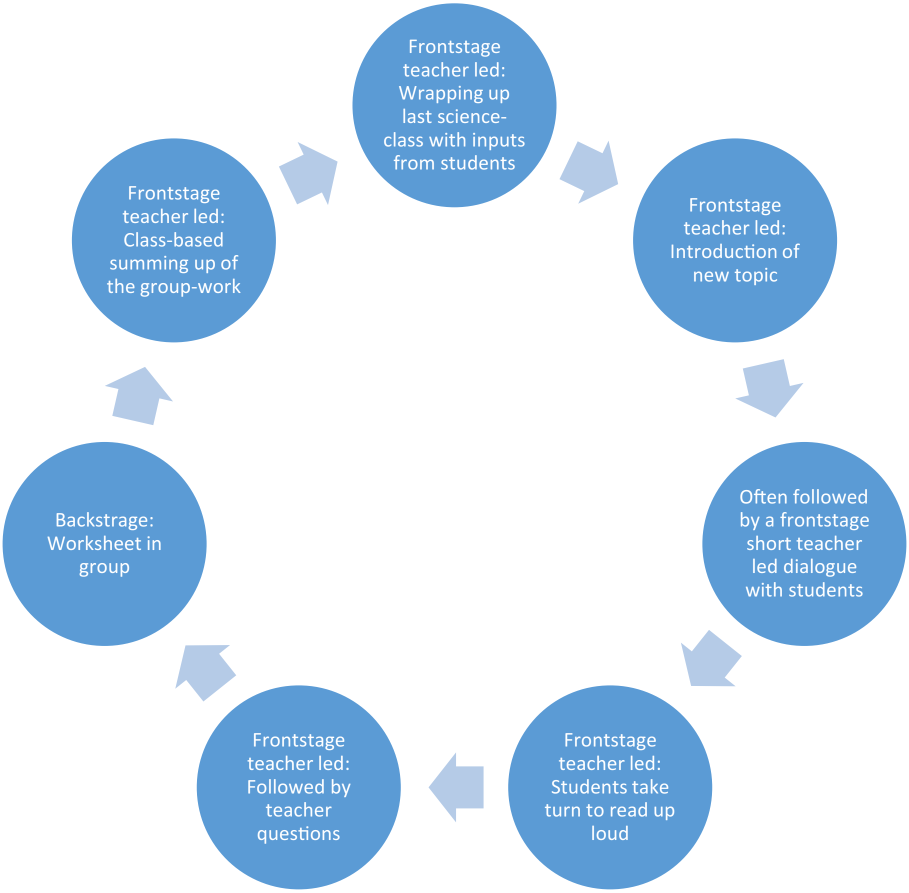


**Fig. 1** Frontstage and backstage activities

## The production of non-participation

### Non-participation through frontstage exposure

In this first theme, we investigate how non-participation is produced through what we call 'exposure'. Exposure refers to positions emerging during frontstage teaching as this teaching practice enables positions that are *'guarded'* by the teacher and classmates. This does not mean that being exposed is not performed at other times or in other ways, but in relation to our theme, we explore exposure as an outcome of frontstage teaching, which shapes the potential of a position subjected to the judgmental eye. Therefore, we conceptualise exposure as an asymmetric power relation that is assigned to, but not taken actively up by, students. It promotes what can be seen as temporary 'locked positions' that decreases opportunities for participation or even in some situations preclude it. From the empirical fieldwork, it became clear that some forms of non-participation were a result of exposed positions. Two subthemes occur under the theme of exposure: scientific language and peer-recognised practices.

## Scientific language

Jane: What does 'scientific term' mean?
Neela: It is these huge words, which no one really understands (Fieldwork notes).

This short extract is a conversation between two students during a science class, and it is just one of many examples in which students expressed insecurities and confusion about scientific language. As described in the section 'The context of science teaching', participation in science classes was often dominated by frontstage teacher-led interactions, and here, a key activity was remembering, pronouncing and applying scientific words or knowledge. This often appeared in the form of an interaction between the teacher and a selected student, either when introducing the theme of the day, or when having a teacher–student dialogue based on the theme of the day, or when talking about the sections read aloud from the book in class or when reporting on group work (see Fig. 1). The example below is from a reading aloud practice:

> The teacher asks Amir to read the first part in the book. When he finishes, she asks him if he knows what the word declaration means. To which he answers no. The teacher starts explaining the meaning of the word, although two other students have raised their hand. The teacher then picks Ronja, who offers an explanation that is recognised.
> (Something else goes on in the class—students contributing to the explanation of the word declaration)
> The teacher continues and explains that, as long as a product is wrapped, there needs to be a label [referring to the term 'declaration']. The teacher returns to the part Amir has read, and she asks him if he knows what nutrients are. To which Amir again answers no. The teacher explains that nutrients are fat, proteins and carbohydrates, which we, as humans, need (Fieldwork notes).

The teacher picked Amir twice to reply to specific questions, and twice Amir had to say that he did not know the answer; once a classmate with the right answer was invited into the dialogue, and the other time the teacher explained the definition of the word. This and other examples from the material show how such classroom practice supports students to perform a position of labelling and describing science phenomena by knowing the right terminology. Consequently, for Amir—who is not able to demonstrate knowledge of the right scientific words—it creates a position in which participation becomes narrowed and definitional. Compared to the student Ronja (a white middle-class girl), the position offered through such teacher interaction challenged the possibility of Amir (a minority working-class boy) participating, as the performance required might be experienced as incompatible. Like Amir, other working-class minority students in particular seemed to resist frontstage interactions with the teacher, and when involved, as in the above example, their contributions were often formulated in short sentences or single words to ensure they were as little exposed as possible. However by doing that they become less successful in relation to the expectations of elaborating on the content matter in the teaching. Brown and colleagues show in several studies how science language is considered challenging to master (and more so than science practices) (Brown 2006) particularly for some minority students whose everyday out-of-school socio-linguistics were experienced as being distant from science language and who, therefore, resisted submitting themselves to applying science discourse (Brown 2004), but students using language for instruction that was different to that spoken at home also struggled with the vocabulary in the science classroom (Duran, Dugan and Weffer 1998).

In general, these types of interactions appeared often, and they seem to maintain a traditional teacher student position in which the teacher provides knowledge, and the students are passive receivers of that knowledge. This type of participation entails performing memorising the right definitions, engaging in labelling scientific concepts rather than elaborating their meaning or investigating their different applications or ways of understanding them. This form of engagement also seemed very narrowly defined through specific prompts and expectations of unambiguous and definitional replies:

> In one science class, they have been working with closed and open mines, which causes Maria to say that it is dangerous to be in a closed mine, to which the teacher asks the class: 'How can you know if there is oxygen in a closed mine?' Ronja suggests that you can use a candle, and then, Maria sarcastically says that you can use a child. The teacher listens to their suggestions but she does not enter the dialogue or try to get them to elaborate their answers. It seems as though the teacher was searching for another explanation but none of the other students engaged, so instead the teacher ended up providing an answer for the question talking about having a bird in the mine. (Fieldwork notes)

The quote both shows how performing good science students follow narrow routes of participation, and that Maria seemed sarcastically to negotiate her performance as participating in a scientific conversation, while not complying with the expectations. It was not unusual for some students to draw on this tangible form of performance. Maria is an example of a working-class student whom we experienced as being active in frontstage teaching; however, she often positioned herself against performing good students and the feminisation of this position. As addressed by Wade-Jaimes and Schwartz (2019), this show how the idea of women as nice, polite, quiet and passive aligns with the idea of a good student, which they describe as students being quiet, polite, prepared for class and achieving good scores on tests (Wade-Jaimes and Schwartz 2019). Thus, interestingly, she often seemed in a subtle way to challenge the frontstage teaching, albeit in ways that did not risk her being reprimanded, but perhaps noticed and ignored. Maria positioned herself with great confidence; although she did not always gain recognition for these frontstage attempts, she was persistent in participating. We interpret Maria's attempts at positioning as walking the line between good student/challenging teaching as negotiations of what participation looks like while avoiding being pointed out as misbehaving (this will be unfolded in the last theme). We do so with inspiration from Dawson and colleagues, who show that some girls constitute agency by challenging available (and limited) positions being available to them, and that performing loudly was one way of negating female performance (Dawson, Archer, Seakins, Godec, DeWitt, King and Nomikou 2020).

## Peer recognised practices

It is not only the teacher who produces this use of scientific language as a key activity in science classes: The students also maintain it as a science practice in their peer-to-peer interactions:

> During a science class, the teacher asks the students to find different examples of scientific illustrations in the book and, for some of the students, that becomes a com-

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petition in finding them. Amalie raises her hand, and the teacher picks her to answer what kind of illustration it is; she says, ‘It is a diagram’. The teacher asks the class what the diagram shows. Liam raises his hand, and the teacher picks him, and he tries to explain that it is something to do with the atmosphere. The teacher says, ‘Photosynthesis’. This causes the student Tobias to say, ‘D’oh’, because his classmate cannot remember the right word (Fieldwork notes).

This interaction shows how positioning yourself as participating in science activities in a way that gains recognition from peer students requires applying the right words, pointing to the right concept and pronouncing the scientific word. These interactions draw on students’ skills of memorising, pronunciation or making connections to phenomena outside the school context. The important aspect of the above activities was the way scientific words became a key element for participating. Skills such as memorising and pronunciation thus provided access to science teaching and, in a range of ways, the opportunity to be seen as participating and gaining recognition. The positions enacted by Tobias and Liam, both white boys, had elements of showing off their knowledge. This was not unusual for the two boys, particularly Liam, but also Tobias, who was interviewed and described himself as a student who was good at understanding the words used in science. These performances were enabled because of the scientific language and although the activity invited the boys to engage, the embodiment of such linguistic performances had the consequence of creating fragile positions with the possibility of singling each other out a way to uphold and reproduce the risk of exposure.

In these kinds of settings, the social process of interactions thus enabled positions of exposure because of the practice of knowing the right words, which contains the risk of being exposed in front of the class as not being able to use scientific words. Even more important was the way these positions came to be performed in the science class when students were positioned either by their teacher or peers. Amir was positioned by the teacher and Liam was positioned by both the teacher and his peer student, Tobias. In general, these practices emerged as dominant and hierarchical, because recognition was dependent on students’ skills in using scientific language, and this influenced students’ ideas of what it means to be participating in science. Asked about what makes a good science student, Emil elaborated:

Emil: One of those who knows everything when a question is asked. And one who would be good at remembering (Interview).

Or as another student, Josephine, explained:

Josephine: Concentrated.
Ethnographer: Why concentrated?
Josephine: Because she [the teacher] is standing at the blackboard pointing at a lot of things and says a lot of words. You really need to concentrate to be able to listen (Interview).

Being exposed thus has consequences for the students’ ideas about themselves as science learners, but more importantly, it produces a feeling of being at risk of not knowing or of not being good at science. Importantly, these positions enact a performance, which for some students might be experienced as uncomfortable, shaping non-participation. In the interviews, this appeared as hoping to avoid being in a position where one needed to use scientific words:

Neela: Okay, I need to say, I also have natural science and technology, which is also

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> one of the things [school subject] which I am not good at. So, now when I think about it, uhm, then for me, it is not that interesting, I think [referring to natural science and technology]
> Author: Why do you think that isn't interesting for you?
> Neela: I don't know, it is like … I think it is … maybe … like … I am not very good at it … I am not good at it.
> Author: Okay. If you could try to describe how you would need to be, if you needed to be good at natural science and technology. How would you need to be?
> Neela: Hmm … like you need to understand it – some, some words that they use in natural science and technology, some of them I don't really get.
> Author: Okay.
> Neela: Like, they use some very long words which I sometimes don't get … and then, uhm, I am really bad at explaining, because, like, we need to explain what we sometimes have learnt in natural science and technology, so that is a little complicated.
> Author: Is it explaining it [the words], is it also because […] they are difficult words or is it …
> Neela: Yes, yes.
> Author: Okay.
> Neela: And I don't know what – how – what the right words are to explain what we have learnt, sometimes.
> Author: Okay, so when you feel like the words could be difficult, what do you do?
> Neela: I just hope that my teacher doesn't pick me (Interview).

Neela's comments showcase how the rightful use of scientific language for some students produces a fear of being chosen by the teacher to answer a question if they do not know the answer. A similar feeling is expressed by Kian, who explained how the worst thing is being cold-called by the teacher without knowing the answer*: 'You need to speed up replying because you might not get picked again. It is the worst thing when you do not know the answer and the whole class gets quiet just awaiting your reply'*. It thus seems that the practice of cold-calling on students to contribute in an open class dialogue with the teacher, together with the narrowly emphasised focus on remembering and correctly using scientific words/language, was a way for some students to position themselves as knowledgeable. Thus, for other students, it entailed a risk of being positioned as unknowing, inattentive or even ignorant in frontstage teaching, and thus in front of peers.

Consequently, several students shared a fear of being exposed, which produced non-participation among those students who were insecure about not remembering the right words or about their pronunciation. The strong focus on what we call labelling words for science phenomena (rather than supporting understanding) produced positions of 'cannot' and 'can' and thus created performances to avoid being chosen. This receives further elaboration in the next theme.

It was notable how the interactions in science classes were structured narrowly on learning to talk 'sciencey', although the teachers would occasionally provide a space for the students to share their own experiences and data.

> During a science class about nature disasters, the teacher makes a connection to a storm that had hit the country the previous weekend, which got a lot of students to raise their hand. One of the students is Mathilde, and she explains how she experienced the storm. This is the only time Mathilde has participated by raising her hand during the observed science class. The sharing of experiences is closed down after a few interactions, and the teacher turns the focus to the teaching book and the subject

of the teaching, where fewer students engage and Mathilde remains passive again (Fieldwork notes).

This incident shows how the teacher tries to make a link between the course content and a concrete experience from the weekend when a storm hit the area. In this setting, the students do not use scientific words, but both before and after this incident, scientific words are the centre of the learning space. This space of sharing experiences creates a more open form of interaction than the narrow dialogue showen in the previous section. Here, everyday experiences were included, and this encouraged students to share without the risk of being exposed. Although this practice enabled participation, it was often strongly separated from the real science discourse in which scientific language, memorisation and doing prototypical science tasks dominated the class. However, these practices seemed to appear as informal openings in the science class that were disconnected from the rest of the science teaching. The data indicate an emphasised focus on the students' skills of being reflective and even more of a focus on how a combination of reflection and vocabulary provided easier access to the science class. This expectation reproduced science practices in which mastering linguistic skills received greater recognition but in a way that was also more accessible and achievable for some science learners.

## The production of non-participation through being 'overlooked'

In this second theme, we investigate how non-participation was produced through what we label being 'overlooked'. We conceptualise being overlooked as positions that emerged through not being noticed in the practices of science teaching. Such positions entailed students who were passively engaged taking care of themselves. The overlooked theme includes two subthemes: *Being isolated* and *Negotiation of the silenced position.*

### Being isolated

In the observed science classes, a large group of students seemed passively engaged and detached from the teaching, particularly during frontstage teaching where at first sight seemed passively engaged, refraining from vocal expressions, outwardly expressive gestures or disruptive behaviour. However, it seemed that those on the backstage performed in a way that could remain unnoticed and invisible on the frontstage such as embodied quiet and silenced movements, engaging in non-related science activities, without oral language or outgoing bodies or gestures as in this example from one science class observation:

> In silence while sitting quietly, Sara and Louise are occupied by moving drops from the water tap to their table. They carefully try to take the drop from the water tap with one finger, then move it without destroying the drop and then place the drop on the table where either it breaks or they spread the drop over the table. This preoccupation by Sara and Louise continues for a while, and they seem concentrated on trying to succeed in their mission while the ongoing instruction continues (Fieldwork notes).

The positions taken up by the two girls did not pose a disruption to the frontstage teaching, they could even go unnoticed since their silenced performances did not cause problems for the teaching where the teacher tried to get through the day's programme; therefore, the teacher also rarely drew such performances onto the frontstage. Similar activities were observed with Neela, who practised her skills of being good at writing fast on the computer

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using a software programme to enhance these skills, this activity had nothing to do with the ongoing instruction. But seen from the teacher's side of the room, it might have looked like note taking and thus seemed to get positioned as good, active student behaviour. It seemed that these non-verbally and silenced bodies were allowed on the backstage as they did not disturb frontstage teaching and in some cases even performed what could be interpreted as 'being a good student'.

Thus, as these performed actions were not interrupted by the teacher, they could somehow go on for longer periods, which, however, entailed a risk that the students became isolated from the actual science teaching and learning activities such as the introduction of new topics and explanations of tasks, or not being a part of summing up the purpose of the day. This also meant that the students were not supported to perform or invited to be involved during frontstage teaching. In stating this, we do not advocate that all learning takes place on the frontstage, as also pointed out be Olitsky (2007) earlier in this paper. Backstage learning can be a place to rehearse unfinished thoughts and ideas. Rather, we want to emphasise that for a big group of students, engaging actively in science learning did not take place either in the front or the back of substantial parts of the teaching. Consequently, these students are often relegated to passive roles as mere 'listeners'. In relation to the described teaching, these positions of being overlooked seem to be shaped in the light of avoiding frontstage exposure, but also it seemed as though some students retained and withhold in a position of being passive, listening backstage participants. For the students, a prominent advantage of this position seems to be avoiding unnecessary attention from the teacher (this will be explained in the next theme).

As a consequence, the students in this category had very limited interaction with the teacher, and some students had almost no, or very little, contact with the teacher over several science lessons. This became even more visible in the case of Sara: from the observations during period one, she interacted with the teacher twice. Once time the teacher picked her to contribute and on another occasion she raised her hand. Compared to a student like Ronja, who interacted more than 17 times during the classes from period one, this shows us that Sara has almost no interaction with the teacher. In the second wave of observations, Sara demonstrated no forms of participation at all.

Critically, these positions of easily being overlooked were shaped during the teaching, which slowly across time disconnected students from being involved and engaged in the science teaching.

## Negotiation of the silenced position

The previous section described the practices of being overlooked during frontstage teaching, practices that are very teacher centred. However, such positions are negotiated in other activities as well, including backstage activities that involve solving tasks or doing experiments in groups. One example is Mathilde, one of the students in our cohort, who often seemed to be retained in backstage activities. In a group work activity of making a model of an oceanic trench, she came up with an idea for how to make the model. Mathilde ensured that the group received extra sand for the model from another group, as they needed it to make the model more realistically ocean-like. During this activity, Mathilde did not have contact with the teacher as she remained out of contact when the teacher went by the group to check in; however, when backstage she actively contributed to the group work. Another example is Sara and Louise, who were actively engaged in group work in an experiment by following the instructions. At one point, their peer-students interacted with

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the teacher by hanging out and informally chatting with the teacher and other classmates at the teacher's desk; however, both Sara and Louise stayed out of sight and focused on getting the job done.

For Sara and Louise, remaining on the backstage, also seemed to be a way to perform 'good student' positions that did not risk interfering with the frontstage teaching and risking being rejected as wrong or strange attempts at science participation. Importantly, these backstage positions were rarely contested, which produced distances between the two girls and their science teacher. We suggest that the 'good student' position enables comfort for students, who might not experience interactions with the science teacher as affording to who they are and how they see themselves, and such relations might seem supervisory rather than collaborative.

So, while the position of being exposed had consequences for students' ideas of seeing themselves as science learners, the position of being overlooked held consequences for being supported in developing science experiences because of the low level of teacher interaction. The position of being overlooked prevented students from interacting with the teacher, which meant that they were presented with fewer opportunities to be supported or recognised in their work, especially during classroom activities. This might create barriers in developing and shaping a science identity.

## Positions of being overlooked as continuoues and stable in science teaching

From the interviews with students who tended to be located in the described positions, their ideas of being good at science closely suited the way science was practised—described in the context of science teaching. In science, these students explained that favourable performances would include 'raise your hand during the lessons and, like, answer the questions (…) and to clean' [referring to cleaning the class after doing experiments] (interview, Mathilde) or 'knowing a crazy amount of things' (interview, Sara) and 'like, you need to understand some, some words' (Neela, interview).

These skills are not something the students see themselves possessing when they are asked if they think they fit them. In this situation, the alignment between *what they do* [their silenced performance], *what they say* [about being good at science] and *what they are offered* [during the science practices] maintains positions that preclude opportunities for participation. This misalignment constitutes the position of being overlooked and as a result lowers the chance of being recognised during the science classes. Recognition practices of participation seemed to be reduced to frontstage teaching establishing a very narrowed field of performance that might be both less desirable and accessible for some students. Instead, they become students doing a job that is performed through passive and silenced performances.

Such performances compromise the chances of students being engaged and developing experiences through the world of science as well as being recognised as science learners as the positions of being overlooked seemed stabilised. Prominent for this theme is the number of girls who took up such positions of silence and passivity. We know from the literature that science is associated with dominant norms and ideas such as whiteness and masculinity (Archer, Godec and Moote 2023) and class, race and gender interfere with students' possibilities of being science learners (Carlone 2004). This aligns well with our data, where we see that the positions of being overlooked showed signs of feminised embodiments (West and Zimmerman 1987). Like Sara, Mathilde and Neela in the above examples, we argue that students, in particular working-class girls and minority girls, are assigned to these positions of performing science silently and quietly on the backstage. Such performances are associated in literature with values and attitudes often aligned with norms of femininity (Wade-Jaimes and Schwartz 2019). The quietness often entailed that the girls were left by themselves and when invited onto the frontstage teaching the girls even portrayed a sense of discomfort in inhabiting frontstage classroom positions. Thus, the position described above was also taken up by the girls, positioning themselves in ways that might prevent them from being noticed by the teacher, while being passive was supported and encouraged during frontstage teaching. This example shows in detail the dialectical process of being positioned and positioning oneself and how that might maintain unnecessary positions for students in science.

## The production of non-participation through disciplining dynamics

In this third theme, we delve into the mechanisms that generate non-participation through a process we call 'disciplining dynamics'. We conceptualise disciplining dynamics within the classroom context as a practice directed towards students who occupy positions that differ from the expected norms in science teaching, thus seemingly incongruent with the prescribed practices and pedagogy. Deviant behaviours are construed as necessitating disciplinary actions, aimed at aligning students with the intended science teaching. However, these forms of disciplining produce non-participation by spotlighting students' shortcomings without facilitating avenues for reintegration into the learning process. This paradoxical effect is exemplified by two subthemes: (1) delineating behavioural norms and (2) students transitioning into co-teaching roles.

### Delineating behavioural norms

In the first section of our analysis, *The context of science teaching*, we describe the most frequently applied structure of science teaching. Following such a structure leaves limited time for detours from the plan of the class, and as a consequence the students also need to behave and perform in certain ways to get through the intended plans. However, from the observations, a group of students can be characterised as 'deviating' in relation to this structure. Below is an example from a science class where we found several examples across the empirical material. In this example, the students are working with tasks in smaller groups:

> The students have been divided into groups where they work with models. At the beginning of the group work, the first author is talking to one of the groups of four boys. I ask them about the model and Tobias explains their model to me. They are using two pieces of paper where they have made a hole in one of the papers so the other paper can get through that hole. Afterwards, the group does not seem to be engaged in the work, and it is noticed how they are observed laughing and doing things at their computers; meanwhile, the model is just lying on the table. After 30 min of group work, the time is up, and some of the students are going to present their model to the class. When the group of boys are presenting their model, it is unstructured, and Tobias explains that they went for a simple solution. The teacher says to the group that their model does not look like an oceanic trench and that it should have been more detailed. Tobias agrees, and he points out that they could have made a model like the one presented before by a group of girls, a bigger model […] instead

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> of using paper. Tobias adds that they may have been too lazy when working on their model. Liam dismisses this statement, but the teacher says that it is not about what they have now, but about reflecting about the process, which stops Liam. During the presentation, the two other boys in the group are passive (Fieldwork notes).

Thus, what happens in this example can be interpreted as a well-meaning intention to help the students strengthen their skills of working scientifically (although it might have been more meaningful to have done it backstage where the students could have used teacher support). The four boys had more than enough time, and this group finished rapidly. In our empirical material, however, we noticed similar situations where frontstage teaching exhibited student limitations and deficits and offered students positions that can be difficult to negotiate, i.e. the negotiation by Liam, Tobias and the teacher on whether or not the group were bad in using their time, being lazy or lacking reflections. In this case, the boys are exhibited and exhibit themselves for lacking details, and the girls' model is pointed out as being more detailed.

Interestingly, this points to the positioning of the students. The girls are being positioned as managing the expected outcome while the boys are positioned for their shortcomings in relation to the outcome. Notably, both positions focus less on students understanding the scientific exercise as well as being supported and enhancing their skills to work scientifically.

Repetition of these situated examples is, however, essential; over time it was observed that the same students were disciplined in both the frontstage classroom and backstage activities such as for being too noisy, solving tasks too quickly or not being on track in group work. As pointed out in our theory, repeating performances risks producing more *permanent* positions, including the potential consequence of not leading and supporting the students back to the teaching by offering alternatives ways of participating and instead leaving the students with an acknowledgement of inaccurate behaviour.

In line with studies such as the one conducted by Jackson (2003), we argue that we can understand the power dynamics of disciplining as intersecting with social categories such as gender and social background. For example, Jackson illustrates how the phenomenon of underachieving can be understood through the lens of performing 'laddish' behaviours. Thus, in the above case, positioning one as lazy can be interpreted as a manifestation of self-protective strategies aimed at avoiding being positioned as lacking abilities, and side-stepping the expectation to conform to the stereotype of the 'good student', which often carries connotations of femininity. Consequently, resistance to engaging fully in school tasks, negotiating assignments, seeking alternative routes, and exerting minimal effort are commonly observed in performing some forms of masculinity that frequently also intersect with social background (Francis 1999).

## Students as co-teachers

The example above shows how some positions might reappear, which shapes an idea of them as permanent. However, disciplining did not only emerge as deviant performance. The performances of 'disciplining' seemed so embedded in school practices that, in some science practices, it offered positions of co-teaching. After visiting a science exhibition the week before, the following class began by summarising the trip, and a conversation ensued:

> The teacher asks Frederik about what he enjoyed about the trip, and he explains that there was something with cold air. Teacher says nitrogen, and Frederik says, 'Yes, I

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> think that was very interesting'. The teacher asks what was exciting. Frederik says that it was cold. Another student, Elena, comments on Frederik's answer and says, 'I think that Hannah [the teacher] expects more of you'. The teacher continues explaining to the whole class that now, when they are in the sixth grade, they need to be able to express themselves with more than one word (Fieldwork notes).

The teacher underlines that it is expected that students will provide more than a one-word answer, which illustrates that they are expected not only to apply scientific concepts (see the theme 'exposure') but also to manage a scientific conversation by applying science language to gain recognition. Interestingly, a group of girls (white-middle class) dominated this practice of engaging in science-related discussions and by doing so could position themselves as implied co-teachers. The positions of co-teaching, seemed to generate recognition from the teacher, because they supported the expected science practices during frontstage performances. The data show that these kinds of corrections of peers' participation (e.g. for being off-task) are common and not hindered by the teachers. As a consequence, such positions seem explicitly to manifest differences among the students on the frontstage. Furthermore, they supported the authority of the teacher's position and some peer-students as 'knowledgable' and produced others as lacking knowledge, and as such reproduced the hierarchical positions among the students but also between the students and their teacher. While Frederik entered the dialogue with experiences that he found interesting, he risked leaving it with the impression of not having shared his experiences in the right way.

The production of such disciplining dynamics entails performing confidence combined with linguistic skills. These positions of co-teaching maintain these ways of doing science and seem to gain implicit support from the teacher. Students' performances of co-teaching enabled positions with the chance to perform authority towards their peers, and this co-teacher imitation was not rejected by the teacher. The co-teacher acted to manifest science practices as remembering, pronunciation and expressing oneself in longer sentences as an individual responsibility and also ultimately supports the described positions instead of challenging them. We argue, that enabling the positions of co-teaching creates an unhealthy learning environment where an asymmetric power mechanism hinders the students from supporting each other in the processes of doing science and being science learners.

Power dynamics becomes even more visible as a pattern of students' backgrounds intersected with who gets disciplined on the frontstage and who are allowed to discipline other students. Here, we found a gendered pattern where girls seemed to take up the position of co-teachers performing good student positions, and where in particular, some of the boys (often including working-class and/or non-white students) were the ones to be disciplined.

Another outcome when exploring these positions of 'disciplining' is patterns of what could be read as oppression. The described science practices showed very fixed ways of participating, which seemed to challenge students, such as when the boys rejected doing group work for 30 min or when Frederik provided a short answer.

## Discussion, conclusion and implications

This paper contributes to the theoretical advancement of the concept of non-participation by building on Avraamidou (2020) and her thoughts of (non)participation as the product of ongoing recognition practices in the classroom and the embedded power dynamics of aligning participation with the subtle norms, values and ideas of what science is, as well as how it should be performed. We expand the concept by applying the concepts of positioning (Davies and Harré 1990) and performativity (Butler 1990) as theoretical lenses through which to critically understand the kinds of non-participation positions that are made available, assigned, performed and practised in everyday science teaching. In this paper, non-participation is to be understood as something produced in science teaching due to practices of recognition rather than a condition embedded in students' preferences for, interests in or motivations towards science. Drawing on ethnographic fieldwork and interviews with students, we offer an in-depth exploration of the production of different forms of non-participation in the primary science classroom, and how non-participation are being shaped in alignment with the intersection of gender, race/ethnicity and social background.

In the analysis, we apply Olitsky's ideas of front- and backstage teaching and learning (Olitsky 2007). We presented three forms of non-participation: being exposed, being overlooked and the dynamics of being disciplined.

In the introduction, we refer to Carlone (2004), as she points out that learner identities are developed when new positions are made available and taken up by the learner. Ufortunately, such new learner identities were rare in our data, which seems to be an outcome of the teaching taking place frontstage that is often very structured, predictable and stationary, and thereby reducing the possibilities of creating such new positions. The positions observed emerged as quite stable across science classes, and thus they serve as barriers for students' to form dynamic and changeable identities as science learners over contexts and over time.

We argue that the amount of frontstage teaching contribute to such stability as well as it prevents students to take on temporal positions (in backstage teaching) and how these stable patterns of recognitions practices, intersect with gender, race and class.

We showed how interactions between the teacher and students often entailed practices of being able to label science phenomena with the right concepts or following manuals rather than exploring meanings or investigating their applications. Being prompted by the teacher offered students positions in which doing science was associated with memorisation, pronunciation and applying the right concepts; unambiguous replies were those that gained recognition from teachers and peers. Narrow positions of participation entailed the risk of feeling exposed as unknowing, inattentive or ignorant, and produced feelings of not being good enough or not being a proper science learner.

We have argued that the strong focus on applying the right scientific language serves as a challenge for students' abilities to take up positions that allow them to recognise themselves as science learners but also prevent them from actually learning the scientific vocabulary as showed in the example with Amir. Not only is labelling practices low on the taxonomy of learning (Forehand 2005), but it is also a practice that goes from science to the learner without considering who students are as persons (their interests, backgrounds and aspirations). It thus entails a presumption that all students have equal access to practising science language. In a study of urban students encountering high school science, Bryan Brown (2006) showed how the students struggled with performing the discursive practices of science, particularly minority students who struggled with seeing themselves that within the '*discursive practices of science classrooms, their comments reflected their belief that science was unique, yet only applicable to the classroom culture' (p. 121).*

In line with Brown, we argue that the strong focus on labelling science concepts might not only be socially inequitable—and thus privilege students who are acquainted with, and confident in applying, academic vocabulary outside school—but also that this practice offers a narrow insight into what science is and what being affiliated with science entails.

We are not claiming that students should not learn science concepts, but we are problematising the way science is practised as hierarchical, passive knowledge unaffected by student input and contributions. Our point is thus that narrow practices and forms of participation in science classrooms risk producing positions of non-participation to avoid being exposed in front of the class. Here the students' gender, race/ethnicity and social background gained importance as we see with Mathilde, a white working-class girl who avoided taking up a position where she needed to contribute or share in plenum.

The other two analytic categories were 'being overlooked' and 'disciplined'; below we discuss their gendered patterns, as both positions entailed what Olitsky thematises as backstage performances (when students engage in forms of participation that are not directly part of the teacher-led dialogue):

Bringing backstage learning out into the open requires a safe space where unfinished thoughts and ideas can be shared without feeling a fear of failure. In the analysis, we showed that not conforming with good student practices (i.e. being too noisy, solving tasks too quickly or not being on track in group work) entailed a risk of being exposed to the entire class, with the consequences of being implicitly 'reprimanded' by being asked difficult questions by teacher or peers. In our analysis, we see that such practices were gendered, which could indicate that the students' are assigned to these positions because of implicit expectations of their gender. In our data, the group of boys being disciplined was relatively stable over time, so negotiating these positions seemed challenging. Studies have shown that some boys are perceived as performing in opposition to 'good student' practices to maintain and nurture a sense of being masculine by not complying with rules and regulations (Archer, Dawson, Seakins, DeWitt, Godec and Whitby 2016). These gendered norms and practices are, however, produced in the classroom. Vincent Basile (2021) has shown how a group of non-white boys resisted forms of racial oppression as a healthy response to the expectations they encountered. The boys in this study were primarily white and lower middle class, but our point is that this group of students, while first perceived as non-participators, were then maintained in backstage positions and not encouraged and supported into participation by being met with respectful interaction, assuming brilliance or positive reframing of their inputs, as other scholars have suggested (Basile 2021).

The unveiling of non-participating showed that gender, race/ethnicity and social background matters when trying to understand why for example different groups of girls were found to be overrepresented in the category 'being overlooked' in particular; these positions were not invited to the frontstage of the classroom, although we found plenty of examples of active participation in the backstage class. The overlooked positions experienced limited teacher interaction, and it seemed that some of the positions within this category were taken up to avoid being exposed in front of the class. To gain a position as being overlooked, silent performances of 'the attentive student' were enacted. In contrast with the 'disciplined' category, the students in these positions did so without interfering with the frontstage teaching, and as such, they went under the teacher's radar. We argue that unnoticed and invisible positions assigned to girls who are troublesome are being overlooked, and these girls risk not being recognised or recognising themselves as science learners (Carlone, Scott and Lowder 2014). Carlone, Scott and Lowder (2014) have shown the significance of supporting identity work in science over time in increasing students' affiliation with science. In the overlooked theme, our analysis showed very low interactions between the teachers and most of the girls. The overlooked category could also potentially hold consequences for the girls in terms of seeing themselves in science in the future. In one study, Calabrese Barton et al. examined young girls' science identities; their longitudinal ethnographic study showed how different contexts of science-related activities interfered with the identity work of girls from nondominant backgrounds. A key factor from that study highlights the fact that future selves in science increase when identity work is recognised in science (Calabrese Barton, Kang, Tan, O'Neill, Bautista-Guerra and Brecklin 2013). In our study, the girls, in particular working and lower-class and minority groups, were not recognised during the science practices, which hindered the work of developing science identities and, even more importantly in the light of the findings by Calabrese Barton et al., the possibilities of creating and picturing future selves in science.

The above studies identified how identity develops over time and across contexts, as well as how this matters in gaining affiliation with science. To gain recognition as a science learner, students might need to submit themselves to practices that they feel do not align with who they are, whereas other students do not feel they have to compromise their identity to gain recognition. For example, when working girls refrain from participating, this might be due to what they are offered during frontstage teaching in science.

Our themes have revealed the emphasis on a centred focus on students, although research has shown an urgent need to shift away from focusing on individuals as responsible for becoming science learners to understanding how structures create inequalities in learning (Archer and DeWitt 2016). Instead of focusing on individuals, it is necessary to focus on creating learning environments where practices that involve different forms of participation are enabled, supported and recognised in particular, as we in our analysis see, some of these performances of non-participation were more dominant than others. We are of course aware that the positions are snapshots of everyday situations in which students are formed, reproduced and negotiate their positions, and they are changeable over time. So, when the positions occur as dominant, it is to be understood as a temporary dominance. Hence, when the position of being *overlooked* emerged it was at risk of being maintained throughout the whole science class, which over time held students in longer periods of non-participation. The opposite seems to be the case with the two other themes: their appearances can be seen as short-term positions constituted by performances that produce exposure or disciplining. Thus, both positions focus on certain forms of participation, which exclude students from being engaged in, and invited into, other positions of learner identities in science. We hope that teachers can use our analysis to disrupt stable positions of non-participation in science classes by offering ways for students' voices to be included as valuable. However we are aware that teachers navigate environments that are often complex and stressful, which is why teacher training is key for working on how participation can be fostered and stable positions of non-participation disrupted.

Our study has implications at various levels. First of all, we are aware that teachers have limited resources, one of which is time. In Denmark, where this study was conducted, a reduction of teachers' preparation time has led teachers to use more prefabricated teaching materials with limited room for pursuing opportunities for learning that might appear during teaching (Camilla and Freja 2021). A first implication is thus a call for action on the stakeholder level to provide science teachers with room to disrupt participation patterns shaped already in primary school, and which potentially can hold consequences for students not seeing science as a desirable future pathway (see, for example, Archer, Moote and MacLeod 2020).

Secondly, we hope that our study can draw attention to educating future science teachers with competences to work with creative and alternative teaching practices that can support making room for the diversity of participation patterns in the classroom for example, by combining what counts as science with focusing on making room for students' thoughts, interests and experiences as suggested by Godec, King and Archer (2017). Such teaching will, however, need to move away from the dominating focus on practicing science as

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narrowly right/wrong and applying exact science language, i.e. not allowing students to rehearse science language through everyday vocabulary as such practices, as we show, lead towards unequal participation.

Thirdly, we identify implications for researchers to maintain the potential for investigating how positions are formed and shaped over time, and we encourage future studies to take a longitudinal approach to explore the possibilities for developing temporal positions in science, to investigate how positions are shaped across different science classes and settings; and to conduct a full analysis of the intersection of social categories such as gender, social background and race/ethnicity to fully understand the power dynamics at stake in the science classroom. Furthermore, we point to future research continuing the conceptualising of non-participation to challenge positions of non-participation as an outcome of teaching practices withholding the potential for students to see themselves as science learners, and combining that with students' feelings and emotions toward being science learners to support them in experiencing the world they inhabit as being associated with science.

**Author contributions** Ene Ernst Hoppe has done the ethnographic fieldwork and all the interviews. Ene Ernst Hoppe has been the primary person to wrote the sections of theory, method and the analysis which Henriette Tolstrup Holmegaard has written, commented and provided feedback to. The introduction and discussion is done in collaboration.

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## Declarations

**Conflict of interest** The authors declare no competing interests.

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# Article III: Transition from sixth to seventh grade: Transformation of science identities over time—change or stability concerning science.

# Transition from sixth to seventh grade: Transformation of science identities over time—change or stability concerning science.

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## Abstract:

This article delves into the crucial transition that students undergo when they progress from sixth to seventh grade. This shift is marked by a transition from studying natural science and technology (N&T) to encountering the three distinct science disciplines of biology, physics/chemistry, and geography. The focus of this exploration is on the potential and ability of young people to develop a sense of connection to science in a way that relates to their lives. This connection can aid in the creation of a science identity over time as they venture into new science settings, making this transition period a significant phase in their academic journey. This investigation combines positioning theory with the concept of science identity and Hazari's addition of interest to the concept of science identity. Additionally, it incorporates Nuthall's three socio-cultural systems: the public system, the semi-private system, and the private/internal system that occur in a classroom setting. The article is based on four in-depth cases of four students' experiences with science teaching and their ways of participating and performing in science during the transition. Throughout the transition period, we can observe both continuity and change in the behavior of the students. The continuity is noticeable in the way they handle the school expectations and their academic performance, which seems to remain consistent. On the other hand, the changes are reflected in their interest and attitude towards the school's framework and expectations, as well as their level of engagement in particular subjects.

## Keywords:

science identities, positioning, science teaching, belonging

## Introduction

In the past couple of decades, research has shown that young people's interest in and aspirations for science are particularly exposed in their middle school years (Archer et al., 2013; Denessen et al., 2015; Hald et al., 2022; Hill et al., 2010). Further, it has shown that the way science is taught is not neutral. Science teaching appears to privilege some students rather than others, related to students' gender, race and social class, as well as the intersection of these social categories and based on particular ideas about how people learn and come to see themselves in science (Carlone, 2004; Godec, 2018). Therefore, studies of why many students lose interest in science have moved from seeing children and young people as unmotivated or not interested in science, making it an individual responsibility to create, maintain and evolve interest in science. Instead, the focus is on how structures create inequalities for learning science (Archer & DeWitt, 2016). Notably, there has been increased attention to the interaction between the students and the social and cultural context in a process where some students develop what has been coined a science identity (Carlone & Johnson, 2007). Why some students see themselves and thrive in science teaching while others struggle to fit in is a question of who you are (Dawson et al., 2020) and how others see and recognise you in science (Avraamidou, 2020). These studies adopting science identity as a lens to explore how students do or do not develop a sense of science being something for them have also emphasised that identity is not something one has, but rather an ongoing process of negotiations of who we are and wish to be in relation to others and to the settings we encounter. This underscores the need for continuous support and intervention in the science education system to ensure all students have an equal opportunity to develop their science identities.

In this process, students' experiences with science teaching play a role. In a longitudinal study, Carlone and colleagues followed the identity work in relation to school science of three students over time. They found that while the students at the beginning of the study had positive views of science, they later began to view science differently, just as the recognition of their class participation changed. This was, inter alia, related to changes in the teaching activities and what kinds of student participation were celebrated and recognised as legitimate. The research showed the importance of making space for students' social identity in science, just as it pointed out that students from marginalised groups did not feel that science was accessible. (Carlone et al., 2014).

Calabrese Barton and colleagues examined young girls' science identities in another longitudinal ethnographic study. Their study showed that the identity work of girls from non-dominant backgrounds was intertwined with different science-related activities occurring in different contexts. The study highlighted that students increasingly could imagine future selves in science when identity work was recognised in science (Calabrese Barton et al., 2013).

The two studies show the importance of employing a longitudinal approach to examine the development of identity work over time and across contexts in science teaching and outside school science activities. As the studies show, identity work is not a linear process. It presents an entanglement of structure, people, settings, and how the students view themselves in and outside science. Students work to create meaning in science, a process where they interpret what they are presented with within science, which differs across context and time. To gain recognition, students may have to submit to practices where they have to compromise with whom they believe they are, or they may refuse to submit at the cost of experiencing being overlooked or seen as unmotivated (Tan & Barton, 2020).

This paper adds to these and other studies focusing on the possibilities and conditions of young people to develop a sense of science being something related to them (Carlone, 2023). While several studies have looked at out-of-school activities combined with in-school activities, like the study by Calabrese-Barton et al. (e.g., Gonsalves et al., 2021), or mainly on out-of-school activities (e.g., Dixon et al., 2023; Rahm et al., 2022), the present paper, similar to Carlone et al. (Carlone et al., 2014), focuses on school science. Further, we study the transition from sixth to seventh grade (approximately age 12/13-13/14), which is a particularly significant transition related to science teaching in Danish schools because students go from having an integrated science subject from grade 1 to 6 to having three separate science subjects based on science disciplines (cf. the section 'Context of study' below). The study covers a short period.

The present paper aims to explore which possibilities students are offered in school science for developing a sense of science being related to them and thus creating a science identity over time as the science settings change from grade 6 to grade 7. Before elaborating further on this aim, we will outline the theoretical framing of the paper.

## Theoretical framing

In this section, we briefly outline the theoretical approach of our analysis, building on the concepts of a sense of belonging and science identity and the different elements in play during classroom activities.

### Sense of belonging

Previous research has found that students' sense of belonging is paramount for their expectancy of succeeding and participation. In an older study of students in grades 6 through 8, Goodenow (1993), building on expectancy-value theory (Eccles, 1983) and self-determination theory (Ryan & Deci, 2000), found that a sense of belonging highly influenced the students' expectations and values. Goodenow defined belonging as

> *… students' sense of being accepted, valued, included, and encouraged by others (teachers and peers) in the academic classroom setting and of feeling oneself to be an essential part of the life and activity of the class. More than simple perceived liking or warmth, it also involves support and respect for personal autonomy and the student as an individual (Goodenow, 1993, p. 25)*

An essential point in this definition is that belonging goes beyond feeling good. It involves feeling valued, included and respected for oneself as an autonomous individual. This point is found across several definitions of sense of belonging (cf., Rainey et al., 2018; Strayhorn, 2018). Sense of belonging means experiencing that one matters to others in the study environment and that one, through this, has a legitimate place there. There may be an age aspect to this. While Goodenow found that the support of teachers appeared to matter more to the student's sense of belonging in grade 6 than that of peers, this appeared to weaken in grades 7 and 8. Similarly, the works of Strayhorn and Rainey et al. concerning college students emphasised peer relations more than support and interaction with teachers or other staff. However, this still affects the students' sense of belonging. However, for children or young people in grades 6 and 7, teachers play an essential role in the sense of belonging in school.

Sense of belonging is a psychological experience and need that not only impacts students' expectancies and perception of value (Goodenow, 1993), but also influences behaviour (Strayhorn, 2018), for instance, on the choice of major, as reported by Rainey et al., or on whether to persist or not.

So far, we see the sense of belonging as related to students' (or pupils') experience of being valued, mattering, and accepted as an authentic individual by teachers and peers. This sense is related to social interactions, teaching, and the content taught.

### Science identity

One way of developing a sense of belonging in science and science teaching is the opportunity to create a science identity. Angela Johnson describes that affinity towards a field relates to the evolvement of self-identity containing enjoyment and ideas of being good in this field. As self-identity might describe interest and desire, it does not say which identities are supported in these science settings (Johnson, 2020), as there might be a discrepancy between a student's interests and the way science is taught. Hence, the role of school science and what is valued in science teaching is of significant meaning in developing a science identity.

In their seminal paper, Carlone and Johnson (2007) posit that a science identity combines competence, performance and recognition. Competence refers to the student's knowledge and understanding of the science content. In contrast, performance refers to the student's ability to participate and act in practices in school science, e.g., using the appropriate language or lab tools. It is possible to perform without competence and vice-versa. Recognition entails recognising oneself and being recognised by others as a science person. Again, one could be competent and perform in the right way without being recognised or without recognising oneself as a science person.

The paper by Carlone and Johnson concerned university-level students who had already decided to pursue a science study trajectory. Hazari et al. (Hazari et al., 2010) therefore added 'interest' as a fourth component when applying science identity to high-school students to capture the question of whether the students had a desire or curiosity "to think about and understand physics" (p. 982). The concept of science identity, in other words, has an element of self-perception (do I recognise myself as a science person, and do I experience an interest?) and an external component (am I recognised by others and by the culture, among other things (but not only), based on my performing school science). Therefore, a sense of belonging in science classes would be strongly related to a sense of recognition from within and without.

The foundation of science identity on performance and recognition suggests that identity is perceived as something that can change and that is related to what one does rather than as something one is. As Barton and colleagues, we work with identity as an ongoing process rather than identities themselves (Calabrese Barton et al., 2013). In that sense, identity work is a negotiation of how individuals see themselves and wish to become, intertwined with the practices of the school science they encounter.

This approach to identity and identity work aligns with the theoretical concept of positioning (Davies & Harré, 1990). Davies and Harré (1990) posit that the subject acts in relation to the variations of social interactions it encounters, shaping different ways to understand oneself. Positions are negotiations of what becomes accepted or dismissed in the context, such as the positions of student and teacher. The positions are continuously shaped through processes where individuals contribute through their language and actions.

The positions emerge from social interactions of positioning oneself and being positioned by others (Davies & Harré, 1990). This is parallel to the two-sided recognition process in the science-identity concept. Adding the approach of positions in science teaching highlights the question of which possibilities the available positions shape for students to create meaning of science, to see themselves in science, and being seen as belonging in science.

To a vast extent, what is recognised is the student's performance – not only what the student does, but also what the student looks like, the interests the student expresses, etc. Competence may not be recognised if not performed in a way that aligns with what is read as a sign of competence. Conversely, one may be able to perform in a way that can be read as a sign of competence, without the performance necessarily building on competence but rather on the ability to perform in a readable way (cf., recognition).

In this paper, we study the identities available in school science over time (from grade 6 to 7), to whom these identities are achievable and desirable, and if they are not, then which possibilities emerge for developing a sense of belonging.

### What is present in the classroom?

This paper concerns students' experiences with science, belonging and science identity in a school context. This means that the positions and possible science identities relate to what is possible and available in school. There may be other possibilities in science practices outside school (cf. Calabrese Barton, 2001; Dixon et al., 2023; Rahm et al., 2022), but our study focuses on the development of a sense of belonging and science identity in school science and the ideas and expectations about student practice in a science classroom (Shanahan & Nieswandt, 2011). Therefore, whenever we write ‘science’ in relation to our study, it means ‘school science’. Further, we focus on students’ practices in the classroom.

However, a classroom is more than one thing. In the study by Carlone and colleagues (Carlone et al., 2014), they draw on the theory about figured worlds (Holland et al., 2001) to point out that in the classrooms they studied, students and teachers drew on different “macro-level figured worlds” (Carlone et al., 2014, p. 839), e.g., the figured world of traditional schooling, but they also drew upon out-of-school figured worlds related to family or childhood. They argue that

> “A classroom rich and thick with threads from different (empowering and relevant) figured worlds, one could infer, is a place where more students have greater opportunities to engage meaningfully in and to develop identities in science” (Carlone & Johnson, 2007, p. 839).

Still, this would supposedly be the case if the different worlds were made to contribute to science activities from various perspectives.

Another perspective on the classroom is that several things are simultaneously going on there but not necessarily pointing in the same direction. Nuthall (Nuthall, 2001) argued that three socio-cultural systems are being simultaneously at play in the classroom:

> “(1) the public system of classroom activities that the teacher designs, organises and manages both directly in face-to-face interaction with the students, and indirectly through individual and group tasks, (2) the semi-private system of peer interactions and relationships within the peer culture that is partly visible, but largely invisible to

> the teacher, and (3) the private or internal system of the student's cognitive and emotional processes. Each of these systems has its own rules, procedures, and outcomes. While these sociocultural systems interact with each other, they are structured differently, involve different processes, and affect the learning process in different ways" (Nuthall, 2001, p. 238)

Nuthall points out that while the overall activity in a classroom is organised by the teacher-managed public system of activities, which he also labels 'the instruction-evaluation system',

> "How an individual student engages in that activity depends on how the student is simultaneously involved in the three contextual systems. […] At any one time, the student must balance or integrate the expectations or requirements of these different systems." (Nuthall, 2001, p. 241)

Based on a fine-grained analysis of student engagement in a year 5/6 science classroom, Nuthall (2001) shows this balancing, how it differs between the students and how it affects the student's participation and learning opportunities. His analysis revealed, among other things, that some students prioritised interacting with peers from other groups during group work and that there, in some cases, was a conflict between what mattered in the peer culture and peer interaction and what the teacher expected the students to do.

Hence, when considering the formation of a science identity and the positioning of students in the classroom, we also need to pay attention to the simultaneous presence of different activity systems.

## Methods

### Context of study

The paper builds on empirical material from longitudinal ethnographic fieldwork where students, as part of a larger research project, were followed throughout one and a half years from grade six when they were 11/12 years old into grade seven when they were 13/14 years old. This is the transition from primary school to lower secondary school. Frequently, this transition involves changing teachers, changing places (a different school building or even a different school for students in grades seven, eight, and nine), and sometimes, new classmates. Also, students get new school subjects. In science, students move from being taught one combined science subject ("Natural science and technology" (N&T)) to having three separate science subjects: biology, geography and physics/chemistry.

By the time of the fieldwork, N&T was scheduled for one and a half hours each week, sometimes integrated with other subjects to extend this time. Occasionally, whole days or weeks could be dedicated to science as project days/weeks. The new science subjects in seventh grade are timetabled for four and a half hours of science(one hour and a half for each subject), meaning that science comes to occupy more time in the students' school timetable.

### Ethnographic fieldwork

The core of the empirical work was ethnographic fieldwork carried out by the first author at two country-side schools in Denmark over one and half years from the beginning of sixth grade to the midterm of seventh grade. The ethnographic fieldwork was divided into three periods: (1) The first author spent three weeks at each school following the students in N&T and other school subjects and breaks. (2) Still in grade six, the first author visited the two classes, but only when they had science subjects. This was done three times at each school. (3) Three weeks were spent at one of the schools and four weeks at the other school. This time, the students were followed in the three science subjects and breaks before and after the classes.

Many hours were spent with the students in the first period, providing time to get to know them and their everyday school life. This included playing different kinds of games outdoors or within the class or other places at the school, going for walks and chatting about movies,

## Participants

We have mapped four students' trajectories over time to understand their possibilities for experiencing science as a place to belong and to develop a science identity.

In total, thirteen students were interviewed (six at one school Y, and seven at the other). The students were interviewed in grades six and seven. Nine students were interviewed in both grades six and seven. Two students had moved away by the time of the second interview, and one did not wish to participate in the second round of interviews in grade seven. Instead, two other students were invited to participate in an interview, and they both agreed. In total, twelve students in grade seven were interviewed.

To obtain diversity, the following criteria for selecting students were used as a guide: gender, ethnicity, peer groups, and ways of participation in science classes. Peer groups were used as a criterion to ensure variation concerning the different groups the students formed. For this purpose, the first author made a map of how the students clustered in small groups so that the interviewed students represented differences in ways of being a student in their class. The last criterion sought to capture differences in participation. Participation was when students contributed by responding to a question or adding something to an ongoing conversation in class, either by raising their hands or shouting their contribution. We looked at the content of the student's contributions, including whether their contributions were answers from working on a task in class, whether they were asking a question, were sharing experiences from practices outside school that related to the teaching, or were contributions that were not associated with the learning. We also considered the form of participation: did students provide short or lengthy explanations, and what language did they use? We finally included students who were quiet, passive or inattentive during observations.

Based on these criteria, six students interviewed in the first round were boys (three of them with a minority background), while seven were girls (one with a minority background). In the second round, six boys were interviewed (three of them with minority backgrounds). However, only one of the boys had been interviewed in the first round. All the girls were interviewed again, except one who had changed school.

### Interviews

The first author conducted all 25 interviews. Nine to twelve months passed between the two rounds of interviews. The interviews were semi-structured. The first focused on students' everyday lives (family, pets, activities/hobbies and friends), their experiences with school in general and the combined science subject (N&T) and thoughts about the future. In the second interview, the students discussed what had happened since the last time. Then we asked them about being a seventh grader, about their encounter with the new science subjects compared to the N&T and then went on to talk about the three new science subjects (separately and what they might have in common). Finally, the students were asked if their thoughts about the future still matched what they said in the first interview.

The paper mainly draws on the interviews, but we also use field notes from the ethnographic fieldwork and drawings made by the students in a workshop to supplement the students' accounts. The combination methods serve as a crystal for gaining a broader understanding and insight into the students' experiences with science (Seale, 2002). In the seventh-grade interviews, the students also drew how they experienced themselves in the three science subjects. This was done to provide time for the students to reflect on the three science subjects instead of creating a typical dialogue, where answers to questions often make us answer faster to avoid silence (Hoppe & Holmegaard, 2022).

### Analytical approach

As the first step in the analysis, we read all interviews to *familiarise* ourselves with the material (Braun & Clarke, 2006). The reading was not entirely open. We focused on comparing the students' descriptions of science in grade six with their descriptions in grade seven. Further, we noted comments related to science as ideas for future jobs. After the reading, we discussed topics emerging from the first analytic step and, based on that, decided in the second reading of interviews and fieldnotes to categorise for interest, competence, performances and recognition among the students to see if these changed during the transition.

What stood out from that reading was the diversity of the students' experiences with science, although there were some similarities, too. This resulted in an interest in unfolding and showing this diversity. Therefore, we selected four cases to be followed for stabilities and changes.

### Introduction to the analysis

The four cases were selected due to their differences (Flyvbjerg, 2011) related to the student's experiences and paths related to science and their identity work in the transition from grade 6 to grade 7. The differences relate to the challenges the students meet and to the different ways they encounter the same challenges.

## The Analysis

### Sara

#### Sara, in grade 6

During the observations in grade 6, Sara was only observed participating in class once. She was often quiet or passive during science teaching, but was chatty during breaks, sharing thoughts and ideas about school life with the first author. Most of the observed science teaching sequences were sequences of the teacher lecturing followed by seatwork and finally summing up, where students participated in sharing knowledge/ideas or answering questions. This kind of teaching required active participation to be recognised, which for Sara seemed less available.

> I: Do you think it is easy to participate and raise your hand in Nature and Technology?
>
> No, because it is about many different things, and sometimes there is something that you don't understand at all. Then, it is very confusing.

Sara's feeling of not understanding and being confused made her hold back from participating. However, this was different in other teaching situations. When group work entailing experiments was a part of the science teaching, Sara was observed taking control and getting things done during group work. Similarly, when the class did a science experiment about burning calories, Sara did not hold back; instead, she shared her reflections and knowledge concerning, e.g., problems with eating particular fast food. As part of the experiment, the students should, in pairs, go for a walk for a specific period. The first author walked with Sara and Louise, who shared their reflections and considerations concerning the experiment. However, when they got back in class, and the students were invited to share their reflections, Sara remained quiet. Interestingly, Sara seemed to thrive in science classes when the teacher was out of sight.

However, when asked what to do to be good in science, she said, "You should know insanely much in class, having read about it before". She mentioned a couple of classmates who fit that description. Sara said she did not know much about herself but did not consider herself at the bottom of her class, because she did not know quite so much. Her formulation about 'knowing in class,' suggests that it is not enough to know it, but one should also express it. However, as already mentioned, Sara was very quiet in class, but still did not rank herself at the bottom, because she knew something, so prior knowledge appeared to be important.

Sara was not uninterested in science-related issues. In the sixth-grade interview and from informal conversations, Sara showed an interest in the environment and climate. In the interview, she said that science classes did not spark her curiosity, but she would have liked to talk more about environmental issues. When asked about why they have science in school, she said that it was so that she could do something about climate change later in life. However, Sara described science teaching as boring, mainly because the teacher talked a lot. The teaching practices observed in Sara's class, with whole-class activities, seatwork and class discussions, limited her possibility of pursuing her science interests and presenting herself as a competent student. This would depend on her being active by raising her hand during the lectures and class discussions. Sara performed as a good student because she did what she was supposed to do and did not cause disturbance in the classroom. She did not, however, perform according to what she believed to be a good science student, because she did not know as much , as the one she identified as a 'clever' student, which she possibly also related to expressing it – to 'know it in class'.

### Sara, in grade 7

In some ways, Sara's performance as the good, silent student continued in grade 7. However, there were also some variations.

In physics/chemistry, Sara responded to questions asked by the teacher, but she also reached out to the science teacher for help with tasks or experiments they were doing. For example, in grade 6, Sara was observed taking a leading position in group work. This performing a co-teacher identity in the group work was more salient in seventh grade, particularly in physics/chemistry, where group work constituted most of the lessons. Sara would often read the assignment, collect the equipment, and ensure all group members had tried the activity. This position also meant that Sara's classmates called her 'grumpy' and 'teacher'. It was not something Sara cared about as long as she got her things done before time was up.

In the interview, Sara said she liked the teaching in physics/chemistry. The experiments made her feel she was learning something because she got to do it on her own and retry if what she did was wrong. She did not feel the same way when doing paper-based group work. Doing paper-based group work, she felt that the work was already done – like the answers were given in advance. About following a plan in the experiments, she said that maybe it could be fun if they did not have to follow a recipe when doing experiments. On the other hand, it could be a waste of materials – and maybe it was better for their safety that they could not mix everything.

Sara's approach to physics/chemistry was structured and organised in many ways. In an observation, for instance, she was working on a paper with facts because she had heard that if you cannot figure out what you learn in physics/chemistry in grade seven, you will not make it in grade eight. One of the physics/chemistry teachers also recognised this approach and identified Sara as a student who would be good in a lab because she was well-structured.

### *Geography,*

Teaching in geography was characterised by long sequences where the students listened to the teacher talking or solved tasks reviewed in class afterwards. Sara got her seatwork done, but like in grade six, she remained silent when students were sharing results from the tasks completed during the seatwork. This was not because she was questioning her competencies in geography. In the interview, she said:

> Yes... so it is not to, to praise myself, but I do that anyway, um, right now, like here. But, uh, the other day, during geography what my teacher was saying was exactly what I had written down. So, if you heard what he said, listened to what I had written, or saw what I had written down, it was precisely the same, just explained in such different words. So, that's why I feel that I'm a little better at Geography than at so much else. Yes.

Sara aligned well with what was expected of the students, but she did not like sharing her results in class. This resulted in her not being recognised as competent, because recognition was based on sharing and participating orally in class. In the interview, she said she liked geography because she felt she could use some of her knowledge of Nature and technology from grade six.

#### *Biology*

In relation to biology, Sara liked the teacher because the teacher was cool and relaxed. The observed teaching showed fewer lectures controlled by the teacher, leaving more room for the students. Despite that, when Sara explained what was required to be good in biology, she said: 'read and write, then I think you will get far in Biology' (Sara, interview). Sara did not have much to say about biology, and it seemed to capture her interest less than physics/chemistry and geography. What she did like was activities where the teacher was out of sight.

In seventh grade, Sara said that the science teaching provided her with knowledge about the everyday world, e.g., specific knowledge about what happens when washing-up liquid is mixed with other things. These topics were actually addressed during the science teaching in both grades six and seven. Still, the teaching was generally structured and organised in a way where the science teacher argued for the meaning of the teaching based on the curriculum rather than letting the students bring their knowledge to the teaching.

### Crosscut – change and consistency.

We see minor changes in Sara's participation in science classes over time. In both years, she was quiet in class but active and talkative during group work. In the interview in grade 7, Sara mentioned this as a general preference. The interviewer commented that Sara often had notes concerning the class discussion but did not raise her hand. Sara said that she; "'has always been the quiet one during lectures. But when we are together individually, I talk so much" and laughed. When asked how this could be, she responded," the thing about making mistakes, or the fact that you can say something wrong, I think so, that has made me quiet". Conversely, she liked group work out of class because she preferred that the teacher was not always observing and checking up on them.

Thus, Sara's engagement and, hence, her position in class depended on the teaching setting, where students had to participate in particular ways to be recognised. When the teacher was absent, she was responsible for completing the practical exercises in an almost co-teacher way. We observed that in Nature and Technology in grade 6 and Physics/Chemistry.

## Amir

### Amir, in grade 6

In grade six, the observed science teaching would often be short or long lectures by the teacher, followed by small seatwork activities, which meant that students mostly sat at their tables listening or doing seatwork. Amir's participation in these classes varied. In some situations, he seemed detached from the science teaching. When Amir participated, it was often sharing results from seatwork or suggesting solutions to a task/problem. These contributions include 'correct' or 'wrong' answers and usually short sentences using single words or numbers. Occasionally, the science teacher challenged this by encouraging the students to unfold their answers.

Hence, when Amir seemed engaged in the science classes, the students often did seatwork in small groups of two at the students' computers. Usually, the tasks would involve calculations, which seemed to please Amir. In these task-based group activities, Amir was sometimes observed explaining or showing what to do to his partner.

When Amir was asked what he liked about science teaching, he said he liked being with his friends. This correlated with the observed science teaching, where working with classmates seemed enjoyable, especially with classmates also defined as friends. This is linked well to Amir's drawing, where he portrays himself and his friend. Other things he liked about science were doing things rather than listening; he liked it when they were outside and when he felt he could understand the subject. Hence, while he did not like mathematics in grade six, he was more optimistic about it in grade seven because he had come to understand more. Finally, the teacher affected whether he liked the subject or not. The teachers he mentioned he liked were experienced teachers who tried to make the teaching fun.

However, for Amir, science is fun if you get to do something other than just being quiet and listening. When he was asked about good science teaching, he said:

> Um, that was a few years ago, at my old school. Yes. There, we had to make batteries, figure out how to put the batteries together, and, what's it called, get some light? Yes, and I think it's funny (…). It's because I don't know why, but I just think it was so funny. It was much more fun than when everyone just sat together and had to be quiet and just... Yes. Just sit and listen.

Amir said, “Some years ago,” when he went to another school. So, even though the observed science teaching in Amir’s class included experiments, this was not what he remembered. Maybe the extensive use of lectures and seatwork in science classes and the fact that the experiments were far apart meant that Amir did not recollect the experiments. Furthermore, Amir did not experience being curious about what the teacher talked about in the science teaching.

Amir’s interest and curiosity concerned football, and when he was asked which activity he would choose if he could decide on a whole day of teaching science, he would choose football. Choosing football was in direct contrast to the more static teaching in class, as it greatly interested Amir.

When asked about the three science subjects in grade seven, Amir mentioned physics/chemistry as a subject where you mix “water-things” together and then “something crazy will happen”.

Amir was not looking forward to biology, geography, and physics/chemistry as that would just mean "more work". He said he did not know what learning about the three new science subjects would be like.

### Amir, in grade seven

Amir's general perception was that they should have the three separate subjects rather than the joint N&T because they should have more hours of classes. He could not see how the three subjects differed from what they had in grade six.

#### *Physics/chemistry*

In the interview, Amir said that he found physics/chemistry boring because the teacher talked a lot instead of briefly explaining what to do and then letting the students try it. Amir said he sometimes forgot to listen, possibly due to his lack of interest in physics/chemistry. Notably, Amir experienced physics/chemistry as very talkative, while our observations showed plenty of activities for the students to do experiments.

The teaching we observed in physics/chemistry was often structured as small lectures, with students doing experiments followed by a summarising lecture. During the exercises, Amir frequently drifted around with classmates he saw as friends. If Amir stayed with his group and participated in the exercise, this position would often be guided by another classmate who had read the assignment and could explain what to do.

Drifting around meant that Amir was present during the 'fun' parts, such as mixing two liquids, but less during preparing and performing status based on the exercise. This might have prevented him from learning what the experiments might have revealed.

Amir's interest in school seemed to focus less on learning and more on getting it done. When asked about his experimenting experiences, he answered, "I just think: finally, I'm done (laughs)". Another experiment he liked because he had done it before and therefore knew what to do. There is a parallel to Amir's preference in grade six for answering briefly and correctly.

### Geography

Amir described geography as boring because the teacher talked a lot, and he did not find the subject interesting. This is in line with the teaching observed, where the lessons often were structured as long lectures, expecting students to remain still and listen for long periods. Occasionally, the geography teacher would invite the students to contribute with their thoughts about the topic or with results from seatwork. Here, the students could share their results if they wished to. Amir was not observed participating in any of these mentioned activities.

Even though Amir did not participate, he did not find geography complicated. He had experienced that he could perform well without being attentive in geography class. They had a test shortly before the interview, where he got 75 out of 100 %, "even though I didn't really pay attention". Again, he focused on being close to 100 %, not on the learning outcomes.

Amir was surprised about what geography was about. "At first, you think it is about farmers", he said, or about countries, but then it turned out that it was more "earth and a bit like history" and why the landscape looks as it does. However, he did not find the content interesting.

### Biology

While Amir has described physics/chemistry and geography as boring, the opposite applies to biology. He said he liked biology because of the biology teacher, described as "young" and "cool". Also, she did not talk too much, making him listen more. He said that being good in biology was about listening. He believed he was "okay" at this, although our observations of his practices in class sometimes contradicted this. Amir was often observed chatting or drifting around during seatwork or group work and being unfocused during the teacher's lectures.

Amir's description of a good lesson in biology was a lesson they had some weeks previously where the class had visited a lake. He liked that they were out for two hours with the possibility of having fun with friends. He generally liked group work as he got to work with friends and ask them for help. When mentioning a situation where he had inquired about something, he mentioned an example he believed was in biology. At first, he said that experiments happen in physics/chemistry but changed it to biology. They should dissect a rat, which he found gross at first, but when the classmates had been touching the dead rat and were "playing cool", he had to try as well, and it was not so bad. Thus, peer pressure made him engage in the inquiry activity.

#### Crosscut – change and consistency.

We see significant changes in Amir's participation in science classes over time. Amir participated in lectures and seatwork in grade six but rarely participated in grade seven. This might be a result of several aspects. Concerning the subjects, Amir described geography and physics/chemistry as boring, and even though he described biology differently, his engagement in class did not differ from how he performed in geography and physics/chemistry. There were significant changes in teaching practices, particularly when the students were asked to unfold their answers to more than a single word. Finally, Amir valued being with friends rather than doing teaching activities.

### Nicolas

#### Nicolas, in grade 6

In grade six, Nicolas is observed as a quiet and calm student, paying attention to his peers and carefully listening to the science teacher. He works concentrated on assignments and participates in lectures. In the interview, he says that he likes science, he finds the activities fun because it is something that he cannot do at home, and he likes to raise his hand as he feels he knows the answers to the questions asked in the teaching. In general, Nicolas seems to enjoy and be occupied with science teaching. However, participating in conversations or contributing with scientific knowledge is performed as less confident and more hesitant.

Salient for Nicolas's participation is his calmer and more thoughtful approach, which stands out in contrast to the more general behaviour observed among some of the boys whom Nicolas often works together with but also hangs around with outside the science class. In science classes, these boys chat, scrabble with things, or occupy themselves with computer gaming. This group of boys negotiate masculinity of coolness, power, competition, etc.

The calm and thoughtful approach performed by Nicolas seemed to suit him. However, it also created a less visible position, which sometimes produced situations where Nicolas was overlooked in the group of boys as his behaviour deviated from the performances of masculinity, such as jostling one another, playing practical jokes or competing in finishing a task first dominated. This seemed to marginalise Nicolas in some situations, particularly during group work, where this masculine behaviour often shaped the interactions. Nicolas usually seemed challenged and awkward in negotiating his masculine positions, which placed him at the low end of the hierarchy unfolding among the boys.

For Nicolas, this produced a position of being the person who tried to get things done, meaning that sometimes he was the only one working during group work. One example was when Nicolas and his group were to work on a model. Nicolas both came up with the idea and did most of the work, although he was not satisfied with the idea he came up with as he thought he might have rushed for a decision. Later, when the group presented the model, they got positive feedback and recognition from the teacher. However, another boy in the group who had not done much in the working process said they could have used more materials for their model. The teacher replied that they had had plenty of time to find materials, but maybe they used too much time on the idea.  Although this was not meant to single out Nicolas, it ended up doing so since he was the one who came up with the idea. It had gone unnoticed that Nicolas had done most of the work as the group had been working independently and on their own during the teaching. During teacher check-in with the groups, time was mainly used to ensure that the students did what was expected, providing less space for conversations and for the teacher to get an insight into the work being done in the group.

The masculinity performed by the other boys dominated the possibilities of how to perform masculinity. This shaped ‘locked’ positions, creating repetitive contributions to the group work, and the relationship between the boys did not change or open up for other ways of working together. Even though the responsibility Nicolas took might provide access to science, it also produced a fragile position where he seemed to disappear among the more dominating masculinity. In some situations, Nicolas gained almost no recognition from his peers even though he put much energy into the group work.

When Nicolas was asked about how one should be to be good at science, he mentioned another boy in the class:

> Erh ... I actually don't quite know that, so (name removed) he's good at uh, uhm, he knows a lot about animals, for example (…) And I think that's pretty wild, uhm, and- yes, I actually do not know

When pointing at the other student, Nicolas celebrated the students’ knowledge, and when the first author interviewed the science teacher, she singled out the same boy and explained that the boy had a natural curiosity and possessed a lot of previous knowledge.

Nicolas was not recognised in the same way. Nicolas followed the norms and expectations of organising the science classes (to listen, be quiet, participate and do the tasks). He performed good student identity (the implied expectations), which aligned with the expected teaching norms, but he did not gain recognition as a science student. The students needed to go beyond the expected –showing something extra to earn that.

This did not prevent Nicolas from liking science, especially doing experiments, but he did not seem to be recognised by the teacher as a science person. As group work took up much space in N&T, and as Nicolas was mainly working with the same group of boys who were less engaged in the class activities, his fragile position related to masculinity could challenge his possibility of seeing himself as a science person.

Nicolas was not looking forward to the three new science subjects in grade seven. He expected them to be advanced, and he was concerned about them getting grades later. He preferred that they had N&T, which he liked because they learned about nature.

### Nicolas, in grade 7

#### *Physics and Chemistry*

In the grade seven interview, Nicolas talks excitedly about physics/chemistry. He finds the subject fascinating because it is about space, which he finds interesting already. At home, he talked about a Danish astronaut in space, about Elon Musk, SpaceX, and the planet Mars. In the interview, he drew himself wearing safety glasses while mixing something to prove a (scientific) law or create something new. When asked whether he had been wearing glasses in physics/chemistry, he said: "Not yet, but I think it will happen soon". He had seen safety glasses on television.

For Nicolas, doing experiments is something he appreciates, although not all experiments are equally fun. What Nicolas likes about doing experiments is that he gets to prove how things work. He explains that when doing these exercises, the teacher hands out text materials focusing on a (scientific) law followed by an experiment the students then do. During the interview, Nicolas talked about a teaching situation in physics/chemistry that he liked because of an experiment. He explained the experiment step by step. When asked by the interviewer what the experiment was supposed to show, he did not quite remember, but said it was something about pressure.

He liked the experiments, but he also said that sometimes you could be placed in a group where people just drifted around and “Sometimes, they just run away like that“. When asked, he said that his role would often be to go tell the drifting group members to participate, but he could also be the one finding some facts for presentations. This is similar to the role observed in grade six, where Nicolas would get the group work going, but did not need attention or recognition. During a science day at the school, all seventh-grade classes should present different experiments for students from younger classes. We observed Nicolas standing in the back of the group, almost isolated from the activity. At the same time, students who thrived or took up space during the presentation seemed to align well with the performance of showing the experiment or demonstrating knowledge. This position of holding back was also observed during another group presentation.

However, Nicolas liked physics and chemistry, and he liked the more controlled activities where the teacher showed videos of scientific content and then stopped the video to explain more systematically the meaning of what they had seen. He answered that when asked how one should be good at physics and chemistry.

> I think you have to be really good at understanding a lot of words, and you have to be good at reading a context or a text that you can get into your head to make sense of.

He said that in physics/chemistry, there were “many difficult words and such, you don't quite know what they are", but sometimes the teacher would explain, or they could look at an online learning resource.

### *Geography*

In geography, Nicolas liked topics like cities and countries, which he described as ‘cosy’. These topics constituted a minor part of the teaching at the beginning of the year, and when Nicolas was asked what they had worked with since, he answered:

> Then we have worked with plate tectonics, and then we’ve worked with cells...no, that was in Biology. Um. And then we've worked with volcanoes too, and all kinds of ... And so, now we've been working on... Yes, now we have geography today, but I can't quite remember … ah, yes, we're working on trade and transport to various locations.

Nicolas remembered parts of the teaching, but sometimes confused geography with biology. Later in the interview, he said that the two subjects in some ways were linked, e.g., learning about deserts in geography and the animals living there in biology. Nicolas described the teaching as often organised in steps, such as students reading text materials, answering questions, and then reviewing them, but he also talked about seeing documentaries. This was in line with the observed teaching. Possibilities for participation occurred when students raised their hands to answer a question, which Nicolas often did. He would do so if he knew the answer, he said. When telling what it took to be good in geography, Nicolas said it was similar to physics/chemistry: knowing something in advance and understanding the texts they read. Nicolas said, he did not know much about geography, but was a good reader. He would raise his hand if he believed he had the correct answer, but sometimes he did not. He wished to be sure the answer was correct, but sometimes he was uncertain or confused because the answer was not always easy to find in the text, so one needed to look twice.

### *Biology*

When Nicolas described biology, animals appeared a lot. He made a drawing of himself and a rabbit because when he heard ‘biology’, he thought it would be about animals. Also, when he described an excellent biology class, it was when they saw a documentary about animals. Being good at biology was similar to physics/chemistry and geography (knowing in advance and reading texts). However, he specified that he did not know so much animal stuff, so apparently, that would help.

They did not do biology experiments, he said, but they read plenty of texts. During the observations, the students worked on a written assignment, which Nicolas noted was cosy ('hyggelig') to work with as they had to search for knowledge independently. They had also produced posters about plant cells, which had been 'hyggeligt' as well, just writing and being creative. In the interview in grade six, Nicolas talked about doing creative activities with his mother as something he liked, and he was also drawing in his spare time then.

During group work in biology, we observed Nicolas reaching out to another group of boys. The group Nicolas reached out to, was occupied working on their task while Nicolas' group was chatting and fooling around. However, the teacher asked Nicolas to get back to his group. Then, a boy from the group who was actually working yelled at a member of Nicolas' group: 'Tobias, pull yourself together and help, Nicolas'. Nicolas got back to his group, though nothing changed, and the teacher even scolded him for being noisy even though he was the only one working.

### Crosscut – change and consistency.

Nicolas' participation in science teaching was without significant changes from grade six to seven. He actively participated in lectures and enjoyed different activities in science teaching. Nicolas, in many ways, fits the expectations and norms in the science classes. He gained recognition for this, but not for being a science person because it would require something extra. Nicolas faced some challenges in group work where the masculinity he performed often positioned him as less visible, minimising recognition from peers and teachers. Nicolas tried to get the job done, doing what was asked, but this form of masculinity was overlooked among his peers' more dominant masculine behaviour.

## Neela

### Neela, in grade 6

Neela is a bilingual student, and during the interview, she sometimes resorts to English words even though she seems to handle the Danish language very well. Neela has an ambivalent attitude towards science. On the one hand, she sees it as relevant for our daily lives. On the other hand, she admits to having some reservations about the subject. Furthermore, she explained that subjects you do not like are also the ones you are not very good at. Interestingly, Neela talked about science-related things she did outside of school, such as experimenting at home and using Mentos after seeing it on the internet.

In sixth grade, Neela was not observed participating in lectures. In group work, she participated more, but dominating students often restrained Neela's possibility to participate.  This was also the case during a group presentation in class where Neela tried to explain the group's work. Neela became unsure whether what she was saying was correct, and she turned to a group member who, instead of helping, swept Neela off and took over. The teacher did not comment on or interfere with this behaviour, and instead, Neela stepped back, and the other student carried on. In the interview, the first author asked about this situation, and Neela said that she had not practiced enough. For Neela, it was a question about performing like her classmate, which she perceived as a question of preparing at home.

Apart from presentations, which Neela said she liked, she was silent in class. During the observed teaching, using scientific terminology took up much space. In one class, the students should write down words from text materials and then figure out the meaning by using the internet, looking at science books, or learning how the words and scientific content are explained in lectures. This teaching practice seemed to silence Neela:

> Hmm ... so you have to be able to understand it, some … some words that they use in nature- nature/technology, some of them I don't quite understand

For Neela, this meant she hoped the teacher would not call her in class, which aligned with some observations where Neela seemed almost invisible. While this behaviour excluded her from being a part of the lectures, it played well in avoiding cold-call situations. However, Neela tried to find out on her own. During one science class, Neela told the first author that when she read a word she did not understand, she tried to google for a definition. Then she read the definition, but then a new word emerged that she did not understand. She would google again, and this could continue.

In general, the focus on using scientific language troubled Neela. This was the case for many students, but as a minority girl who arrived in Denmark when she was seven, Neela faced two linguistic challenges: Danish and scientific terminology. In the interview, she was fluent and barely had an accent, but she sometimes used English words instead of Danish because she spoke English in the family, and she mentioned that she felt challenged by the language. This feeling and the focus on scientific language could explain her silent and passive behaviour in class because she was afraid to give the wrong answer if speaking up.

Instead, Neela seemed to feel safer doing things on her own, and when talking to the teacher, she seemed to look for opportunities for one-to-one interactions. When working alone, Neela was observed as concentrated, dedicated, and explorative. This was demonstrated during a self-defined science project where the students had to create a model. Neela worked on a model she enthusiastically spoke about to the first author. She searched the internet and found YouTube videos explaining the scientific process of how the heart works.

The model had excellent and small details, but Neela had struggled with sticking the two heart parts together so that she could close and open the heart. In a conversation with the science teacher about this problem, the science teacher suggested some solutions to Neela, but this was not what Neela had in mind. The teachers ended by saying that Neela could finish the parts of the heart, and then they could find a solution. Rather than staying in the process with Neela, it seemed more important for the teacher to complete the conversation by postponing the solution. There may be reasons for this, but Neela's reaching out to the teacher (which the teacher had emphasised at the beginning of the teaching because the science project was about being explorative and outreaching) was not recognised. The science teacher provided different possible solutions for Neela to pick from. However, the focus seemed to centre more on the end goal of finishing the product than on exploration. These signs of explorative scientific performances were often neglected in favour of the scheduled program. In this case, it restrained Neela from performing the requested explorative science behaviour.

Despite her engagement and excitement for the science project and her research on the Internet, Neela did not consider the science subject particularly interesting. Even though she gave examples of why the subject was relevant to the world outside school, it was not one of her favourite subjects. One reason for this was that for Neela, something was interesting if she was good at it—not vice versa.

Still, Neela mentioned that sometimes she heard something interesting and enjoyed being in the particular science room with its equipment and a skeleton. She was looking forward to the three new science subjects. She thought she would be good at it, and she added:

> I feel like I'm going to learn about- so I was thinking about chemistry, which- real[ly]- quite a lot actually, like, how it happens, how it works, everything... I'm actually

> looking forward to it; it actually sounds very interesting, how, like, things work, it actually sounds- I'm looking forward to it.

In sixth grade, while Neela was silent in class and did not consider science a favourite discipline, she worked independently and occasionally showed that she enjoyed science and was curious.

### Neela, in grade 7

#### *Physics/chemistry*

In seventh grade, Neela still did not participate much during lectures. However, she took a more active position regarding group members in activities like group work. We also observed group interactions where other group members held back Neela, as she was not recognised as good enough. In the interview, she mentioned some of her peers being dominant in group work.

Neela loved physics and chemistry, mainly because she liked the teacher who made learning fun. She also enjoyed doing experiments. She often did not believe what she read, but then she would do the experiment and then believe. A reason could also be that the experiments provided access to knowledge in a way that text materials did not.

She described physics/chemistry as containing difficult words. In a physics/chemistry class, a teacher with specialist knowledge of reading gave a lecture about reading scientific texts, where the students engaged in activities focusing on what to do with difficult words in physics/chemistry. Neela described this as an excellent lecture, but during the lecture, she struggled a lot with the assignments, and when the first author asked about her results, she said that the science teacher had given her some of the answers. For Neela, language in physics/chemistry stood out as a prerequisite for participation. Although she did not mention language as challenging in geography or biology, she faced language-related challenges in those subjects.

### Geography

In geography, the observed teaching often followed a structure with lectures (where students engage by answering questions), group work and watching short videos. Thus, variations related to the content rather than to the activities, and it was rare that students worked in different ways, e.g., using scientific approaches. Possibilities for participation occurred when students raised their hands to answer a question or occasionally were called out by the teacher. Neela did not like the cold-calling, just as she did not want to raise her hand. Neela generally found the subject interesting, but it was sometimes boring as they often just read and did tasks.

When asked about how one is good at geography, she pointed at some of her classmates:

> Mmm. Um. I know, ok, I know 'Student1' and 'Student2' they are really good at it, it's because they do it at home too, yes, I know. 'Student1:' She does it like that a lot at home because her father, her father is very interested in Geography. So if you do it at home, and if you do flash cards like this, with countries and basic things like that, and then primary, more complicated stuff like that, then you can get better.

Neela emphasised that the two students worked on the subject at home, partly with parents, but in the quote, Neela linked this with diligence, spending time at home working on memorising with flash cards and 'basic stuff'. She was being prepared by practising at home, which occupied Neela and was something she liked to do. She felt it could strengthen her skills in the subject, making her feel less exposed to teachers' cold-calling in class. In math, she had experienced that taking extra classes with a math tutor in grade six had improved her understanding of math, so that in grade seven, she felt better, and therefore, she also liked math better.

### Biology

When talking about biology, Neela suddenly stopped, looked at the author and said:

> Because um. OK. OK. Let me just… Biology, it's chemicals and stuff, right

Interviewer: Biology, the…

... such as chemicals and things like that...

Interviewer: It's the subject you have on Mondays...

...or about the body..., or is it about the body... I'm a bit lost here. What is Biology?

Biology was blurred for Neela, and when she talked about things they had done in the class, it related to something they had done in grade six science teaching.

The biology classes often started with an initial presentation by the teacher, followed by group work. The group work sessions were usually long. In one observation, Neela and her group were almost alone for a whole hour, and when the teacher checked in, it seemed more formal as no dialogue of their work or process unfolded. These situations seemed to leave the students to themselves. However, when a teacher-student interaction occurred, Neela liked how the teacher engaged in the dialogue, letting them think first instead of just giving them the answer.

Neela's practice from grade six, where she worked on her own, also showed in biology. During group work, Neela left the group to visit the library to talk with the librarian about books relevant to the science project the group was working on. She did not share this with the group members. Noteworthy, neither classmates nor teachers experienced these initiatives from Neela. However, for her, they were often the times when she was energetic, as opposed to the more silent and passive performances observed during teaching or in the group work, which Neela said she liked, but often felt they worked less and talked more.

When Neela was asked how one should be for being good at biology, practising at home came up again. Neela said one should reflect, take it seriously, be attentive in the teaching, and then practise at home—that would make one better. When asked whether this applied to her, she said that while she was in grade six and was very interested in learning more about the body, she would look up videos on YouTube, but she did not do that so much anymore.

### Crosscut – change and consistency.

Neela's way of participating in science classes continued in sixth and seventh grade. While being passive in class, Neela sometimes worked individually away from others with science content. Neela seemed to become more active in the groups in grade seven, but still, more dominant group members could silence her. She could become interested when new things were presented to her, which could make her engage in looking up knowledge in school and outside. In both cases, she would work independently, meaning the teacher and peers did not see her engage with science. In class, the teaching practices silenced her because they emphasised the students' skills in using scientific language. Neela felt uncomfortable with that, and she felt a lack of proficiency in Danish. Neela could relate science content to contexts outside school, but her interest in a subject was based on being good at it. Because the teaching practices did not capture her engagement when working independently but instead favoured memorisation and language use, she perceived herself as not good in science, and therefore, the subjects were not her favourites. This was the case in both grades six and seven.

## Across the cases

This section will look at our four cases regarding similarities and differences. As we underscored in the introduction to the article, we wish to comprehend the opportunities that primary and lower secondary science teaching offers students. We do this to understand what that means for the students, shaping their science identities and fostering a sense of belonging to the subjects. Exploring the possibilities offered for participation is particularly relevant in the period from grade six to seven because, during this period, the framing of the science teaching the students receives changes profoundly.

The transition from grade six to seven is a transformative time for the students' science education. Until the seventh grade, students have N&T once a week for two hours, a subject that spans across science disciplines and approaches and where the teaching has the opportunity to be more open. From grade seven, students are taught three subject disciplines, where the teaching goes more in-depth with the discipline's methods, approaches and forms of knowledge. It is a significant transformation in science teaching which one might assume would also cause a change among the students in their ways of being students in the natural sciences. Based on our cases, however, a different picture emerges.

Contrary to our expectations, the students' participation remained remarkably stable over time, both during the transition and across subjects. The students' participation indicates a habitual position that seems to be maintained through repetitive actions, raising questions about the teaching and what it offers the students. The students' participation shows what is available in teaching and how they negotiate and renegotiate what they are offered.

We saw some changes, but they mainly related to the institutional level, particularly that the students became aware of grades and exams, which, for some of the students, increased their awareness of their way of acting in the subjects. This is a result of students' attention to the evaluation system. In the following section, we will first discuss the participation related to the three systems and the participation related to teaching in relation to the students' interests.

### Teaching, participation and the three systems

In our fieldwork, we mainly saw lecture-based teaching with seatwork, group work, experiments, and fieldwork, and finally, students working on a project on their own. These teaching formats offered different opportunities for participation and related differently to the three systems in class: the instruction-evaluation system, the peer relation and interaction system, and the individual's internal cognitive and emotional system.

In lecture-based teaching, the students have little influence on what is happening. They either receive information, work alone or in pairs on specified tasks while seated, or attend a class-based interaction, frequently revolving around answering questions or reporting from the seatwork. The instruction evaluation system frames the activities, while the peer system has limited room. Basically, there are two ways of participation: responding to the teacher's questions or not participating. Nicolas was recognised for his participation in class, but his performance was deemed lacking the 'extra' that is needed. Amir tried to participate in grade six without elaborating on his short, fact-based answers, but in grade seven, he withdrew from class interaction.

Neela and Sara both did not participate in class because of the interaction between the evaluative system and their cognitive-emotional system. They were not sure to give the right answers and, therefore, remained silent. Giving the right answer included using the right scientific language. This took up much space and attention in the teaching, which applies at both levels. In grade seven, language is even more important because the language is different for the three subjects. What is problematic is not that the students should learn the language, but how dominant it is for the teaching, and created challenges for Neela. In many ways, language becomes the competence that receives the most attention and might overshadow other competencies to be learned in science.

In grade seven, Sara's interpretation of the evaluation system and the grading coming up increased her silent participation through notetaking. This was acknowledged, but not as a science-related competence.

Group work, experiments and fieldwork left more room for control and active positions for the students. Sara was both active and talking during group work, taking on the responsibility of getting the work done. However, she did this away from the teacher's attention and, therefore, did not earn recognition for it, but it did not bother her. Sara felt that having control was important if she should ‘make it’ in subsequent classes. She took on the managing role in the group and did not care about being called ‘grumpy’ by her peers.

Nicolas and Neela were also actively engaged in group work, but their participation also showed the increased importance of the peer-related system in group work. Nicolas struggled with his wish to participate actively in group work and his marginal position in the social system. The other boys in his group did not recognise him or his wish to get the group work done. He could only do what he could do by himself since he did not have a position to influence the group like Sara. This, inter alia, is related to the way he performed masculinity differently than the dominant form of masculinity in the boy group. This created exclusion oversaw other potentials and maintained some unequal positions of power. His way of being a boy was not recognised. Nicolas' situation was also an example of how the teacher’s decisions in the instruction system related to the social system by managing group formation. Here, the teacher could have changed the groups and opened up new participation opportunities for Nicolas.

Neela also occupied a marginal position in the groups but in a different way than Nicolas. First, she sought the marginal position and pursued her own interests and inquiries without being dependent on others. This moved her practice out of the group and the public but also made her less visible in the instruction evaluation system. Sometimes, she tried to take part in group work but was sometimes passed over by her peers. This Neela perceived as due to her not putting enough effort into the work.

For Amir, the peer system seemed to become more important, and his participation in the instruction-evaluation system changed from sixth to seventh grade. In group work, this led him to drift away from the group, focusing more on interacting with friends than engaging in the group task. Similarly, he liked fieldwork because it offered time for being together with friends.

Summing up, the teaching formats offered different possibilities for participation, but they also presented different relations between the three systems, particularly between the instruction-evaluation system and the peer system. The more open group-work formats allowed for more peer interaction, which could support learning, but also presented the students with challenges, e.g., being marginalised in the group or drifting away from task-related activities by peer interaction. Further, some of the activities in the group activities were not seen by the teacher, leaving classroom participation as the main path to recognition. Hence, group-based participation would not necessarily add to developing the recognition-related dimension of building a science identity.

In grade seven, the instruction evaluation system focused more on grades and the exams in grade nine. Sara was conscious of this, but she appeared more focused, e.g., on getting through the steps of the experiment and getting everyone involved rather than on the insight and knowledge offered by the experiment. Nonetheless, the focus on assessment affected her participation. Thus, Sara and Amir represent two ways of moving toward or away from the evaluation system.

### Teaching, interests and participation

While students seemed interested in some parts of the subject, they generally exposed or expressed a lack of interest in the teaching. Some students were unsure about the content of the subjects and why they had them, like Amir, who suggested that the reason they went from one to three subjects was to fill out the school timetable.

At the same time, the students' interests were not always related to the subject's curriculum. This concerned countries and cities that did not take much time in geography or animals in biology. For Neela, who carried out experiments outside school out of interest, this did not open up an interest in the subject. To put it bluntly, none of the four students seemed interested in the subjects, and even when they expressed an interest related to science, it could be challenging to see the connection, like Sara's interest in climate issues. We can say that their interests were not redeemed, as the students did not experience any connection between teaching and interest.

The teachers rarely appeared to recognise or include the students' interests in the teaching. Because the students were relegated to a passive role during lectures and left alone in group work, there were few opportunities for their interests to intersect with the subject matter. Further, most teacher-student interactions occurred in large groups, where some students felt uncomfortable participating.

Another significant repetition prominent in the students is what they experience as being good at science. Three things were mentioned. First, when students pointed at classmates who were good at science, they would point at students who knew about science before (typically about animals). Second, it would be about mastering a particular terminology and, thirdly, about general school skills (being quiet and attentive). Although the language is also science, in the way the students talk about it, it seems like the terminology is detached from the content it is related to. The students are supposed to use the terminology, but in the fieldwork and interviews, it is difficult to see signs of the words and the phenomena being linked.

Performing science competencies in school apparently did not necessarily imply performing something related to the natural sciences in school. The knowledge the good students possessed was not acquired in school, and general school skills are precisely not related to science. As for language, while learning science (or any discipline) is also learning a language (Airey, 2012), the way the students related to the terminology seemed like learning phrases and signs rather than learning the phenomena the language concerns.

What is interesting about the four cases is that even though there are, in fact, significant changes in science teaching in the transition to grade seven, these changes are not experienced by the students. Our analysis suggests that because the students' perception of being a good science student mainly concerns things not related to the content of science teaching, the changes in the subjects and their contents pass almost unnoticed. The available forms of participation in science teaching do not relate to science; just like being recognised as performing a good student in science classes is more about being a student than about science, the students' sense of belonging in science class is detached from an interest in science. It also means that the interest dimension of science identity is not really addressed in the teaching. Thus, the ways of participation are limited; performing and recognition are related to general school skills, and interest is not evoked in class while students are not sure of the meaning of the subjects. Together, these are difficult conditions for working on developing a science identity.

## Discussion and implications

Our analysis shows how the transition involves both continuity and changes, which we will discuss in the following section.

### Participation as repetitions – competencies in science

Over time, there seems to be little change in the kinds of participation available to students, where it can take place and eventually lead to recognition. The possibility of recognition is present during classroom teaching, where the teachers control the dialogue. Participation that may earn recognition is raising one's hand and answering questions using scientific terminology. This participation form depends on the student's skills in mastering the scientific language and general school skills.

This form of participation is also described in the research as the good (science) student identity (Wade-Jaimes et al., 2022). However, it has also been known to slow down the possibility of experiencing and creating meaning with science for some groups of students (Carlone, 2004; Godec, 2018; Wade-Jaimes et al., 2022). In our empirical material, this restrain takes place over a long period.

In the study by Carlone and colleagues (Carlone et al., 2014), they saw a decline in participation over time, which, inter alia, was the result of how the students were recognised. This recognition was linked to general school-oriented competencies. In our study, participation is generally low and remains so throughout the study period. The low participation can be seen as an outcome of limited recognition practices. At the same time, the preferred form of participation silences some students, and the silence continues throughout the period of time. This silence created by the available forms of participation can be interpreted as students being uninterested. At the same time, our study shows how being recognised as a science learner is primarily linked to performing well as a student and using scientific language. Therefore, the identities that are enabled and shaped in science classes have only little to do with science or science interest but are somewhat related to students' general performance and shaping of school identities.

Other studies also show how students can experience science as less relatable to everyday life and as decontextualised (Bøe et al., 2011; Tytler, 2014). Thus, science teaching is not contextualised for the students and appears distant and inaccessible. While the impact is noticeable in our study already in sixth grade, it gains momentum when students are introduced to the new science subjects in seventh grade, as the meaning of these more academically orientated disciplines seems to be lacking among the students. Although the division into three subjects allows some students to identify topics in a subject they like rather than others, the general understanding of the science subjects is vague. This seems to impede students' ability to become engaged with and learn scientific competencies.

The kinds of participation offered by the teaching prevent students from understanding some science-related competencies, e.g., inquiry. Furthermore, in the observed group work and experiments, the teachers seemed inattentive to how the peer-interaction system interfered with the learning opportunities. Increasing the teacher-student interaction outside classroom teaching could make room for talking about the work and, e.g., clarifying when science competencies are used. This might also create a space for other forms of participation to emerge. This is particularly relevant since the skills that the students will learn in science are not necessarily distant from what they already know. At the same time, working with competence goes across the transition and might support transparency between the combined science subject and the three new science subjects.

However, when students participate in science activities in class, they focus on performing well in the subject rather than experiencing the teaching as an invitation to learn and understand the contents and potential of science. As a result, the emphasis is on adapting to the teaching rather than developing a sense of belonging and curiosity. This approach restricts the students' opportunity to engage with the subject. Instead, it forces them to conform to its power and pre-existing structures, which can be exclusionary (Avraamidou, 2020) and might limit students' potential to evolve in science teaching.

### The language is a barrier to students' identity work.

As we have shown, scientific language takes up much space. Judged by the observations and interviews, it appears to be the one among scientific competencies mentioned in the curriculum that receives the most focus compared to competencies such as using scientific methods, designing hypotheses or reflecting.

Reducing the focus on using scientific terminology in the conversations in class might entail the potential to gain insight into the students' thoughts and reflections on science and science teaching and getting to know the students. In this way, having a science conversation that encourages students to talk without feeling restrained by the scientific language increases the possibility of having more diverse and inclusive scientific discussions. In particular, some students feel a distance between the scientific language and their everyday life and thereby resist adapting to utilise science discourse (Brown, 2004).

Group work is often seen as an opportunity for the students to have conversations about science. These conversations could familiarise the students with reflecting on science and give the teacher access to students' thoughts and reflections on the subjects. However, as we showed in the analysis, group work also has some challenges.

Firstly, the students were on their own for a substantial part of the time. There is obviously a limit to the time the teacher can spend in each group because there are several groups to attend. Still, it reduces the insight gained and the facilitation of the students' conversation. Secondly, the social dynamic in the groups could hamper the learning potential. The challenges experienced by Nicolas in getting to work on the tasks and the inclination of Amir to drift away from the task with his friends both suggest that there is a need to consider how group discussions could be scaffolded. This is even more important because group activities occupy more space in science than other subjects (Howe & Tolmie, 2003). This aligns with our empirical material, and we would argue that group work has an untapped potential.

The group work entails the potential to establish dialogues with the students that go deeper than being able to answer correctly, as a different conversational structure can take place than the one often occurring during lectures. In lectures, students answer the teacher's questions and have their responses evaluated, also known as the I-R-E model (Cazden, 2001; Mehan, 1979). Disrupting this activity might also include the possibility of challenging the more fact-based teaching that often structures science and can be said to support this model. Introducing different interaction and dialogue patterns in class, but preferably also in activities outside class, could lead to active positions that can be recognised by the teacher without occurring during lectures, which some students do not like. Conversations between the teacher and smaller groups could allow this to be precisely done. Furthermore, the teachers' involvement in the group is essential in supporting and deconstructing positions to provide recognition and offer other alternatives. It would also offer an opportunity to challenge the assumption that silent students are uninterested in science.

Besides that, it is worth considering scientific terms and words, especially in sixth grade, where students only have two hours of science. It might be relevant to ask whether the emphasis on using scientific words and terms could be minimised to the advantage of other scientific competencies. This is not to remove the scientific language as it still needs to be learned, but to ask what would happen if it was not allowed to dominate every teaching in science, especially as it can lead to non-participation, which withholds students from actually learning to use and understand the language (Hoppe, accepteret 2024)

### To create a sense of belonging

Among students, we see sporadic signs of interest in science, but we do not see an interest in the disciplines or science as a whole. Despite the students expressing joy and excitement to do experiments and the fact that it provides more active positions, whether it supports the students in understanding and making sense of science can be questioned. For some students, these activities have less to do with science and more to do with being together with friends (Tobin & Gallagher, 1987). Similarly, some of these active positions might also be less about learning to work with science-related content as the student instead functions as a co-teacher. Positions like these might lead to unequal opportunities for learning (Doucette et al., 2020).

Much of the observed teaching took place in classes using computers, doing seatwork or experiments with limited contact with nature and the technologies they were taught. For some students, it is not clear why they have science. The lack of relating teaching to the context could be one explanation for this, just as the limited focus on tactile, observational, and sensory experiences could be another. Both may limit the students' understanding of and relation to science.

Our study reveals that students' identity work in science is not a smooth journey. It is often challenged over time, with recognition being inconsistent across different practices. Despite their potential, students usually do not get to engage in science-related competencies. Instead, their performance is primarily tied to the behaviour of the good student in general. In light of these challenges, we argue that students' experiences from science classes have little impact on their work on shaping science identities, and even when participation occurs, it does not significantly strengthen their connection to the field. The potential to create meaning and perceive the value in what is learned is often hindered, posing significant challenges to the students' identity work. Fostering a science identity can be daunting when the path is unclear and the benchmarks set have little to do with science.

Based on our analysis, the need to develop a relation to science and to be able to recognise oneself is a challenge. However, these challenges manifest themselves very differently for different groups of students. From research, we know how minority students experience marginalisation in science education. Here, we see how gender, ethnicity and class intersect with students' opportunities in science teaching. Katherine Wade-Jaimes and Renee Schwartz have shown how African American girls are positioned as outsiders because they do not perform the expected identities and can provide recognition (Wade-Jaimes & Schwartz, 2019).

However, what allows recognition can be experienced as not in accordance with the student's experiences of themselves – for example, experiencing science as being for nerds (Bøe et al., 2011) but not experiencing or identifying oneself as a nerd. In that relation, it has been shown that science activities outside school can create opportunities for challenging the ideas of who science is for (Calabrese Barton et al., 2013; Gonsalves et al., 2013). Since STEM clubs are less common in a Danish context, this means that when students engage in science, it is primarily at school. Challenging ideas about who science is for needs to take place in school, and it would be obvious to draw inspiration from these studies. However, the institutional differences (e.g., being in an exam-oriented setting or not) must be considered. At the same time, the inspiration from out-of-school activities could also emphasise the part of the purpose of science teaching in school focusing on educating citizens for democracy, and therefore also emphasise the importance of equity and social justice, as it can help focus on the differences that contribute to creating inequality in students' opportunities to participate (Calabrese Barton, 1998).

In this paper, we have shown that science teaching offers limited opportunities for participation in science classes, which causes limited opportunities for being recognised as a science person and developing an interest in science. Thus, the opportunities for developing a science identity are limited. This pattern persists over time because even though the science subjects change, the teaching appears not to. To address this problem, making the subjects more transparent to students could help them better understand science and how it can be used to comprehend the world. This would allow students to integrate their existing knowledge and creations and feel a sense of belonging in the subjects. This approach creates space for students to engage with science and empowers them to see themselves as active participants in science.

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# Article IV: Repeated, essentialised and reproduced at the transition: Lower secondary school science teachers' practices of recognition and positioning

# Repeated, essentialised and reproduced at the transition: Lower secondary school science teachers' practices of recognition and positioning

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**Abstract**

This study aims to understand science teachers' experience and perception of working to settle lower secondary school students into new science subjects. International studies show that science teachers are crucial to how students are positioned as science students. The process is complex and involves a multitude of sociological mechanics that work to distribute privilege. Analysing interviews with seven Danish science teachers and their teaching, we explore their take on challenges associated with the middle school to lower secondary school transition. Aided by a domains-of-power framework combined with positioning theory, we investigate how each domain, institutional, disciplinary, cultural, and interactional, shapes positioning patterns relative to science teaching. The analysis leaves us with a sense of science subjects congealed into a configuration that leaves students unaided in their work to position themselves to be recognised as meaningfully belonging in the science classroom. Rather than a matter of inattentive or irresponsible teachers, this framework allows us to understand the situation as a consequence of a system-of-power that leaves teachers unable to disrupt the inequity produced here. Implications are discussed.

Keywords: gender/equity, pedagogy, school culture, teaching context

## Introduction

This paper is born out of an intention to understand lower secondary science teachers' experiences with establishing a science learning environment for their seventh-grade students transitioning from middle school into lower secondary school. From earlier studies, we know that science teachers play a significant role in supporting students' identity work across contexts and over time (Archer et al., 2010; Barton et al., 2008; Carlone et al., 2015). Carlone and colleagues (2014) conducted a longitudinal investigation of three minority students' identity work as they moved from elementary to middle school. As the students grew older, the authors interpreted their racial and gendered positions as more pronounced and oppositional to the science-positive positions these children appeared to take up when they were younger. In this process, students work to interpret and take up available subject positions. The authors argue that how teachers approach this work and their teaching practices are crucial to students' identity work and in constituting who is recognised as legitimate science behaviour. The authors showed that teachers creating space for active participation, personal relevance, and collaboration in science supports students' engagement, confidence, and competence in scientific knowledge and work (Carlone et al., 2014). Thus, it is not only learning and becoming a science learner that teachers are in positions to change or maintain. In the articles by Wade-Jaimes & Schwarts (2019) and Wade-Jaimes, King & Schwarts (2021), it is pointed out that the teachers' position is of significant meaning to either reinforce or challenge stereotypes and expectations towards students, in these cases for African American girls', engagement and success in science. By recognising and addressing cultural, social, and gender biases in science, teachers can make science more relevant for students as it allows and includes diverse voices, knowledge, and ways of 'doing' science. Ways may often differ from what is recognised within science and what the students recognise concerning their identity. In this way, the three authors seek to acknowledge the intersections of identities and backgrounds among students and encourage teachers to play an active role in creating different positions for students in the classroom. To establish a more equitable and inclusive science education, particularly for groups historically marginalised or overlooked in STEM fields (Wade-Jaimes et al., 2021; Wade-Jaimes & Schwartz, 2019). All three studies also emphasise the power of cultural production in shaping ideas and beliefs about gender, ethnicity, class, and social backgrounds, as well as how this influences science as these ideas, representations, and stories perpetuate schools.

We see that science teachers have the potential to address and form what becomes recognised. However, what creates these practices of recognition are not isolated processes between two or more individuals but complex processes involving multiple intersecting dynamics (Carlone & Johnson, 2007). Processes include different ideas and expectations, such as scientific discourses associating science with masculinity and cleverness (Archer et al., 2012) or being a nerd (Bøe et al., 2011). Thus, institutional structures as change in teaching practices, curriculum and science teachers (Kaur et al., 2022) and new competencies (emu-redaktionen, 2019), as well as the use of scientific vocabulary (Lemke, 1990) as the enacting of Western epistemologies in science, which is formed on white, middle class and masculine ideas (Askew & Wade-Jaimes, 2023) and the idea of science as being without emotions but also value-free (Aikenhead, 1996). These are just some of the aspects intersecting with these processes of recognition. Furthermore, these processes of recognition are also racialised, gendered and classed, limiting students' possibilities and participation in science (Avraamidou, 2020)

In our work with science teachers, we noted that they seemed lost between expectations and requirements as they experienced what we identify as an everything-all-at-once process. This frustration among the science teachers made us reflect on the system the science teachers encounter every day. Previous research shows that teachers may significantly influence students' opportunities, but their actions also take place in institutions where layers of power produce possibilities and challenges for science teachers (Navy et al., 2018; Richmond & Wray, 2023).

As described in the introduction, this study looks at how secondary school science teachers experience middle school students transitioning from a generalised science and technology subject into the set of more distinct science disciplines Danish public school students take during grades 7, 8 and 9. In particular, we are interested in teachers' acts of recognition and positioning students. We want to understand how they think about the learning and teaching task at hand when they work to introduce students to new subjects and new ways of knowing. We look at how equity considerations inform their thinking on students' preparedness, pedagogical decisions, and curricular demands relevant to their science teaching.

Based on this, the transition is worth looking into, as the potential for changes is enabled as students encounter new school subjects, curricula, teachers, and expectations. Thus, do the teachers experience such potential?

We place this paper within this tension and how it influences the science teachers' ways of teaching science. We do this to understand what this system does for teachers and students when new spaces for science learning are to be established. To do so, we draw on Patricia Hills Collins's (2009) *'domains of power'* framework to explore practices of recognition in science teaching as an outcome of how power works through each of the four domains. Thus, we ask:

At a time when new science subjects are introduced in lower secondary school, how do science teachers describe their science teaching, and how do they recognise and position their students as science learners?

**Theoretical framing**

Practices associated with positioning and recognition to allow participation are about negotiating norms and applying them to specific situations. Thus, recognition is not neutral. Avraamidou (2020) suggests that individuals learn to recognise themselves and be recognised, i.e. positioned, as science learners through layers of power that intersect with the norms and practices in science teaching as described in our introduction. Furthermore, these forms of recognition are continually negotiated and (re)shaped in a complex ongoing process in which teachers play a centrally important role (Carlone et al., 2014; Wade-Jaimes et al., 2021; Wade-Jaimes & Schwartz, 2019).

To capture how norms and layers of power intersect when Danish science teachers understanding of students, we uses Patricia Collins' (2009) domains-of-power framework. The framework was created to understand racism in the US as a specific form of power that mediates disparity between societal domains. Specifically, Collins identifies four domains of power that maintain and produce systematic oppression in society that marginalises, notably, women of colour. The domains are structural, disciplinary, cultural, and interpersonal. While Collins uses the framework to understand how power works to racialise marginalised groups, she also insists that it is applicable to understand and challenge any form of systematic exclusion (se for example: Johnson, 2020; Nielsen & Madsen, 2023).

The structural domain gives attention to how the level of institutions work to structure, reinforce, and ultimately justify oppression, for instance, allowing for oppression to appear as a societal pattern, e.g. as a necessity or an unfortunate mechanism that no one intended for, or a distinguishing characteristic, such as housing or unemployment, of a marginalised group. The disciplinary domain of power is about the rules and regulations that regulate people's behaviour, i.e. discipline people into submitting to the structural domain. The cultural domain, however, captures the ideas, representations and stories that make us believe that the other domains and the actions that ensue are just (or unjust). Finally, the interpersonal domain of power translates structure, discipline and culture into (inter)action. The interpersonal domain captures everyday life and interactions that reinforce (or challenge) marginalisation and exclusion.

In combination with Collins's domains of power, we use positioning theory (Davies & Harré, 1990), which provides a lens through which to approach and explore how science teachers recognise and position students in relation to the domains of power. Positioning theory explains how subject positions are made available through social interactions of language, a dynamic and complex process of recognition practices that includes reasoning regarding context, situation, body language, symbols and signals (Davies & Harré, 1990). Positioning is not one-sided, as positioning and recognition interact dialectically (Davies & Harré, 1990). Since science teachers can be understood as significantly influential to students' practices of self-recognition and positioning as science learners, we can think of the teachers' acts of recognition and related positioning as making science learning practices available to the students. Simply put, when teachers position and recognise students as science learners, they make learning possible and vice versa. This perspective allows us to explore how teachers make science learning available from their recognition practices. Using Collins's framework and position theory will enable us to understand these interactive practices in a context that ties to the school as an institution, the disciplining effects of science activities, and the norms that tie to science learning culture.

## Methods

### *Context of study – lower secondary school*

In Demark, most children begin schooling around six years old, with 80-90 per cent attending the public school 'folkeskolen' (Sievertsen, 2015). The remaining children attend private schools or are home-schooled. The public school system is a nine-year mandatory education corresponding with primary school (grade one to six) and lower secondary school (grade seven to nine), including one year of nursery school (age six) (emu-redaktionen, 2023). The two schools presented in this article are located in Denmark. One of the schools is a countryside school, and the other is a suburban school. This paper focuses on seventhh grade, the first year of lower secondary school.

As students move from sixth grade (middle school) to seventh grade (lower secondary school), they experience various changes. One is the tripling of the combined science subject. The curriculum changes, and so do settings and expectations and who the science teachers are (Kaur et al., 2022; Speering & Rennie, 1996). In Denmark, they move from a minimum of 60 hours of science teaching in grade six to a minimum of 60 hours in each of the three science subjects 'biology', 'physics/chemistry' and 'geography'. Common for all four science subjects is the development of students' skills in four areas: inquiry, modelling, perspective and communication—a form of continuity.

However, each of the three new science subjects has its agenda, although there might be similarities in teaching practices and topics. After three years of teaching physics/chemistry, biology, and geography, the students are going to be assessed in an oral joint examination (Danish Ministry of Children and Education, 2023). The test is interdisciplinary with a common focus; thus, the students must argue for each of the three subjects' purpose and meaning during the examination (Danish Ministry of Children and Education, 2021).

Approximately two months before the final examination, the students are randomly assigned a topic. Their task during this time is to prepare a related problem statement and plan how to address it. They do this under supervision from their science teacher. The examination can be completed as a group or individually (Danish Ministry of Children and Education, 2021). Additionally, students can be assigned a written examination on one of the three science subjects (Danish Ministry of Children and Education, 2023).

### *Data production*

The analysis builds on qualitative data produced during the first half year in seventh grade. This entails interviews with seven lower secondary science teachers as field notes from the observations. The first author produced the data.

#### *Interviews with lower secondary science teachers*

Some of the interviewed teachers taught all three science subjects, while others only had one, thus in combination with other school subjects. Of the seven teachers, only one did teach in the combined science subject. At the two research sites, these three science subjects are taught as double lessons (2*45 minutes). However, geography is divided into two separate 45-minute lessons at one of the schools. The first author produced the seven interviews – five at school Y and the other two at school X. The interviews were completed at the teachers' affiliated school and were scheduled to be 45 min to one hour. However, this was only an estimate. If more time was needed, there was a time for that. All interviews were semi-structured, recorded and transcribed (Kvale, 1994).

The semi-structured interviews centred on the following themes: Background, Education, and why they became science teachers. Teaching is divided into two parts: general questions related to the new science subjects and how they see science in relation to other school subjects. The second part focused on their teaching and what they found exciting and challenging about teaching the new science subjects. Materials used to support teaching and what works. The school; how the school prioritises science and their future; this theme was an open question about how they see their role as science teachers develop in the near future.

*Interviews with students*

Semi-structured (Kvale, 19949 student interviews (n=12) were carried out in the last week of the observations. The questions were related to school in general and the transition (moving from the combined science subject to three new science subjects). Then, talk about the three new science subjects: what they liked, why they had science, and what it meant to be good in science, and talk about similarities and differences between the three science subjects. The interview also contained creative activities, such as drawing oneself in the three science subjects.

*Observations*

During the observations, the first author participated in the science teaching and hanging out in the breaks before and after the learning to chat with students or to join activities such as playing ping-pong to create moments for more informal conversations about school life (Powell, 2022). The first author noted the students' behaviour and participation during the observations. Who participates, how is their participation expressed, who does not participate, and how does this non-participation manifest? What activities engaged the students, and what did not? What are the students occupied with that might not relate to the ongoing teaching, and are there signs of repetition or disruptions, and how might these patterns emerge or be expressed? Additionally, what kinds of relations are developed between the students and between students and their science teachers?

A range of field notes have been produced and conducted as empirical materials. The essential materials are written on paper as 'jottings' or on a computer, depending on the situation (Emerson et al., 2011). All notes are transferred into a document after the end of the day.

**Analytical approach**

In this paper, we analysed the interviews with the science teachers to understand their thinking about teaching seventh-grade students who are encountering the disciplines of biology, physics/chemistry, and geography for the first time. The first author conducted an initial open reading of the interviews, coding for themes and topics that emerged from the material. After this reading, the first author presented the initial themes to the second author. One theme that stood out from the initial coding was the teachers' ways of pointing out problems related to their science teaching. It seemed that when teachers identified issues related to their teaching, they, in different ways, indirectly seemed to disclaim responsibility in their explanations. Inspired by the steps of Braun and Clarke (2006), we then conducted a second and a third more focused coding of the interviews, resulting in six overarching themes: (1) The parents/home, (2) Youth culture (e.g. screens, technology), (3) Testing, (4) The science subjects as challenging to teach in, (5) The teacher's perceptions of teaching science (6) Students as the problems.

In working with our themes, we got interested in Collins's framework as our coding slowly showed a science culture that shaped expectations of students as insufficient. This structure seemed to be a barrier to the teachers' capacity to design engaging activities as they were bound to realise these expectations based on tests and examinations. This outlined a dynamic where perceived requirements translated into actions that seemed disciplined. Together, this complex appeared to challenge student-teacher interaction. So, guided by Collins's (2009) work, we looked at the interviews with the science teacher through a system of power to explore the spans of the cultural, structural, disciplinary, and interpersonal domains in seventh-grade science teaching. To understand what that meant for practices of recognition in relation to the students, we added the theory of positioning. As mentioned in the study context, the three science subjects present their scientific discipline; thus, in this analysis, we examine the subjects in relation to shed light on common challenges in science teaching. Lastly, the extracts used in our analysis are not to be interpreted as belonging only to the domains they present, as we experienced them entailing more than one domain. Hence, using them as we do is to show how the domains shape science teaching and influence how science teaching is structured and organised.

## Results

### *Structural domain – the incongruous*

In Collins' model (2009), the structural domain comprises societies' institutions. This paper uses the structural domain to explore how the public school *Folkeskolen* structures power to position and marginalise groups and individuals. One significant change concerning the structural domain when looking at science teaching and learning is the transition from grade six to seven. The transition, as mentioned, marks the tripling number of science subjects, the time students spend in science classrooms, new settings and teachers, and new expectations for the students. Here, we focus on the examination for the three science subjects (educational politics), which is formed of the structural domain and emphasised in teacher interviews. This is just one of many structural changes. Thus, the interviews took up a lot of space.

*How to work*

In the interviews, we see that the science teachers talk about the final examination in two ways: either meaningful for the way it structures their teaching or how it creates challenges for some students. In the extract below, the science teacher, Philip, talks positively about the part of the examination that teaches the students to work problem-based, as that fits the science subjects well.

> Problem … Yes, problem-solving, I think they can do that easily. Like, I am a pretty huge fan of this examination, which is made for the science subjects now, where they have to formulate a problem. And I also think it is easier to motivate them as it … you can almost always set them up with a topic that aligns with the exam and they think is a little exciting. You can always turn it in a direction they would like afterwards and then ask them hard questions they can't answer right away. But then you can give them sub-questions they might know something about already and then dig deeper into it, right [*Asked about how Philip plans this process*] Hmm. Yes, like I don't think I have, like a specific tool. It's more like, you just pose counter-questions to their opinions.

We see that Philip says that he is a "fan" of how science is exanimated in Denmark because it motivates students by allowing Philip to encourage students to prepare by working with topics they find interesting. Philip finds it easy to guide the students into choosing a topic that aligns with what they will be tested on at the exam. The students' job is to develop good questions that Philip helps structure into manageable sub-questions. When asked how Philip helps students learn how to structure inquiry, he responds that there is no particular tool. Instead, Philip "just poses counter-questions to their opinions." As a structured outcome, Philips's strategy seems powerful. Still, there is no indication that he considers the uneven effects in relation to students' performing of expertise in problem-based inquiry and, more importantly, what it means for students to be positioned as someone who must defend opinions about a science inquiry that they were asked to choose themselves. Indeed, when observing Philip's science class, this strategy appeared problematic:

> Students had settled into small groups to work on the task, and Phillip was placed at the teacher's table, where students could drop by and ask questions if needed. While this happened, another teacher dropped by and asked the class what they were up to. Philip said that the students were doing problem-based work, so he had little to do. Shortly after that episode, the first author approached two students and asked them about their work. One student, Christian, responded that he did not know what they were doing. The first author stayed and talked with Christian and his partner, Jimmy, and it became clear that Christian had not been involved in the work because Jimmy had taken charge of the process. At that point, the class was almost over, and most students had not talked to their teacher. It seemed like they were supposed to figure out how to work problem-based independently. (Translation from observation notes, fall 2022)

Planning for students to be able to do science inquiry unproblematically might be well-intentioned. It signals that Philip thinks of the students as competent. However, it is an approach that runs at the risk of overlooking students like Christian while privileging students like Jimmy. The observation shows how Philip's approach leaves students fragile to be overlooked or excluded. It appears plausible that if left unchecked, this strategy will work as a disciplining power that makes some students hide and passive, missing opportunities to engage in learning. In contrast, others will inhabit the privilege, take initiative and thrive while positioned as active learners. As such, Philips's approach does not seem to do anything but reproduce patterns that may have been established in middle school years, and the final examination that he thinks allows students to work on projects they find interesting would actually work to make students continue to grow into the subject positions that were created for them in their early years of schooling. As such, the structures reproduce behaviour patterns that render the final examination inequitable.

*Who is to blame?*

Compared to Philip, some of the other teachers see challenges due to the structure of the final examination. As Tom explains:

> So this exa… I mean, this exam favours those who are self-driven and structured and can figure things out. [It] loses those students who cannot do things by themselves. It is like the project they also need to do, which puts hard emphasis on their ability to formulate a problem, pose their working-hypotheses, be explorative; it loses the weak students [*asked if it is difficult as a teacher*] Yes because you will have to make the probl … like, and you need to sit down with them, and say, you need to formulate a problem. I'll help you with a problem (Interview, Tom)

We see that Tom knows how the final science examination favours some students over others. He explains that it is because students need to be able to formulate a problem, which some students cannot do on their own. "It loses the weak students," Tom says, and it would appear that Tom feels the examination is unfair. However, it does not seem like Tom acts on the unfairness due to the structure. He will tell the students that he is going to help them formulate a problem, maybe even give one to them, but it would seem like there is only so much he can do.

Consequently, some students' behaviour is interpreted as suitable to the structural expectations while others are not and need to be helped. Although this is with good intentions, it creates situations where some students might experiences to learn to work problem-based while other students experience the task as something done to them. Accordingly, the structure positions teachers like Tom and Philip as inactive in creating alternatives for groups of students that do not align with the dominant norms that govern students' behaviour. Therefore, despite having different approaches, the outcomes are the same. In both examples, the opportunity for students to explore, take up or be assigned different positions in science is impeded. Positions that could differ or offer new positions from the ones they had experienced during their first six years of schooling.

***Cultural domain – the advantage***

Collins (2009, p. 69) describes aspects of power in the cultural domain as reflecting "our beliefs about what is possible, desirable, forbidden impractical, and true". In this paper, we use the idea of a cultural domain of power to capture the ideas teachers use to decide and describe what it means to do well in seventh-grade science subjects. We do this because such ideas inform action and intention; they encompass essential aspects of the norms that govern behaviour in their science subjects.

*A good science student goes beyond teaching.*

One way to think about what makes students do well in science is to consider how their life outside school qualifies their in-school participation. Teachers explained how they believed that students' participation in their classroom is more likely to be successful if they also engage with science outside of school, through, e.g., visits to science museums, being in nature, or at home with parents who have a scientific profession.

> I don't know if I can see a particular group. I'm thinking… maybe they aren't the best at writing long Danish essays, for example […] And then it also matters a lot what mom and dad bring into a conversation kind of. Right, if one parent works as a

laboratory technician at Novozymes, well, then there might already be some knowledge about enzymes and stuff like that (Interview, Michael).

The quote above is the conclusion of a longer passage where the teacher, Michael, is thinking about what might be challenges for the students in science. Firstly, writing essays on the Danish subject could help Michael identify a particular group of students challenged in his teaching. Michael suggests that there is something about not writing long sentences. Secondly, Michael suggests that “it also matters a lot what” the parents do. Thirdly, Michael observes that students who do not have a sizeable Danish vocabulary also tend to focus their language practices on science facts. Michael equates a small Danish vocabulary to having a limited worldview—the focus centres on the written and spoken language. Then, being recognised in Michael’s science classroom is linked to students’ abilities in the Danish school subject and having access to resources through the parents’ occupation. In this case, it is necessary to know already in order to be recognised in science class. This combination creates narrowed possibilities for recognition that are far from equally available to the students.

This might not only limit who is recognised among the students but also limit Michael’s possibilities to recognise. Accordingly, recognisable forms of science classroom engagement entail being able to use a scientific vocabulary developed outside of school, i.e., at home. Other literature describes this as the production of the white-middle-class child (Askew & Wade-Jaimes, 2023; Gilliam, 2009).

In another example of how students’ life out of school equips them to be recognised as good science students, a teacher, Charlotte, talks about recognition in terms of ‘good fit’:

> Yes, like …, if you are … if you are curious by nature then you fit very well with these subjects […] And it is also often those, who has …, who will watch a show on television Sunday evening, The Perfect Planet [sic] or something else that was on.

> Like, it's those who are curious about their surroundings, right, it is you know […] I think it's whether you … if you see things, if you get out into nature […] I think, somehow home influences you in relation to what a … Yes, I think you are … Yes, a 100 percent. If you, like, go to… if you go to the science museum with your parents or you take … or … like … that …. If you do that … yes (Interview, Charlotte).

Charlotte points out that a student who is curious by nature fits well in science as a student who is curious about the outside world. This was linked to seeing programs (with scientific content), and when asked about other things, evoking the curiosity of visiting nature or a science museum also aligned well with adapting scientific practices. We argue that such a belief of being curious by nature produces an idea that places curiosity as inherent, possessed or not. In that sense, the good science student is someone recognised as being naturally gifted (with curiosity).

On the other hand, Charlotte, like Michael, also addresses home activities such as watching programs with scientific content, which implies that doing well in science links to activities at home. We do not want to draw general conclusions because our data site is relatively small. Nevertheless, the interviews showed a slight tension between skills favourable in science and skills gained outside the school, thus embodied in science teaching. This might be why it is accepted rather than rejected. We argue that the activities are recognised as favourable rather than problematised (for being beneficial) because they facilitate a smoother transition to conform groups of students to the norms, rules and expectations in the three new science subjects that the science teachers feel obligated to maintain due to the regulations of science. This might cause intentional and unconscious reactions to the students and show that practices for recognition are far from neutral.

***The disciplinary domain – the preparation***

According to Collins (2009), the disciplinary power domain is about how organisational structures work to rule and regulate our daily interactions. In this domain, we see power at play in how individual actions, behaviour, and interactions reinforce or challenge rules. In this paper, we use the domain to emphasise aspects of teachers' thinking that describe the dynamic of translating perceived requirements and normative scientific practices into actions that discipline students, whether it be intentionally or unconsciously.

*Brains and curriculum*

Below, teacher Linda talks about the three last years of public school when students have biology, geography, and physics/chemistry following six years of studying science as one integrated subject.

> A lot happens between $7^{th}$ and $9^{th}$ grade. I think, sometimes in $7^{th}$ grade, they simply don't get what we're talking about. Basically, I don't think some of their brains have developed yet to understand the abstract we are talking about. Like, I mean, we talk about electrons flying around… while they are more interested in the boy at their table… (Interview, Linda)

For Linda, some students cannot engage with the content she is supposed to teach in seventh grade. This is a matter of biology, which in part ties to a perception that biological brain development connects with cognitive ability, and in puberty, and the students' interest in 'the boy at their table' Consequently, the structural requirements (teach abstract materials) is then largely incongruent with students' biological limitations (cognitive development and puberty) as perceived by Linda. Accordingly, this creates few alternatives for students, which separates students as those who ‘simply don’t get’ it and those who participate in ‘what we are talking about.’

The incongruence allows Linda little flexibility to use the science classroom as a place where students are recognised and positioned as other or more than a product of their biology. Linda says the biological imperative disappears over time, but in terms of the transition between sixth and seventh grade, the opportunity to renegotiate students’ positionality in relation to science is missed. Consequently, biologising students keeps them from what Linda considers abstract science teaching.

In that sense, disciplining takes place by not supporting students in taking up positions of being competent science learners. This is especially problematic in grade seven, where the foundation to begin developing and evolving meaning, skills, and opportunities to try out and work scientifically should be established.

Another example of this is expressed by the teacher Victor, who explains how he structures his teaching for seventh graders differently from nineth graders’:

> I: Do you think, that they can connect what they read and what they work with? Sometimes. It takes some training. The 9th graders are starting, now. They have caught on to how important it is, this thing where you have models, you have experiments, which you relate to a, you might say an actual situation. For the 7th graders it might still be a little diffuse, the thing with, what are we actually gonna use it for? That is also why, when we do these experiments, I go over them first: what is it I want to get, what is it that we are going to look for we are going to do something here, so we know that we are not going into the lab to do an experiment, and then guess at, what we are going to use it for. Instead, so we’ve somehow put some words and some focus on what we are about to do (Victor, interview)

Victor said that students in seventh grade needed to learn how to understand the purpose and process of doing experiments in science, which is why Victor organised the teaching by emphasising the introduction to the experiment. First, he goes over it. Then, the class repeats it. In the quote, Victor also describes this strategy as productive. By nineth grade, the students had started to catch on. Victor's attitude leads to thinking of the student perspective as guesswork, invalidating students' previous six years of experience in school and science. Victor's approach might ensure that students can reason about science as Victor intends. This form of organising learning spaces is routine-based and controlled by the teachers, which disciplines students into taking on a more passive position rather than recognising the student as someone with a valid perspective as an already experienced science learner.

It is a form of teaching often observed by the first author during the ethnographic fieldwork. Characteristically, only a few students were actively participating. These relatively short excerpts show that structures force Victor to organise a teaching that works as a barrier to student-teacher interactions. It somehow forefronts seventh graders as incapable and unready in ways the curriculum does not allow for. This, in turn, constricts the teachers' capacity to design learning that centres on engaging students. However, rather than talking about potentiality, shedding old habits or reinventing students as science students in the interviews, lower secondary school science teachers talked about feeling restricted by the nature of the seventh-grade science classroom by aspects of their experience that we interpret as belonging in the disciplining domain.

***Interpersonal domain – the problem(s)***

The interpersonal domain takes place in everyday life, focusing on the interactions between individuals and the power shaping these relations. In this theme, we explored what science teachers recognise in their interactions with students due to what might be accepted or rejected as legitimate behaviour in science.

*The implied expectations*

Observations of students during sixth and seventh-grade science showed a pattern where only a few students participated actively.:

> The dynamics were complex. Take the student Mathilde, who consistently in lectures appeared quiet during all the observed classes in the three science subjects. Her classmate Rebecca, however, often contributed in class and seemed to align well with what is expected of a good student. In interviews, they both signalled interest in science. Their interactions during class were frequent because Mathilde and Rebecca initially preferred to work together, thus mostly in grade six. However, while Rebecca appeared engaged in the science teaching, Mathilde seemed less involved in situations where the science teacher was present. During an observation, Mathilde talked to the first author about experiencing difficulties gaining entry to legitimate ways of participating. Mathilde gave an example of how Rebecca and the science teacher could talk while Mathilde was left out. Mathilde said she did not know how to speak science like they did. In an interview, the same teacher referred to Mathilde as "a student who always smiles. But if she learns anything, I'm less certain." The teacher was satisfied that Mathilde appeared outwardly happy in both action and talk. However, Mathilde was trying to express a desire to learn science but was misread as someone who was contemptuous of the status quo (Translation from observation notes, fall 2022).

Several factors might be at play. We argue that the example with Mathilde and Rebecca illustrates how the domains interconnect to shape a relationship between Mathilde and the teacher, where the teacher does not teach Mathilde.

We showed how the power in the cultural domain works to assign privilege to the white middle-class students who are recognised as good science learners through their encounters and engagement with science in settings outside of school. Rebecca comes from a white middle-class family and could tell the first author about having science conversations at home and reading scientific magazines introduced by the father. This aligns very well with observations of Rebecca taking up a position in class and interactions with Mathilde as an active science learner. We thus see how interaction in class is read and interpreted by drawing on norms that originate or tie to other domains. The interpretation excludes some students while, for other students, relying heavily on classed dispositions learned elsewhere.

This way of interpreting students to explain their exclusion from science also emerges among other teachers. Furthermore, their reasoning fits with notes from observations of students being preoccupied with their computers, chatting with each other or acting disengaged in ways that sometimes presented as hunched-over and silenced bodies. The teacher, Charlotte, understands the latter as a lack of interest, again relying on predispositions as an explanation for interactive patterns:

> Well, that is for those; it means nothing to at all […] For whom this is entirely irrelevant, where you think, they don't give a s… about what lives in that lake or what is happening. It is just a lack of interest, right, that … Yes, they lie across their table and can't be bothered, like. Yes, they just don't have the interest. They simply can't, not at all, see the purpose why anyone would ask you to do this at all. There is no purpose at all. (Interview, Charlotte)

For Charlotte, some students are not interested, which she sees as embodied by children who lie across the table and present as indifferent. Other reactions to science were described as 'being fearful' of, e.g. carrying out an experiment or 'negativity' (interview, Linda) towards learning, which was used to explain why it is hard to engage students. This way of understanding the students seemed to connect with feelings of exasperation, positioning the teacher as non-agentic and never identifying areas of accountability. It would appear that teachers who understand students as problems or potential problems, as was the case with the smiling Mathilde, whose learning the teachers kept themselves ignorant of, function to close the room for the teachers to act and react. Viewed primarily as a matter of interaction, it looks like teachers refuse responsibility. However, understood across the four domains of power, we see a structure that supports the notion that it does not lie within the domain of the teachers' responsibilities to include otherwise excluded students.

## Discussion and conclusion

The qualitative analysis presented in this paper explores how Danish science teachers create opportunities for students to (re)establish themselves as science learners as they move from a sixth-grade generalised science and technology subjects into seventh grade, where three new science subjects, namely biology, geography and physics/chemistry, are introduced. The analysis was carried out on a dataset consisting of seven interviews with seventh-grade science teachers and observations of some of their teaching, using Collins' (2009) domains-of-power framework in combination with positioning theory (Davies & Harré, 1990).
This perspective helped us unpack the teachers' perspective on teaching seventh-grade science, which characteristically entailed a nuanced identification of inequitable patterns directly associated with their science teaching. However, the teachers remained passive to these patterns and did not associate their insight with an obligation to (re)act and disrupt. To understand why or how the teachers who were involved in this study did not look to solve the problems they identified in their teaching, we started by thinking about the inequity they describe as an expression of a 'congealed' system (Fornet-Betancourt et al., 1987), where inequitable interactions repeat, where beliefs are reproduced and behaviour essentialised.

Collins' (2009) perspective allowed us to explore this congealed system as anchored and expressed through four interconnected domains of power: a structural, a disciplinary, a cultural and an interactional domain. The analysis reveals seventh-grade science as embedded in a culture where students are 'left' and kept in situations that their teachers think of as inappropriate and which prevent the students from working with the methods and materials and engaging with the knowledge that constitutes the science subjects that are otherwise structured to encourage students to make science a part of their identity (Kim, 2018); not just in school, but going forward. The seventh grade would especially seem pivotal for developing science identity (Barton & Tan, 2010; De Moor et al., 2023). The moment marks a transition between middle school and lower secondary school, and three new science subjects are introduced. However, only some students are positioned as belonging and valuable to the school setting. For the rest, (re)negotiation of practises around new opportunity remains elusive, and there is no indication that they will be encouraged or allowed to (re)position and be recognised, to learn to think of themselves as science persons (Carlone & Johnson, 2007). It is a place where students can be perceived as unfit, wrong, or unfinished, and when they are not allowed the opportunity to learn to experience the world through science.

Showing situations as congealed in a system-of-power have specific essential implications. While teachers are responsible for their students' learning and everyday interactions, they are also shaped by allowing meaning and justification through and enacted in a more extensive system of power. This means that far from placing responsibility for creating their classroom practices with the teachers alone, we can identify a collective responsibility for an institution that does not encourage the disruption of inequity. Cultural relevant pedagogies, such as those derived from feminist scholarship and critical race theory, have long addressed inequity as systemic (Ladson-Billings, 2023). We see in the current Danish school system that science teachers are adept at recognising and describing the causes of the inequity produced in their science classrooms. But we also see these science classrooms placed in a context that is not intended to disrupt inequity, which is also confirmed by a Danish feminist NGO (KVINFO, 2023), which recently showed that Denmark was alone among the Nordic countries in not having a curriculum that explicitly addressed equality as a purpose. The present study shows that this has tangible and avoidable consequences for students and that science subjects are effectively used to keep marginalised children in marginalised positions.

According to Collins, an essential attribute of the domains-of-power system is that it can be used to understand how marginalisation works across levels of society, spanning the individual to the systemic, but it can also be used to locate opportunities for disruption. Going forward, we need more research that identifies explicitly ways in which teachers in the science subjects can work to disrupt the inequity that the Danish school works to reproduce. For one, such research can offer a way for teachers to embrace a meaningful existence as science teachers. Still, it can also be a way of locating accountability and driving change. The current study looked across science subjects and did not offer an analysis that tied to the disciplines specifically. However, it is clear that biology provides ways to engage individual students that are different from physics and chemistry. Going forward, we would suggest that research engage with questions that, on the one side, tie to the disciplines individually, but on the other side, engage with investigating how the science subjects in tandem offer a multitude of legitimate modes of engagement that can help students be recognised as science persons. A successful interaction with peers and teachers around a lake in biology might help the student figure out how to do systematic inquiry in the chemistry lab. Collins (2009) shows us that rethinking the curriculum to increase participation entails rethinking what counts, and notably when, where and to whom it counts.

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# Discussion

As I outlined in my introduction, this thesis brings perspective to the field of science education by focusing on students' participation opportunities as they progress from sixth to seventh grade. I delved into the intricate relationship between student participation and identity development within science education. In this chapter, I present the findings of my project and their alignment with the influential literature in the field. During the discussion, I include examples from my empirical material to illustrate my points.

In each article, I took a different perspectives on the project's aim: to explore students' participation in science classrooms. Therefore, I will use this discussion to go across my three articles and discuss them together. I focused on the processes that facilitate or prevent inclusion and exclusion to understand what that means for students in shaping science identities. Specifically, based on the existing literature and my theoretical approach, I examined: (1) How do gender, ethnicity, and class intersect with students' ability to participate in science? (2) What challenges and opportunities emerge during the transition for students' identity work in science? (3) What recognition practices enable students to participate, and what are the possibilities for identity work in science? Through my observations of the students, I discovered that science teaching is structured in a way that necessitates special participation for students to fully engage with the subject. As my findings revealed, this participation focuses on the student's ability to grasp specialised terminology, general academic skills, practice of recognition, as well as interest and assumptions of science. Below, I discuss these findings.

## The production of non-participation in science teaching

As the literature and my project results clearly show, different groups of students are being excluded from science teaching. From that perspective, we are already capable of organising science teaching that includes a particular group of students while excluding other groups of students. In the literature, the group that fits science teaching comprises students who are quiet, prepared, and well-behaved, and often performed by a white, middle-class student (Carlone, Huffling, et al., 2015; Wade-Jaimes et al., 2022), or as described by one of the teachers in my project, those who are self-driven and structured, which implicitly refers to students who reach out to teachers, perhaps even outside the classroom. Over time, I saw how ways of participation often appear equivalent. This is a combination results from what students are offered in science teaching, practices of recognition, and their experiences and expectations of science teaching. This complex interplay of factors enable or do not enable forms of participation.

My findings reveal how patterns of participation can lead to non-participation. Based on the results from article two, I highlight three different practices that shape, maintain, and reproduce non-participation. Here, I focus on how being exposed, overlooked, or disciplined creates low or invisible participation patterns for students because it prevents them from achieving positive recognition but also understanding the content of what they learn, having supporting interactions with their science teacher and peers, or being offered other alternatives to be a science student. The central point is how these positions are repeated and how the same students are often exposed to repetition. Similarly, categories of gender, ethnicity, and class play a role in the formation of participation.

Other researchers have recognised the impact of these social categories. For example, Wade-Jaimes and Scwartz wrote in their study of African-America girls that *'there were no Discourses available for students who were, for example, enthusiastic, social, playful, and resilient that would also receive positive recognition'* (Wade-Jaimes & Schwartz, 2019, p. 25)

Thus, African-America girls were position as outsiders in science because they did perform what could be recognised. Expectations of who and what can be recognised in science teaching impede other ways of participation. When these other ways of participation emerge, as with the boys from theme three in article two, it might not always entail positive recognition. Likewise, and as explained in the influential literature, these recognition practices are formed by structural and cultural factors like science being associated with dominant ideas of masculinity. This is made visible by exploring how girls navigate and negotiate their identities in relation to dominant associations of science such as cleverness and masculinity (Archer et al., 2012). Therefore, for groups of students, recognising oneself as a science learner is not a straightforward process. Rather, it is a delicate interplay of negotiations, heavily influenced by teaching practices and what is recognised. This underscores the significant role of these factors in shaping participation in science. In that sense, the findings highlight that several aspects influence the opportunities to participate, excluding other ways of participation as they cannot be recognised as legitimate. In article two, legitimate participation by students includes being active and participating during lectures, using scientific language, and doing what is asked, like following the instructions for an exercise. In reverse, other forms of participating such as not remembering scientific words cannot be recognised. As noted in article two, those practices are repeated and often involve the same students. In that sense, the students are disciplined into a special kind of participation that reproduces and maintains positions that either enable participation or produce non-participation resulting from the recognition practices. Regrettably, these recognition processes often lead to unequal participation patterns in science teaching.

## The practice of recognition in science

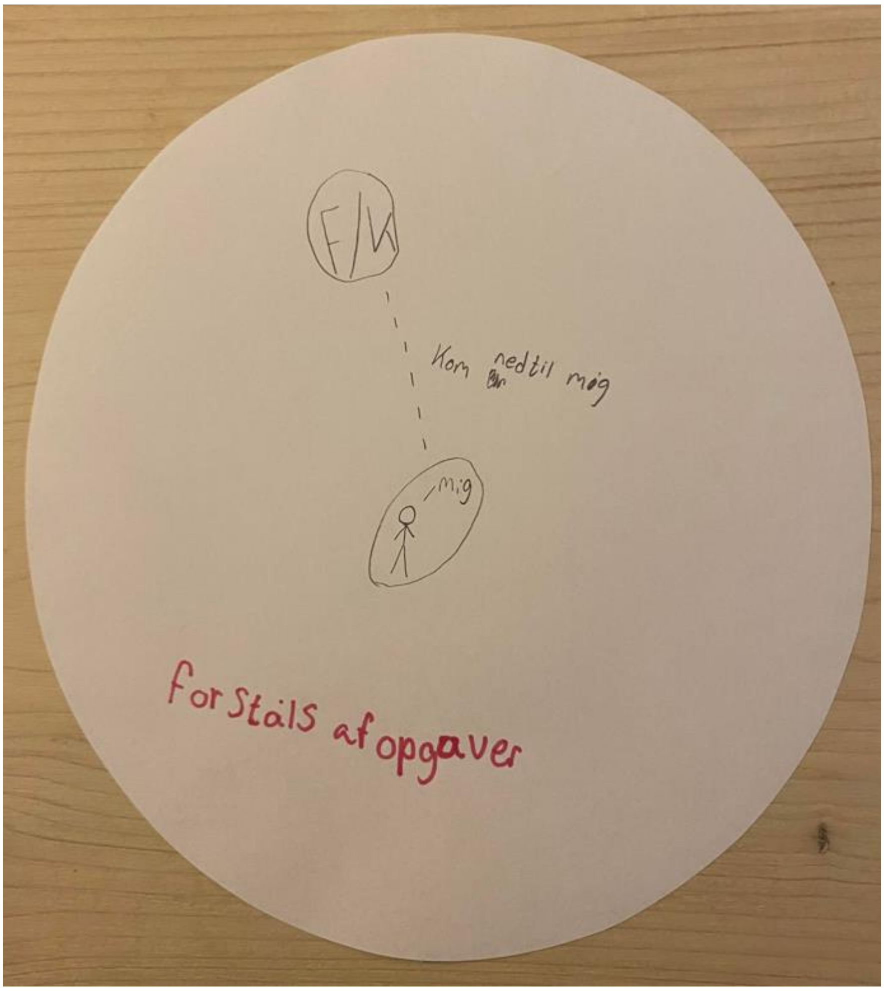
The described recognition practice reoccurs in articles two, three, and four in different ways. Here, the production of non-participation (article two) or lectures as silencing students (article three) serves only to recognise some students, and the results show how this is linked to ethnicity, gender, and class. These processes of inequality are a result of cultural, historical, and structural conditions that set the expectations for what can be recognised (Avraamidou, 2020). Science is also seen as an institution that has been shaped by a socio-historical context linked to positivism placing science teachers within a setting entailing a 'depoliticized, completely objective images of science and science education, where everything follows a coherent and linear progression' (Bazzul & Kayumova, 2016, p. 284). My findings show how this is expressed in the ways that students work and is also expressed more implicitly when a science teacher describes material that might be too abstract for the students. The interviewed teachers expressed structural limitations and cultural expectations, although they recognised that there did not seem to be much to do to change these issues. From that perspective, structures prevent science teachers from actively creating different positions for students during teaching because they feel subjugated to institutional expectations and demands.

Similarly, recognition practices are heavily influenced by the resources and opportunities that students have access to outside of the traditional classroom environment (Archer, Dewitt, et al., 2015). The interviews with the teachers revealed how they draw on cultural ideas, like how students from homes where they do science-related activities are better positioned to learn science. Family background, socio-economic status, educational resources, extracurricular activities, and community support systems support inequality as they are not something for which the students are in charge. These external factors can greatly impact students' recognition and success in science settings, creating disparities in recognition among students from different backgrounds. Other studies have shown the significance of recognising and valuing students' diverse backgrounds and perspectives as essential to engagement and motivation (Barton & Tan, 2010). Based on the findings, it might be helpful to address the specific challenges that science teachers face in their classrooms and to explore how they can tackle disparities. Trying to change the entire educational structure can be daunting, but focusing on how teachers communicate and interact with their students may be a more feasible approach.

## Developing competencies in science teaching

Another recurring theme from the findings is the notion of competencies in science. In articles two, three, and four, science competencies are conflated with ideas, beliefs, and assumptions that have little to do with science. In particular, as I used the concept of science identity, I found that other science competencies beyond language are hardly present among the students. This was especially notable in seventh grade, where the students were introduced to biology, geography and physics/chemistry. Here, the students showed that they experienced the subjects differently in the form of content, but ideas of being good across the three science subjects had similarities. The students related being good to competencies such as listening, writing, or understanding text material. Although these competencies might be good for students' processes of learning science, they are not unique to science. In article two, the students expressed similar notions. Based on this, the notion of what it means to be good in science seems to be a concept that has remained largely unchanged throughout time. This observation implies that the principles and values that define being good have a significant degree of consistency and continuity over extended periods such as the transition from sixth to seventh grade. Therefore, it is reasonable to assume that students are exposed to relatively stable and consistent science teaching across this transition with only minor variations. This points to a teaching approach where students are less active or involved in their learning processes and elaborating or developing science competencies compared with more general school skills. While these more general school competencies might provide academic success, they do not embrace or engage more deeply with science (Carlone et al., 2014). However, these competencies are what count for students.

To illustrate this, below is a drawing made by one of the seventh-grade students, Sara, when she was asked during the interview to draw herself in the physics/chemistry.




The drawing shows Sara as a receiver of the knowledge, where knowledge from the subject drips down to her. In this position, being good at listening is an advantage. Similarly, the drawing is quite accurate in showing the teaching structure that dominated serval of the science teaching observed. This kind of teaching is also described as learning practices where knowledge is something that is transferred to students (Osborne & Dillon, 2008). Critically, the drawing shows how Sara expects to experience that she will receive something. In that sense, the drawing describes the deductive form of teaching, which leaves less room for transformative identities. That kind of teaching limits the opportunities for students to develop agency and identity in science (Barton & Tan, 2010), perhaps mainly because the inclusion of inquiry-based teaching and bodily experience is less present (Siry, 2013) in favour of more passive learnings position. Of note, when other and more active positions occur, they are performed as co-teachers or as an opportunity to hang with friends, as shown in article three. Furthermore, the drawing illustrates something that appeared among the students, encapsulating a distinction between the subject and the students.

Although this separation between the students and the subject emerges differently depending on the students' experiences and understandings of science, it shows that students have a more fragmented experience of science. I noted this experience when I asked the students what they thought the science subjects entailed. For example, did most of the students experience biology as a subject that deals with animals, even though that was only a minor part of the teaching. In addition, when they expressed interest, this was rarely or never related or contextualised, which could drive students to do things on their own, as shown in article three. From that perspective, the students did not seem to expect that the science subjects had something to do with them.

Based on this, becoming a good science student seems to be less about learning science competencies and more about fulfilling some expectations relating to more general school competencies and performing good student behaviour. Likewise, being good at subject is not related to an interest in sciences. Thus, creating links between interests and the science subject is, in many ways, absent. In that sense, the approaches to teaching science primarily focus on the benefits of receiving rather than the benefits of actually doing science. Such teaching practices do, to a lesser extent, support the development of science competencies beyond language skills, but they focus on enhancing more general school competencies and strengthening the performance of a good science student.

## Possibilities for developing science identities

As mentioned previously, I focused on the significance of participation concerning students' possibilities to develop and work on identities in science. My results indicate that students' identity work in science is narrowed and impeded by recognition practices, ideas of doing well, and an interest that is fragmented and less related to science.

As I wrote in my introduction and as shown in the literature about the transition, challenges to the transition have been identified and categorised. These relate to factors such as communication between teacher teams (Sølberg & Trolle, 2013) or students' disappointing experience of teaching in lower secondary school because of the lack of practical teaching activities (Kaur et al., 2022). However, based on my findings, the transition from sixth to seventh grade seemed less overwhelming for the students. Although the transition entails significant changes in relation to the science subjects, this did not seem to be experienced by the students. Conversely, the fact that the students did not experience the change in the subjects as particularly defining does not mean that variations did not occur.

What emerged most clearly was that students started to be more aware of exams and grades, which, for some students, seemed to influence their thoughts about participation and their participation in classes, like taking notes to ensure they are able to do well in eighth grade. Some students negotiated their possibilities in relation to more structural conditions than science teaching. Other students started to orientate themselves towards places outside the school. A commonality is that the students' negotiation of their identities was, to a lesser extent, related to science but to the practices that organised the teaching, including the potential to be with friends or performing good student behaviour as making sure that the group did what was expected of them to do.

Similarly, interests were less related to science teaching, although it was still followed by some students but mostly on their own. This suggests that interest is not negotiated in science teaching, producing identities that move away from teaching. From that perspective, it could be argued that it is not about a lack of interest or that they are not able to put their knowledge at stake in relation to the subject, but rather more about how practices of recognition ideas of doing well and science, as fragmented, impeded the ability to create that connection.

The findings show that students tend to focus more on developing general school skills and performing well as a student, rather than developing a science identity. This does not mean that science teaching is not about science, but it often takes a back seat to the student's identity work to negotiate their identity as a good student. As mentioned, the students talked about being good at listening or raising a hand, which are certainly useful skills for learning science, but not necessarily science skills in themselves. As a result, learning science competencies tends to be overshadowed, and students' science identity development is limited. Notable is that even those students who do well in science did likewise not develop a science identity. This weakens the opportunities to relate to science and, thus, to negotiate identities that relate to science. When the students, contrary to the teachers, do not experience the transition as revolutionary, it may be because they do not similarly experience a connection between the science subjects in sixth and seventh grade. It also means that the subjects in seventh grade can be experienced differently than science is in sixth grade, so even though they have had science for six years, it, to a lesser extent, plays a role in what they will learn in seventh grade. This undermines the fact that they have already worked with and become familiar with science approaches. In article four, this emerged in controlled teaching practices, where the students are assigned some more passive positions, minimising students to be recognised for already being competent.

## Implications from the thesis

Based on the discussion, we need to start challenging practices of recognising ideas of doing well and science as fragmented, impeding the creation of a connection between students and science and science teaching. Studies have shown that social justice and equity provide a means to challenge established practices. Here, social categories such as gender, ethnicity, and class are not background variables; they should be considered if we want to create more inclusive teaching. To illustrate this, I have brought an example from my empirical material. In this example, the students were taught about food production and food habits. The students were encouraged to share their eating habits, and the teacher chose Amir, who is a minority student:

> On one occasion, the science teacher tried to get Amir to reflect on food habits in relation to his culture. Still, Amir rejected the invitation by saying aloud in the class: 'I do not understand *what you mean*'. The teacher asked directly if the food they had for the traditional celebrations differed from the food they generally eat, to which Amir simply responded '*no*'. During the exchange, it did not seem clear to Amir why he should share the information asked, and this lack of relevance remained unclear, although he expressed confusion (fieldnotes).

From an outside perspective, the teacher might have tried to create a space for Amir to share cultural knowledge – a well-intentioned meaning. However, Amir rejected the invitation. For Amir, accepting the invitation would have positioned him as different from his peers. Such a position might be less desirable as it entail the risk of being 'othered'. That is why studies have focused on the need educating teachers in social justice (Calabrese Barton, 1998; Carlone et al., 2011; Rodriguez & Morrison, 2019).

Understanding how gender, ethnicity, and class interact with students' identities has the potential to create more inclusive and equitable practices in the classroom. Identity can be used as concept and could also be used to create more diverse teaching in science. Studies have shown the significance of focusing on students' social identities to learn how science is relevant to them (Barton et al., 2008; Calabrese Barton, 2013; Carlone et al., 2014)

With the potential to focus on students and who they are, students can be supported in experiencing that they have something to offer to science teaching. Similarly, we need to challenge and deconstruct practices of recognition, focusing on the potential to create links between students and the science subjects from a more general view. Likewise, developing science competencies other than language might provide space for other participation opportunities and students' identity work in science.

The challenges faced in science education today go beyond the science classroom. They require the involvement of various stakeholders, including educators, science teachers, and politicians. It is essential that we examine how we educate science teachers and with what purpose. This approach would help us to identify the strengths and weaknesses of our current science teacher education systems and to develop new strategies that are more aligned with the needs of the science education community. Additionally, it is crucial to recognise the value of examining science identities among students and science teachers and to look into the science communities offered to them. This would enable us to provide science teachers with the necessary tools, resources, and support to foster their confidence, motivation, and sense of belonging to the science community. Ultimately, this would lead to a more effective and inclusive science education system that benefits students, teachers, and society as a whole.

## Methodological reflections

An essential contribution to my thesis is the longitudinal methodology combined with ethnographic fieldwork, interviews, and workshops. The different methodological choices provided different perspectives and opportunities to investigate participation. In particular, being able to follow the students over time allowed me to explore what changed and what did not and what this meant for the students' opportunities to participate. I got very close to the processes where obstacles or limitations were created for students' participation. I also gained insight into teaching practices, recognition practices, and students' interest in and assumptions about science.

With my methodological approach, I demonstrated how positions reproduce and lead to non-participation and how students' identity work involves, to a lesser extent, science-related competencies and understandings; this applies over time and thus challenges the opportunity to develop a science's identity.

Being close to the students gave me some unique insights into their everyday lives, creating a better understanding of what the students told me in the interviews. At the same time, I also experienced how ethnographic fieldwork allowed conversations that, contrary to the structure of the interviews, offered more informal and spontaneous dialogues. This became particularly clear with the students who delivered short answers or found it difficult to answer the questions. Here, my fieldwork and observations made it possible to create space for a less guided conversation. Likewise, the dynamic relationship between what was said and what was seen was a decisive factor, as I had the opportunity to experience what the students experienced and hear them put those experiences into words and vice versa. It was also supported by including a creative approach, where the students expressed themselves through more visual methods. Although the creative approach provided the ability to structure the dialogue differently and to challenge power relations and made time for reflection, I found it challenging to analyse that empirical material. Indeed, analysing drawings and illustrations requires a balance between not falling into subjective opinions and interpretations and the challenges of using image analysis.

I also experienced other obstacles in my methodological work. I found it challenging and uncertain to follow the participants over an extended period, as changes can occur, such as students changing schools or no longer wanting to participate. I also experienced how difficult it was to approach the field with a theoretical approach, where identities are fluid and changeable. In contrast, the experience of oneself and the participants expressed coherence and continuity of self. However, this balance between moment-to-moment observations and the longitudinal perspective strengthened the understanding of how individuals always negotiate their possibilities and, thus, identities.

I took a more general approach when discussing the four subjects and their shared understanding of the opportunities and challenges in teaching science. As a result, I did not delve into the specific content and curriculum of the individual subjects such as looking at how students read and understand text materials and what that might mean for being involved and engaged with science, which may be essential to explore further. I saw hints that geography was more challenging than physics/chemistry, as the experimental part of physics/chemistry motivates students, although it could be argued that the content in geography might be more relatable than the content in physics/chemistry.

# Conclusion

This thesis provides knowledge about students' participation in the science classroom, focusing on what facilitates or prevents inclusion and exclusion. I endeavoured to understand the meaning it might have for students' identity work when they progress from sixth to seventh grade, a time when science teaching changes from being a combined science subject to being divided into three more academic disciplines (biology, geography, and physical science/chemistry). I used a qualitative approach to examine what prevents or facilitates participation in science education due to challenges and opportunities concerning students' identity work in science.

This dissertation shows how the teaching practices that students encounter are exclusionary and, to a much greater extent, create non-participatory positions rather than encourage participation. What becomes particularly critical is how these practices are repeated, thus keeping some students in positions where they do not participate. In that regard, it is clear that gender, class, and ethnicity intersect with the processes that shape non-participation. The non-participatory position shows that what the students are offered in teaching is a combination of what might be recognised and ways of navigating what they are taught and negotiating what they are offered due to different practices.

This thesis sheds light on the transition that students undergo in their scientific education. Interestingly, it reveals that science teaching has little to do with actual working and learning scientific competencies, aside from the use of specific terminology. Likewise, it shows that students' beliefs, values, and personal experiences influence how they engage with science and how they perceive themselves in science. In that sense, the students do not experience the transition as revolutionary when it comes to science teaching because the change is experienced more in relation to institutional conditions. At the same time, students have a more fragmented interest in the subjects, even when they can see the connection between them and everyday life. It reveals how the students to a lesser extent expect a connection, but also how teaching is shaped from structural and cultural factors that impede a meeting between interests and the content of the subjects to be created.

Recognition practices are also shaped by structural, cultural, and social conditions, which create notions, expectations, and assumptions that help recognise particular groups of students. Students can be recognised as less competent or interested in seventh grade even though they have had six years of science education.

This thesis contributes to understanding who is excluded, how that exclusion occurs, and how identities in science education are less science based. In the future, there is a need for research that examines how participation can become more versatile with an understanding of how it is affected by gender, ethnicity, and class. Furthermore, there is a need to understand how science education can be improved to make it more engaging and relatable for students. The aim is to help students view science as a way to explore the world and to discover more about themselves. To achieve this, it is important to consider the complex relationship between teaching practices, student interests, recognition practices, and how science is perceived. This can lead to more inclusive and equitable science teaching.

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# Appendix

These interview guides are in Danish

**Interviewguide 6. klasse**

| **Introduktion** | | |
|---|---|---|
| • Projektet<br>• Interviewet<br>• Anonymitet og indberetningspligt | Projektet<br>• Som du ved, så handler mit projekt om, hvad I unge mennesker synes er spændende og interessant særligt her i skolen.<br>• Jeg bruger det til i samarbejde med lærere at blive klogere på den undervisning I bliver tilbudt i naturfagene.<br>Interviewet<br>• Der er ingen rigtige svar og jeg vil bare gerne vide, hvad du synes og tænker om de ting jeg spørg om.<br>• Jeg har et papir med spørgsmål, det er ikke hemmeligt det der står, du må gerne se. Det er blot så jeg kan huske hvad jeg gerne vil spørge om.<br>Anonymitet og indberetningspligt<br>• Det du fortæller mig kommer til at være anonymt. Det betyder, at jeg ikke fortæller det videre til dine forældre, lærere eller søskende. Det er kun mig og min vejleder, der ved det, du fortæller.<br>• Det er kun hvis du fortæller noget, hvor jeg tænker at du har brug for hjælp, så bliver jeg nødt til at sige noget, men så er det noget jeg aftaler med dig først. | Spørg gerne om den unge er nervøs – det kan hjælpe at italesætte det, og høre om det hjælper efter forklaringen af hvad vi skal. |

<table>
<tr><th>Hverdagsliv</th><th>10 min</th><th></th></tr>
<tr><td>Fokus: Hjemmet, Fritid, weekend og ferier</td><td>Papir med som de kan tegne på, hvis de har lyst.<br><br>Hjemme<ul><li>Hvem er der i din familie? (NB: kæledyr og delte familier)</li><li>Hvordan er der, der hvor du bor? Har I altid boet der?</li><li>(Snakker I andet end dansk derhjemme?)</li></ul><ul><li>Hvad kan du godt lide at lave, når du er hjemme?</li><li>Hvad laver du sammen med dine forældre, dine søskende?<ul><li>Hvad laver du, efter dine forældre er kommet hjem på en hverdag. Laver I noget sammen? Hver for sig?</li></ul></li><li>Hvad laver dine forældre? På arbejdet? I fritiden?</li><li>Er der noget dine forældre er rigtig gode til?</li></ul>Fritid<ul><li>Hvad laver du, når du ikke er i skole/går du til noget fast?</li></ul>Weekend og andre steder og ferier<ul><li>Når det er weekend, hvad kan du så godt lide at lave?</li><li>Tager du og din familie nogle gange steder hen? (Bibliotek, museum, udlandet, ferier, til sport…)</li></ul></td><td></td></tr>
</table>

| **Natur og teknologi** | **10 min** | |
|---|---|---|
| **Fokus:** Hvad laver de, med hvem laver de det, og hvad kan de især godt lide ved det, og hvor foregår det<br><br>**Øvelse**: Tre cirkler med ordene natur, teknologi og natur/teknologi. Plus tomme cirkler. De unge associerer og tilføjer ord.<br><br>- | **Øvelse 1**<br>Jeg har de her to cirkler med, hvor der står natur og teknologi. Når du hører ordene, hvad tænker du så på?**<br><br>**Naturen**<br>• Hvad er særligt interessant ved naturen?<br>• Nu har jeg fulgt jer i nogle uger og mens jeg har været her, så har I ikke været så meget ude i naturen. Er det ellers noget, I normalt gør eller er I mest på skolen? Kunne du lide det? Hvad kunne du særligt godt lide? Kunne du godt tænke dig mere af det? (Hvis de slet ikke gør, så spørg om, det er noget de kunne tænke sig)<br>• Interesserer du dig for natur? Er det vigtigt for dig?<br><br>**Teknologi**<br>• Hvad er særligt interessant ved teknologi?<br>• Jeg har set at i ret ofte anvender computer i løbet af skoledagen. Er du glad for det? Synes du, at du er god til det?<br>• Har du sammen med skolen besøgt et sted, hvor der arbejdes med teknologi?<br>• Er det vigtigt for dig?<br><br>**Profilbilledet:**<br>Forstil dig, at det er dig på profilbilledet. Nu vil jeg gerne have dig til at placerer cirklerne så det du synes er interessant er tættest på billedet og det du synes er mindre interessant er længere væk.<br><br>**Ekstra cirkel hvor der står natur/teknologi** | *to øvelser: 1) Barnet placerer deres egne cirkler ved de to temaer. 2) barnet placerer dem ved profilbilledet.<br><br>** Her kan de vælge at tegne og skrive. De kan gøre det selv, og vi kan hjælpe dem med at gøre det.<br><br>Hvis de har svært ved at associerer til ordene, så hjælp dem:<br><br>2) Tag udgangspunkt i noget de har fortalt indtil nu og hjælp dem i gang f.eks. hvis de har fortalt om gaming kan man bruge det: ’Nu fortalte du om at spille computer før, det tænker jeg selv kan have noget med teknologi at gøre...’<br><br>Husk at få dem til også at lægge de tre brikker med natur og teknologi i forhold til sig selv. Gerne efter de cirkler de selv har |

<table>
<tr><td></td><td></td><td>skrevet, hvis de selv starter med dem.</td></tr>
<tr><td>Skole og natur/teknologi</td><td>10 min</td><td></td></tr>
<tr><td></td><td>Hvordan synes du, det er at gå i skole?<br><br>• Er der nogle fag du især godt kan lide? Hvorfor?<br>• Er der nogle fag, du især er god til?<br>• Er der noget der er svært i skolen? Hvorfor?<br><br>Hvordan tror du, at lærerne gerne vil have, at I er elever på i klassen? Kan du være elev på den måde?<br><br>Naturfag<br>Nu har jeg fulgt jer i nogle uger og været med i jeres undervisning bl.a., når I har haft natur/teknologi.<br><br>Jeg tænker, om du ikke kan prøve at fortælle mig, hvorfor du tænker, I skal have natur/teknologi?<br><br>• Kan du huske en time i natur-teknologi, du særligt godt kunne lide? Hvad var det, du især godt kunne lide?<br>• Hvad var det læreren gjorde for at det var sjovt?<br>• Hvordan skal man være i din klasse for at være god til natur-teknologi?<br>    o Hvordan passer det med dig?<br>Hvad synes du, om den måde jeres lærer underviser på?</td><td></td></tr>
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<tr><td></td><td>Hvis du kunne bestemme en time i natur/teknologi, hvad skulle I så lave?<br><br>Nysgerrighed og undersøgende adfærd<ul><li>Bliver du tit nysgerrig eller undres over det I lærer i natur/teknologi?<ul><li>Hvad kan få dig til at stille spørgsmål i natur/teknologi?</li><li>Hvad får dig til at blive nysgerrig på noget?</li><li>Hvor finder du svar?</li></ul></li></ul>Klassen<br>Hvordan vil du beskrive din klasse?<br>Synes du, I er gode til at hjælpe hinanden i klassen?<br>Hvordan vil du beskrive den i forhold til n/t?<br><br>Kan du godt lide det lokale I er i, når I har n/t?<br><br>Snak med forældre om skole<ul><li>Taler du med dine forældre om det du laver i skolen? fagene, lærerne, kammeraterne, oplevelsen af hvad der spændende osv.</li><li>Taler du med dine forældre om, hvad I laver i natur/teknologi?</li></ul></td><td></td></tr>
<tr><td>Sammenhæng mellem fagene</td><td>7 min</td><td></td></tr>
<tr><td>Fokus: Sammenhæng mellem fagene</td><td>Overlap mellem det de lærer i n/t og de andre fag<ul><li>Kan du nævne noget fra n/t, som hænger sammen med noget af det I laver i de andre fag?</li><li>Er der nogle ting I lærer i de andre fag, som kan bruges i n/t?</li></ul></td><td></td></tr>
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<tr><td></td><td>Naturvidenskab<ul><li>Hvad tænker du på når du tænker naturvidenskab?</li></ul></td><td>Hvis jeg havde skrevet naturvidenskab i en cirkel, hvad får det dig så til at tænke på?</td></tr>
<tr><td>Drømme og Fremtiden</td><td>7 min</td><td></td></tr>
<tr><td></td><td><ul><li>Hvorfor tænker at du skal gå i skole?</li></ul>7. klasse og fremtiden<ul><li>Efter sommer så skal du i 7. Klasse er det noget du ser frem til? Er der noget, du særligt glæder dig til?</li><li>I 7. Klasse skal I have fag som kemi, fysik, geografi og biologi, er det nogle fag du glæder dig at få (uddyb efter svar).</li><li>Hvad tror du, at du kommer til at lære i kemi, fysik, geografi og biologi?</li></ul><ul><li>Når nu du ikke skal gå i skole mere, hvad vil du så gerne lave?<ul><li>Hvor har du hørt om det? Kender du nogen der laver det?</li></ul></li></ul></td><td></td></tr>
<tr><td>Afrunding</td><td></td><td></td></tr>
<tr><td></td><td><ul><li>Er der noget andet du gerne vil sige inden vi slutter?</li><li>Er der noget du gerne vil spørger mig om?</li></ul></td><td></td></tr>
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**Interviewguide til 7. klasse**

| **Introduktion** | | |
|---|---|---|
| Skitser projektet | Projektet<br>● Som du ved, så handler mit projekt om, hvad I unge mennesker synes er spændende og interessant særligt her i skolen.<br>● Jeg bruger det til i samarbejde med lærere at blive klogere på den undervisning I bliver tilbudt i naturfagene.<br><br>Interviewet<br>● Der er ingen rigtige svar og jeg vil bare gerne vide, hvad du synes og tænker om de ting jeg spørg om.<br>● Jeg har et papir med spørgsmål, det er ikke hemmeligt det der står, du må gerne se. Det er blot så jeg kan huske hvad jeg gerne vil spørge om.<br><br>Anonymitet og indberetningspligt<br>● Det du fortæller mig kommer til at være anonymt. Det betyder, at jeg ikke fortæller det videre til dine forældre, lærere eller søskende. Det er kun mig og min vejleder, der ved det, du fortæller.<br>● Det er kun hvis du fortæller noget, hvor jeg tænker at du har brug for hjælp, så bliver jeg nødt til at sige noget, men så er det noget jeg aftaler med dig først. | |
| **Hvordan er det gået siden sidst?** | | |
| Uformel opstart | Vi begynder med, at de lige kan få lov at fortælle, hvordan det er gået siden sidst.<br>- Ny interesse(r)? | Tjek interview i forhold til det de har fortalt med interesser. |

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| | - Sommerferien/efterårsferien, hvad har de lavet og med hvem? | OBS: hvis de har fortalt noget nyt, mens jeg har været på skolen, så husk det. |
| **Skolen** | | |
| **Fokus**: på at de er begyndt i 7. klasse, hvordan er det? | **Generelt:**<br>Kan du ikke fortælle mig, hvordan det er at være 7. klasses elev?<br>*Oplever du, at der er nogle nye forventninger til dig*<br><br>Hvad oplever du, som den største ændring fra 6. klasse til 7. klasse?<br><br>*I har fået nye klasser, hvordan er det?*<br><br>Kan du huske, at du sidste år fortalte mig at dine yndlingsfag var (indsæt) er de stadig det?<br>➔ Hvis det stadig er, hvorfor? Og har noget ændret sig?<br>➔ Hvis ikke, hvorfor? Har noget ændret sig? | Tjek, hvad yndlingsfagene er. |
| **Overgangen fra n/t til naturfagene** | | |
| Indledning til at begynde at fokusere på at de har fået kemi/fysik, geografi og biologi | **Overgangen:**<br>Noget af det, jeg er særligt interesseret i, det er jo naturfagene. Et af de naturfag, I har her på skolen er natur/teknologi, som ikke har mere, nu har I i stedet biologi, kemi/fysik og geografi. Vil du ikke fortælle mig, hvordan det har været at gå fra at have n/t til at have biologi, geografi og fysik/kemi.<br><br>Er der noget, af de I lavede i natur/teknologi, som du kan genkende i et eller flere af fagene? | **OBS:** Cirkel med fagene - Cirklerne er printet ud, hvor der står de fire naturfag. Bruger dem som visualisering. |

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| | Er der noget, du har lært i natur/teknologi, som du kan bruge i et eller flere af fagene?<br><br>Jeg tænker, om du ikke kan prøve at fortælle mig, hvorfor du tænker, I skal have de her tre nye fag. Så, hvis nu vi begynder med (udpeg cirkler) | |
| **Fysik/kemi** | | |
| | Nu har jeg fulgt jer i nogle uger og været med i jeres undervisning bl.a., når I har fysik/kemi<br><br>Kan du huske en time i fysik/kemi, du særligt godt kunne lide? **Hvad var det, du især godt kunne lide?**<br><br>Hvad var det læreren gjorde for at det var sjovt?<br><br>Når jeg er med i undervisningen, så har jeg set, *at I laver forsøg*, *I får tavle undervisning og så løser i opgaver*, hvad kan du bedst lide? Hvorfor?<br><br>Hvad synes du, om den måde jeres lærer underviser på?<br><br>Hvordan skal man være i din klasse for at være god til fysik/kemi?<br><br>Hvordan passer det med dig? | Her skal de tegne. Så mens vi taler om fagene, så kan de tilføje.<br><br>Vi begynder med at tegne, så kan de nemlig få lov at sætte dagsorden. |
| **Biologi** | | |
| | Nu har jeg fulgt jer i nogle uger og været med i jeres undervisning bl.a., når I har biologi | |

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| | Kan du huske en time i biologi, du særligt godt kunne lide? **Hvad var det, du især godt kunne lide?**<br><br>Hvad var det læreren gjorde for at det var sjovt?<br><br>Når jeg er med i undervisningen, så har jeg set, *at I får tavle undervisning, I læser højt, løser opgaver og I har også set film* hvad kan du bedst lide? Hvorfor?<br><br>Hvad synes du, om den måde jeres lærer underviser på?<br><br>Hvordan skal man være i din klasse for at være god til biologi?<br><br>Hvordan passer det med dig? | |
| **Geografi** | | |
| | Nu har jeg fulgt jer i nogle uger og været med i jeres undervisning bl.a., når I har Geografi<br><br>Kan du huske en time i Geografi, du særligt godt kunne lide? **Hvad var det, du især godt kunne lide?**<br><br>Hvad var det læreren gjorde for at det var sjovt?<br><br>Når jeg er med i undervisningen, så har jeg set, *at I får tavle undervisning, I læser højt, I laver forsøg*, hvor I bl.a. er udenfor og løser opgaver, hvad kan du bedst lide af det? Hvorfor?<br><br>Hvad synes du, om den måde jeres lærer underviser på? | |

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| | Hvordan skal man være i din klasse for at være god til geografi?<br><br>Hvordan passer det med dig? | Afslut med tegning, hvordan deres lærer ser dem. |
| **Overlap mellem fagene** | | |
| | Er der noget, du tænker, de her tre fag har tilfælles?<br>Overlap mellem naturfagene og de andre fag?<br><br>Giver det mening for dig at I har de her fag, er der et af de her fag, du oplever, du kan bruge mere end de andre. | |
| **Naturfagene som film** | | |
| At skifte fokus: Efter at have læst art-artiklen igen, blev jeg lige mindet om, at vi nævner det her begreb om defamiliarisering, hvordan det at vende tingene en smule på hovedet kan være med til at forstå, se og tænke anderledes over noget, som er blevet selvfølgeligt i vores hverdag. | Okay, vi skal lave noget sammen nu, du og jeg, jeg har ikke prøvet det før, men jeg er nysgerrig på, om det måske kunne være lidt sjovt. Hvis nu, kemi/fysik var en film, hvilken slags film, vil det så være?<br><br>Filmens genre, filmens karakterer, hvilken rolle ville du have? | |
| **Refleksion/nysgerrighed/læring** | | |
| På baggrund af feltarbejde og interviews med lærerne dukker nogle bestemte ord op, dem kunne jeg godt tænke mig at høre elevernes forståelse af. | Hvad vil du mene, det betyder at være reflekterende? Oplever du, at du kan være reflekterende i naturfagene? | |

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| | Hvad vil du mene, det betyder at være nysgerrig? Er nysgerrighed noget, du oplever i naturfagene?<br><br>Hvad vil du mene, det betyder at være undersøgende? Oplever du, at du være undersøgende i naturfagene? | |
| **Fremtiden** | | |
| Afslutter kort med at spørge indtil det de fortalte sidst om fremtiden. Er det stadig drømmen eller om det ændret sig. | | Hvad ville de gerne være, tjek interviews. |
| **Afslutning** | | |
| | Er der noget, du synes jeg mangler at spørge om?<br><br>Er der noget, som du gerne vil spørge mig om? | |

| **Introduktion** | | |
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| **Baggrund** | | |
| Fokus: hvorfor er de endt som naturfagslærer. | Vil du ikke til at begynde med fortælle lidt om dig selv? Bl.a. hvad der har gjort, at du er blevet naturfagslærer? (Er der noget af det, som har ledt dig henimod at blive naturfagslærer?)<br><br>*Uddannelsessted* | |
| **Undervisning udefra** | | |
| Fokus: set udefra | Hvad er det bedste ved at undervise i …<br><br>Hvordan ser du naturfagene i forhold til de andre fag?<br><br>Hvad synes du, det er naturfagene tilbyder? | |

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| | Hvad synes du, er det overordnet mål med at undervise i naturfagene? Og her tænker jeg ikke på den politiske agenda for faget, men det du finder vigtigst.<br><br>Hvilke udfordringer ser du, når det kommer til at undervise i naturfagene? | |
| **Undervisning indefra** | | |
| | Hvis du skulle beskrive en undervisningsgang i (indsæt fag), du synes er god, hvordan ser den så ud?<br>- Hvordan oplevede du eleverne i den undervisning?<br><br>Hvornår oplever du, at have elevernes opmærksomhed?<br>- Hvad tror du, at der gør det?<br><br>Hvilke emner oplever du, at eleverne finder særlig interessante?<br>- Det mest spændende/sjoveste i (indsæt fag)<br><br>Er der emner, hvor det er svært engagere eleverne? Hvorfor?<br><br>Hvilke elever/elevtyper oplever du passer bedst ind i (indsæt fag)?<br>- Hvorfor tror du, at de elever er nemmere at engagere?<br><br>Hvilke elever/elevtyper oplever du har størst udfordringer med naturfagene?<br><br>Hvad oplever du at faget er bedst til, når det kommer til at understøtte elev-interesser og elev-præferencer?<br><br>Hvad oplever du som særligt udfordrende ved naturfagsundervisningen? | |

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| | Er der undervisningsformer, materialer eller elementer ved undervisningen som understøtter nogle elever bedre end andre? | |
| **Undervisningsmateriale(r)** | | |
| | Hvilke overvejelser gør du dig om planlægning af din undervisning?<br>- Hvad tænker du, om det undervisningsmateriale I har adgang til i naturfagene?<br><br>Anvender I andre undervisningsformer end det jeg har set, når jeg observerer? | |
| **Skolen** | | |
| | Ud over de undervisningsforløb jeg har observeret, arbejder du så med andre formater? Ud af skolen, konkurrencer etc.<br>- Har I deltaget i nogle naturfaglige konkurrencer?<br><br>Hvordan oplever du skolens holdning til faget – såsom aktiviteter, hvor der er fokus på naturfagene<br>- Herunder muligheden for at spare med de andre naturfagslærere?<br><br>Har I haft gæster udefra, der arbejde med naturfaglige problematikker | |
| **Fremtiden** | | |
| | Hvis nu du kunne spå fremtiden, tror du så naturfagene vil have samme betydning, som den du har beskrevet eller tror du, at fagene vil have en anden betydning? | |