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BODIES IN SCIENCE EDUCATION

A VIDEOGRAPHIC STUDY

BY
LIV KONDRUP HARDAHL

DISSERTATION SUBMITTED 2019

AALBORG UNIVERSITY
DENMARK

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Dissertation submitted

.

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CV

Liv Kondrup Hardahl graduated with a Master of Arts in Learning and Innovative Change from Aalborg University in 2009. She also holds a bachelor in English, Language and International Studies from Aalborg University, which she graduated in 2006. In 2012 she started working at Aalborg University at the Faculty of Medicine and Health, first as an external lecturer, and since as an research assistant. In 2012, she began her Ph.D. project. In 2015, Liv changed her workplace from Aalborg University to University College Absalon, Center for Social Education, but maintained her collaboration with Aalborg University regarding her enrollment as a Ph.D. student.

In 2014, Liv participated in a summer school in Helsinki, Finland, organized by the Nordic Centre of Excellence JustEd, part of the NordForsk programme “Education for tomorrow”. The visit provided a platform for collaboration, and resulted in a contribution to a book called “Troubling Educational Cultures in the Nordic Countries”, which was published in 2017.

Liv supervised many student projects and taught a number of courses within humanities in the sports sciences program at Aalborg University. At University College Absalon she maintained a focus on health related courses, while extending her teaching in learning and didactics to encompass subjects such as pedagogy, early childhood education, and inclusion. The involvement in these areas initiated a collaboration with Louise Hvitved Byskov, which resulted in a publication concerning the role of communities for student participation in school; this will be published in 2019.

In 2017, Liv visited Stockholm University, Department of Mathematics and Science, to collaborate with Professor Per-Olof Wickman. The visit resulted in a collaboration on an article with Per-Olof Wickman and Cecilia Caiman, which is in process.

ENGLISH SUMMARY

In Denmark, there has been a growing interest both publicly and politically in the benefits of physical activity on learning. In 2014, this interest was manifested in an act mandating schools to ensure an average of 45 minutes of exercise and movement per day. This includes being physically active outside of dedicated physical education classes, including in subjects like science. Most research concerning the benefits of movement for learning has conceptualized movement as physical activity and studied the effects of moving more in relation to measurable psychosocial and cognitive effects. Little is known about the pedagogical implications of the mandate, and how the integration of movement becomes meaningful within subjects that are not physical education. Few studies indicate that upper primary can be a segment of schooling particularly difficult to integrate movement into, identifying students' experiences and feelings about being physical as a challenge. The main focus of this dissertation is thus the students' subjective experiences about being physically active in upper primary science education. The dissertation is hereby also a contribution to a field that we have limited knowledge of.

In this article-based dissertation, I explore what it means to integrate physical activity into a Year 8 physics class. I chose to focus on science education, as this has been identified as a school subject that has a history and culture of separating body and mind. An embodied science education pedagogy would require that learners and teachers consider new types of approaches to integrate and work with bodily experiences. French philosopher Maurice Merleau-Ponty, American pragmatist Richard Shusterman, and Canadian sociologist Erving Goffman inspire the study's theoretical framework. The aim is to explore how movement is conceptualized, how it can be made part of an embodied pedagogy, and how this kind of pedagogy is experienced. This research focus therefore foregrounds the voices of both teachers and students. The dissertation is a videographic study (ethnographic research utilizing video data) and followed, in particular, a science unit about light and sound and a double lesson on ions. In addition, teachers were interviewed. In my analysis, I have focused on two aspects: 1) how students experience an embodied pedagogy in science; and 2) how teachers can work with an embodied pedagogy in science education. In addition to the analysis of the empirical data, I also posed a methodological question, since the examination of embodiment in science education is a complex endeavor. As such, this study also examined: 3) how an embodied pedagogy in science education can be researched.

The findings from the investigation show that teachers may plan for certain movement to afford particular embodied experiences, yet these intentions can be challenging to realize in the science classroom. First, students usually experience embodied learning as tacit content; that is, embodied knowledge that cannot be easily transformed into (scientific) language. As such, embodied pedagogy in science education can present

difficulties in connecting embodied with verbalized ways of knowing. Second, utilizing an embodied pedagogy in science education also challenged students' notions about how to learn in science. In some cases, this was a welcome break, but for others, embodied learning seemed irrelevant and disorganized. Third, anticipating or engaging in physical activities are emotional experiences where students have to decide how much risk is associated with being physically active in front of others. Fourth, the traditional context for being physically active at school – physical education or sport class – shapes students' emotional expectations. These experiences carry ideals of performativity that are transferred into the context of the science activities, and thus influence how this engagement is interpreted.

This study also revealed that science education holds many opportunities for including an embodied pedagogy, and that the body can be utilized in diverse ways to learn science ideas and provide embodied experiences of scientific phenomena. Utilizing an embodied pedagogy provides new ways of exploration and shifts perspectives on where and how science can be explored beyond the confines of the classroom. This study identified four aspects that stood out as central to how teachers can develop an embodied pedagogy in science education. First, by identifying an embodied pedagogy that is more than including movement into teaching and learning. It involves careful consideration about the embodied experiences that can be experienced and created. Second, an embodied pedagogy needs to consider that people experience the world through their body in different ways, and this makes it very difficult to plan for the same kind of embodied learning experiences. An embodied pedagogy approach will need to find opportunities to talk about these different experiences and what value they add. Third, an embodied pedagogy will require that teachers and students relearn how to learn through their whole body and what it adds to their experiences. Fourth, teachers need to integrate these aspects into their planning, so they are better prepared to implement this into their everyday teaching and are prepared to explain this to their students since this is not necessarily how students have been taught to learn in science.

Finally, this study demonstrated how an embodied pedagogy can be researched through adopting a theoretical framework that sheds light on the inherently embodied and social condition of perception and action. Yet, while a theoretical framework allows close examination of embodied meaning-making, actually capturing such situations is not without difficulty. It is challenging because such deeply personalized and contextualized meanings can be hard to access, and potentially involve sensitive situations. The study found that video observations were an invaluable data since videos captured situated embodied processes. Video recordings had to be supplemented with the emic perspectives of the observed students to better interpret and, where needed, adjust researcher interpretations and validate findings.

Overall, the findings suggest that the embodied identities of students should be given much more attention to identify how the integration of movement into teaching and learning can be achieved. Recognizing the integration of movement is about more than ‘just’ making students move. It involves considerations of the subjective experiences of those involved and understanding that this impacts on what is taught and learned. An embodied pedagogy in science education could help in devising more body-sensitive policies and teaching strategies that create opportunities for all students to enjoy the affordances of including the body into teaching and learning.

DANSK RESUME

I Danmark har der været en voksende offentlig og politisk interesse i fordelene af fysisk aktivitet for læring. I 2014 manifesterede denne interesse sig i et lovkrav, der pålagde skoler at sikre gennemsnitlig 45 minutters motion og bevægelse om dagen. Størstedelen af forskningen vedrørende fordelene af fysisk aktivitet for læring har begrebsliggjort bevægelse som fysisk aktivitet og studeret effekterne af bevægelse i relation til målbare psykosociale og kognitive effekter. Der er kun begrænset viden om de pædagogiske implikationer af lovkravet, og hvordan integrationen af bevægelse bliver meningsfuld i andre fag end idræt, mens der er endnu mindre viden om elevers oplevelser af bevægelse. Der er få studier, som indikerer, at udskolingen er blandt de dele af skolen, hvor det er særligt svært at integrere bevægelse, og som har identificeret elevernes oplevelser og følelser omkring bevægelse som en udfordring. Hovedfokus i denne afhandling er elevernes subjektive oplevelser af det at være fysisk aktiv i folkeskolens udskoling. Afhandlingen er dermed også et bidrag til et felt, der er begrænset viden om.

I denne artikelbaserede afhandling udforsker jeg, hvad det betyder at integrere fysisk aktivitet i fysikundervisningen i en folkeskole i 8. klasse som en del af udskoling. Jeg har valgt at fokusere på naturfagene, da de historisk og kulturelt set kan identificeres som et af de fagområder, der har adskilt krop og sind. En kropsligt orienteret pædagogik i naturfagene kræver imidlertid, at elever og lærere overvejer nye tilgange til at integrere og arbejde med kropslige oplevelser. Den franske filosof Maurice Merleau-Ponty, den amerikanske pragmatiker Richard Shusterman og den canadiske sociolog Erving Goffman inspirerer dette studies teoretiske ramme. Mit formål er at udforske, hvordan bevægelse begrebsliggøres i en naturfagskontekst i udskolingen, hvordan en kropslig pædagogik egentlig ser ud, og hvordan denne form for pædagogik opleves af eleverne. I afhandlingen er fokus derfor både på elevernes og lærernes stemmer. Afhandlingen er et videografisk studie (etnografisk forskning, der anvender videodata), som følger et bestemt naturfagsforløb om lys og lyd, og en dobbelt lektion om ioner. I tillæg dertil blev udvalgte lærere også interviewet. I min analyse har jeg fokuseret på to aspekter: 1) Hvordan eleverne oplever en kropslig pædagogik i naturfagene; og 2) Hvordan lærere arbejder med en kropslig pædagogik i naturfagene. Som supplement til analysen af den empiriske data har jeg også stillet et metodologisk spørgsmål, siden undersøgelser af kropslighed i naturfagene er en kompleks bestræbelse. Derfor undersøger denne afhandling også, 3) Hvordan en kropslig pædagogik i naturfagene kan undersøges.

Resultaterne af denne undersøgelse viser, at lærere planlægger bestemte bevægelser i undervisningen som afsæt for at give eleverne særlige kropslige oplevelser, men at disse intentioner kan være svære at realisere i naturfagslokalet. For det første oplever eleverne for det meste kropslig læring som et tavst indhold; det vil sige en kropslig viden, som kan være svær at omforme til (videnskabeligt) sprog. Som sådan kan en

kropslig pædagogik i naturfagene afstedkomme vanskeligheder med at forbinde kropslige måder med verbale måder at vide noget. For det andet udfordrer brugen af en kropslig pædagogik elevernes forståelse af, hvordan man lærer i naturfagene. I nogle tilfælde præsenterer bevægelse en velkommen pause, mens det for andre opleves som irrelevant og uorganiseret. For det tredje er forventningen om eller deltagelsen i fysiske aktiviteter en følelsesladet oplevelse, hvor eleverne må afgøre, hvor stor en risiko der er forbundet med at være fysisk aktiv foran andre. For det fjerde den traditionelle kontekst med hensyn til at være fysisk aktiv i skolen – idræt eller fritidssport – former elevernes følelsesmæssige forventninger. Deres erfaringer med bevægelse præges af performative idealer, som bæres med ind i naturfagskonteksten, og den påvirker, hvordan elevernes engagement tolkes af andre elever.

Dette studie afdækker også, hvordan naturfagene rummer et væld af muligheder for at inkludere en kropslig pædagogik – at kroppen kan bruges på mange måder til at lære naturfagenes ideer og tilvejebringe kropslige erfaringer af naturfænomener. Brugen af en kropslig pædagogik skaber nye måder at udforske på og skifter perspektiv til, hvor og hvordan naturfagene kan udforskes ud over klasselokalets grænser. Dette studie identificerer fire aspekter, der fremstår som centrale for den måde, lærere kan arbejde med og udvikle en kropslig pædagogik i naturfagene. For det første: er en kropslig pædagogik andet og mere end at inddrage bevægelse i undervisningen. Det involverer følsomme overvejelser over de kropslige erfaringer, der skabes og opleves i undervisningen. For det andet: bliver en kropslig pædagogik nødt til at forholde sig til, at mennesker oplever verden forskelligt gennem deres kroppe, og at dette gør det meget svært at planlægge for ensartede kropslige læringsoplevelser. En tilgang, der bygger på en kropslig pædagogik, bliver nødt til at finde måder at italesætte disse forskellige oplevelser, og hvilken værdi de har. For det tredje: kalder en kropslig pædagogik på, at lærere og elever (gen) lærer, hvordan man lærer gennem hele kroppen, og hvad det bidrager med til deres oplevelser. For det fjerde bliver lærere nødt til at integrere ovenstående aspekter i deres planlægning, således at de er klædt på til at udmønte det i deres daglige undervisning og samtidig også er forberedte på at forklare det til deres elever, eftersom denne tilgang ikke nødvendigvis er den måde, eleverne tidligere er blevet undervist i at lære i naturfagene.

Slutteligt demonstrerer dette studie hvordan en etablering af en teoretisk ramme der belyser de gennemgående kropslige og sociale betingelser for perception og handling kan bidrage til at forske i en kropslig pædagogik. Til trods for brugen af en teoretisk ramme der tillader fingranskning af kropslig meningsskabelsesprocesser, er selve indfangelsen af sådanne situationer ikke uden besvær. Det er vanskeligt fordi sådanne dybt kontekstualiserede og personlige meninger kan være svære at få adgang til, og potentielt involverer følsomme situationer. Dette studie fandt at videoobservationer blev en uvurderlige datakilde, eftersom videoen var i stand til at indfange kropslige processer. Dog måtte videooptagelserne suppleres med emiske perspektiver fra de observerede elever for bedre at kunne fortolke og efter behov, justere forskerens fortolkninger, samt validere fund.

Overordnet set, tyder afhandlingens fund på at elevers kropslige identiteter fortjener langt mere opmærksomhed i forhold til at identificere hvordan integrationen af bevægelse i undervisningen kan lykkes. Der er behov for en anerkendelse af, at integrationen af bevægelse handler om mere end 'blot' at få eleverne til at bevæge sig. At lærerne gør sig overvejelser og omtanke for de subjektive oplevelser af de involverede, og forståelse for, at bevægelsen har betydning for hvad der undervises i og læres. En kropslig pædagogik i naturfagene kan bistå i udvikling af mere kropsligt sensitive politikker og undervisningsstrategier der kan være med til at skabe muligheder for alle elever til at udforske kroppens potentialer i undervisningen.

ACKNOWLEDGEMENTS

This dissertation is the culmination of seven years' work. In those seven years, I have become a researcher, a teacher, a mother of two, and a wife. I have changed work place; substituted sports science at a university with social education at a university college. I have travelled the world, experienced new cultures, and come to know new research fields. These encounters have shaped this dissertation, and would not have been possible without a number of people that I would like to thank.

To my supervisor, Professor MSO Kathrin Marie Otrel-Cass, I offer my deepest gratitude for her guidance and unwavering support in conducting this study. She has stuck with me throughout these seven years, which at times have resembled an obstacle course. My abilities as a researcher have grown through my work with her, and my insecurities lessened with her unconditional belief in me and in the study. I am grateful that she has opened up her network up for me, and pushed me to extend my views.

To the students and teachers with whom I conducted this research. Thank you for letting me in, sharing your experiences, and hearing your voices. I am grateful for your trust and that I was able to take part in your lives for a little while.

To my husband, Thomas, who never doubted that I could do this, even when I waivered. Thank you for always being there, and for knowing me the best. To my parents, for teaching me persistence and the value of hard work. To my sister and brother, who ground me and push me to always be real.

Per-Olof Wickman and Cecilia Caiman, I thank you both for making my visit in Stockholm so inspirational and fun. I have rarely enjoyed research so much, and I treasure our conversations. I am grateful to have had the opportunity to talk science education with both of you and for your interest in my project.

Dr. Siry, Dr. Johansson, and Dr. Brooks, thank you for taking time out of your busy schedules to review this dissertation, and to serve on my dissertation jury. I hope that this is the start of many research conversations to come.

I would also like to thank all my wonderful colleagues at Professionshøjskolen Absalon. I treasure the wisdoms, laughs and lunches we share every day. A special thanks to those of you in leadership positions, who have made sure that I was able to finish this dissertation without external funding. To my former colleagues at Aalborg University, and in particular those of you who shared my journey from Learning to HST, thank you for providing a fun and supporting working environment.

To my two beautiful children, Bjørn and Sigrid, Mom finally finished her big project. You are the light of my life, and the reason why I do this, so that you too will have teachers who provide safe spaces for exploring the world through your bodies.

Lastly, thanks to friends and family for accepting my absence and frustrations this past year. Thank you for your continued support over the seven years that it has taken me to complete this study. You continually show interest in my study without judgement, and have provided a safe space for sharing successes and perhaps most importantly, failures.

OVERVIEW OF DISSERTATION

This dissertation is based on the published or accepted research publications that are listed below.

A. Kristensen, L. K., & Otrel-Cass, K. (2017). Emotions - connecting with the missing body. In A. Bellocchi, C. Quigley, & K. Otrel-Cass (Eds.), *Exploring Emotions, Aesthetics and Wellbeing in Science Education Research* (pp. 165–185). Springer International Publishing. https://doi.org/10.1007/978-3-319-43353-0

B. Otrel-Cass, K., & Kristensen, L. K. (2017). Troubling an embodied pedagogy in science education. In T. Vaahtera, A.-M. Niemi, S. Lappalainen, & D. Beach (Eds.), *Troubling educational cultures in the Nordic countries* (pp. 69–91). London: Tufnell Press.

C. Kristensen, L. K. (2018). “Peeling an onion”: layering as amethodology to promote embodiedperspectives in video analysis. *Video Journal of Education and Pedagogy, 3*, 3. https://doi.org/https://doi.org/10.1186/s40990-018-0015-1

D. Kristensen, L. K., Caiman, C. & Wickman, P. O. (accepted). The body and the production of phenomena in the science laboratory: taking charge of a tacit science content. *Science & Education*

The dissertation consists of eight chapters. In chapter 1, I briefly introduce the dissertation, present my research question, and provide an overview of structure of the dissertation. In chapter 2, I introduce embodied pedagogy in the context of Denmark, where I contextualize the study and discuss the background for implementing mandatory exercise and movement in Danish schools. Chapter 3 explores how science education research has positioned the body in teaching and learning to position this study as well as explore arguments for including movement into science education. In chapter 4, I delineate the theoretical framework of this dissertation, while chapter 5 outline and discuss the methodology and methods of the study. This chapter also contains the summary of article C. Chapter 6 introduces the context of the study and present summaries of articles A, B and D. The chapter also contains analysis of previously unpublished data. In chapter 7, I discuss the findings, and in chapter 8, I present the conclusion, as well as implications and future research.

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"Scientific thinking, a thinking which looks on from above, and thinks of the object-in-general, must return to the "there is" which underlies it; to the site, the soil of the sensible and opened world such as it is in our life and for our body – not that possible body which we may think of as an information machine but that actual body I call mine, this sentinel standing quietly at the command of my words and acts."

(Merleau-Ponty, 1964, p. 160-161)

CHAPTER 1. INTRODUCTION

This dissertation is about an embodied pedagogy for science education. The work focusses on how teaching and learning that foregrounds movement can become meaningful in upper primary science education, in a context where teachers are mandated to integrate movement. The thesis also explores the tensions that develop when movement is made part of the pedagogical conceptualization for science education. This dissertation seeks to delineate what an embodied science pedagogy is or could be, and what it looks like in practice when teachers implement an embodied science pedagogy. This introduction presents on what grounds this topic was selected and describes to the reader how this thesis has been put together.

1.1. THE CASE OF MANDATED MOVEMENT

In the context of Denmark, there has been a growing interest both publically and politically in the benefits of physical activity on learning. Based on a general focus on children and young people’s health, and supported by a body of research that claims the positive potentials of physical activity on learning (Bailey et al., 2009; Bangsbo et al., 2016; Kunststyrelsen, 2011), the Danish government passed an act[1] in 2014 mandating schools to ensure an average of 45 minutes of exercise and movement per day (Regeringen, 2013). The intention is to get students more physically active and to create the conditions for healthier and better learning, and movement has been identified as an important pedagogical tool to fulfill these intentions. Since the mandate’s introduction schools and teachers across all subject fields (not only physical education) have taken to this challenge through different approaches (Rasmus Højbjerg Jacobsen, Andersen, & Jordan, 2016; Rasmus Højbjerg Jacobsen et al., 2017) to ensure that *all* students move *every* day.

Since the introduction of the mandate it has become part of teachers’ professional tasks to integrate movement into their teaching (Jensen, 2017b). Multiple national surveys show that this is challenging (Jacobsen, Flarup, & Søndergaard, 2015; Jacobsen et al., 2016, 2017) and teachers report a lack of knowledge about how they can integrate more exercise and movement into their subjects. In particular, teachers in upper-secondary primary school face challenges when it comes to incorporating movement in a meaningful manner that supports their particular subject teaching. They point to, on the one hand, the difficulties of connecting movement with learning as the content becomes increasingly complex, and on the other hand, using movement in a way that challenges and motivates the students. Furthermore, integrating movement also fades into the background as the students get older, both due to the role formal testing takes in the last years of primary education, but also due to the fact

[1] Law no. 747, §15

that young people at times feel embarrassed about being physical (Center for Ungdomsstudier, 2016; Jacobsen et al., 2017). That students' experiences and feelings have reportedly been identified as a challenge to integrating movement into teaching and learning, supports the focus in this project to study people's subjective perspectives on movement in school.

One argument for why teachers experience a lack of knowledge in terms of how to respond to the mandate may be located in the paucity of pedagogical research found in the arguments for the benefits of increased movement for learning. The research underpinning the mandate predominantly consists of intervention studies focusing on the implementation of physical activity seeking a causal relationship between movement and learning, conceptualized as process, intelligence, cognition, and academic performance (Jørgensen, 2017) and individual growth (Copenhagen Center for Team Sport and Health, 2016; Jørgensen, 2017; Kunststyrelsen, 2011). Yet, in practice, the operationalization of physical activity becomes too narrow for teachers to make sense of in their practice, where much broader conceptualizations of movement are in play (Jensen, 2018). According to Dumas and Anyon (2006), the classroom is a battlefield or a site of struggle, where educational policies necessarily undergo a process of transformation. This is also the case with this mandate, where teachers and students have to re-conceptualize what learning activities entail.

1.2. TEACHING AND LEARNING THAT INTEGRATES MOVEMENT

To talk about the broader pedagogical phenomena of integrating movement into teaching and learning, this study adopts the notion of an *embodied pedagogy*. Conceptualized slightly different across teacher education research (Forgasz & McDonough, 2017), an embodied pedagogy is a term that emphasizes the body as central for knowing, and thus also teaching and learning. While the mandate itself does not use the concept of an embodied pedagogy, it indicates the frame for such thinking, as it requires teachers to consider and conceptualize the role of the body for teaching and learning.

In approaching this research topic initial inspiration was found in the works of Latta and Buck (2008), who were drawing on Merleau-Ponty's phenomenology to argue that embodied teaching/learning

> "…assumes a teacher's relation to a teaching/learning situation is not that of a thinker to an object of thought. The classical distinctions of form and matter, subject and object, do not apply. Nor can the teacher be conceived as consciousness deliberately deciphering teaching/learning situations according to a pre-formulated plan. Rather, embodied teaching and learning is about building

> relationships between self, others, and subject matter; living in-between these entities." (p. 317)

Building on the premise that pedagogy is always inherently embodied and that embodiment should be the starting point of any account of teaching and learning, Latta and Buck (2008) direct attention towards the process of actual teaching/learning experience – towards the very bodily experiences and relations that constitute the manner in which learners come to know the world.

An embodied pedagogical perspective on mandated movement prompts the question about the kind of experiences afforded through such pedagogical initiatives, and how these experiences then become ways of knowing a subject.

1.3. A FOCUS ON SCIENCE EDUCATION

To ground the focus of an embodied pedagogy this study identified science education as the school subject field to investigate closer. Science education has a very strong culture of its own (McKinley, 2005), and integrating movement and the body into this subject is challenging for a number of reasons. Firstly, science has been identified as a school subject of economic importance, and closely coupled with scientific literacy, a thinking competency, to address the needs of technologically driven economy (Hodson, 2003). The implication of this is that science education emphasizes a very specific scientific knowledge and skills development (Hodson, 2003) and failing to echo such views counters the economic value placed on – and educational response to – international testing such as PISA (OECD, 2010). Secondly, what it means to infuse teaching and learning with movement and body is particularly interesting, for science education that is still shaped by "the Cartesian split that separates mind from the world and the body from the mind" (Roth, 2011, p. 85). Hence adopting a focus on learning that considers embodied dimensions requires a changed emphasis for learners, teachers, and researchers to consider the type of dialogue necessary to understand bodily experiences (Arvola Orlander & Wickman, 2011).

Research related to embodiment, bodies, or movement in science education has predominantly focused on the body as foundational for learning, with little attention paid to how students come to experience and make sense of the body and movement. Yet with the increased focus on including movement also in science classrooms, it is necessary to understand what explicit integration and/or foregrounding of movement in science may look like.

1.4. OBJECTIVES AND RESEARCH QUESTIONS

This dissertation is driven by an interest in the push for increased movement specifically in science education and what this means for the way in which science is taught and learnt. I am furthermore intrigued by what this approach to teaching and learning entails in upper primary, as reports (Center for Ungdomsstudier, 2016; Jacobsen et al., 2017) show that this is a segment of schooling particularly difficult to conceptualize and implement movement initiatives in. The aim of this dissertation is to study the social reality that unfolds in an upper primary science class for both teachers and their students where an embodied pedagogy is part of teaching and learning. This leads me to formulate the following overarching research question:

- *What does it look like when movement become part of the teaching in a Year 8 Physics class?*

The use of the phrase 'what it *looks* like' is deliberate since I intend to analyze observable classroom interactions as they unfold in the context of a school where mandated movement policies are part of everyday teaching and learning. Such an analysis examines how these science-learning activities situate the students, and how the students, through interaction with each other and the surroundings, make sense of the tasks. By asking what it looks like when *movement* becomes part of teaching, I moreover seek to examine how the idea of movement and its role for learning is conceptualized and transformed in the meeting between the subject of science education, the environment that it takes place in, and the students and teachers as embodied actors. On this basis, two sub-questions transpire:

1. *How do students experience an embodied pedagogy in science?*
2. *How can teachers work with an embodied pedagogy in science education?*

Since the examination of embodiment in science education is a complex endeavour this study also poses the question:

3. *How can an embodied pedagogy in science education be researched?*

1.5. STRUCTURE OF THIS DISSERTATION

This dissertation is organized into two parts. The first part contains eight chapters, and the second part comprises four articles.

Chapter 2, *Embodied pedagogy in the context of Denmark*, contextualizes the study and discusses the background to the Danish government's push to increase movement in primary schools. The chapter explores how movement is conceptualized both in the research that has inspired educational change and in the actual mandate for increased movement, and problematizes the diverging rhetoric and its implications for practice.

Chapter 3, *Bodies in science education research*, explores how science education research has positioned the body in teaching and learning. The different research presented in the chapter should highlight the diversity of approaches to conceptualizing the body and guide the reader through what literature arguments informed the theoretical and methodological framework for this study, as well as position this study within existing fields.

Chapter 4, *Theoretical framework*, delineates the theoretical framework that underpins this study. The aim of this study is to query how an embodied perspective may privilege what takes place in the classroom when movement is part of teaching and learning. The conceptualization of movement proposed in the framework in this chapter takes a point of departure in the philosophy of Maurice Merleau-Ponty, but is also inspired by pragmatist philosopher Richard Shusterman, and sociologist Erving Goffman, as well as others.

Chapter 5, *Methodological considerations*, presents the qualitative interpretative research methodology of the study, as well as the methods that consist of video observations and ethnographic fieldwork including interviews. In addition to detailing the data collected for the study, the methods, and the process of analysis, the chapter also presents a summary of article C (*"Peeling an onion": layering as a methodology to promote embodied perspectives in video analysis*) that presents the methodological framework utilized for video analysis used in this study.

Chapter 6, *Context and findings*, introduces the context of the study and situated features that became important to the way in which data was collected and interpreted. The chapter contains an overview of the data, before presenting summaries of three of the four articles (articles A, B and D) included in this dissertation, as well as additional previously unpublished findings.

Chapter 7, *Discussion*, responds to the three research questions and reflections on what may be learned from the findings and the significance of these in relation to the field.

Chapter 8, *Conclusion*, casts a final look back at this dissertation and its aims, to sum up the presented arguments about an embodied pedagogy in science education and its consequences for teachers and students. The chapter presents the implications and limitations of the study to guide future research in this area.

1.6. BRIEF REFLECTION ABOUT USING THE WORD 'BODY'

In this dissertation, I often use the term 'the body' or 'bodies' as a way of talking about students' embodiment. It would be much more correct to just talk about students since talking about 'bodies' may appear distant to the actual people I am interested in. By using the term 'body' my intention is to draw (my own and the readers') attention to the dualistic accounts that report the separation between the mind and body. My intention is to maintain an embodied perspective and think about the consequences of being embodied in science. Inspired by Alsop (2014), I prefer to use the term body, because the term offers multiple opportunities to connect with dominant narratives and imaginaries within science education. Moreover, my preference for the term body allows explorations of the sensual, emotional, and fleshy connotations of the term, which are easily lost when talking about the student or the student self as an abstract ephemeral state. Despite the potential of creating an alienating feeling when referring to 'bodies', I also think that there is a potential of losing sight of the body if I only talked about students. To remind myself and the readers that I am dealing with people and their experiences and how they feel about their embodied selves, I write about *students* and *students' bodily* or *embodied experiences*, as a way to stress the livedness of the 'body' and 'bodies' I studied in this research.

CHAPTER 2. EMBODIED PEDAGOGY IN THE CONTEXT OF DENMARK

This dissertation examines what it looks like when an embodied pedagogy is made part of teaching and learning in science education. In order to come closer an understanding of what an embodied pedagogy means in the broader context of education in Denmark, this chapter addresses the role granted to body, embodiment, and movement in primary schools by researchers and politicians shaping educational policy. The chapter begins by exploring the research foundation prompting an enhanced awareness of the benefits of increased movement in schools, before discussing an example of how such research has inspired educational change in Denmark in the form of mandated movement in schools. The two dimensions provide grounds for identifying the challenges schools and teachers are faced with. The chapter concludes with a summary of the findings and points to the gaps in the literature that were identified as central to understanding and examining an embodied pedagogy in subject specific teaching and learning.

2.1. RESEARCH AS SOURCES OF INSPIRATION FOR EDUCATIONAL CHANGE

In the last 10 years there has been remarkable growth in the number of scientific publications and projects concerning movement in schools and how it is correlated to health, wellbeing and learning (see e.g. Howie & Pate, 2012). Such research is of relevance to this dissertation because it, on the one hand, has been used to argue for and substantiate the push for more movement into schools (Copenhagen Center for Team Sport and Health, 2016), but also because it has shaped the way in which teachers understand and conceptualize movement (Jørgensen & Troelsen, 2017).

In Denmark, two consensus conferences were held, in 2011 and 2016 respectively, where invited researchers met with the aim of building consensus around the effects of physical activity (Bangsbo et al., 2016; Kunststyrelsen, 2011). While the aim of reaching consensus amongst researchers may be critiqued for its focus on harmony on the expense of nuanced and critical perspectives, at the same time, the “complexity reducing” (Jensen, 2017, p. 81) approach may be the source of its political impact. That is, the recommendations published in the first consensus conference were picked up by politicians and brought about a greater focus on physical activity in the educational reform of 2014 (Copenhagen Center for Team Sport and Health, 2016), which is discussed in section **Fejl! Henvisningskilde ikke fundet.**. The two consensus conferences concluded that “there is a documented correlation between physical activity and learning regardless of age” (Kunststyrelsen, 2011, p. 5, authors own translation) and that “Physical activity before, during and after school promote children and young people's achievement in school" (Copenhagen Center for Team Sport and Health, 2016). Overall the kind of knowledge presented in the two consensus conferences was mainly representative of evidence-based research, which traditionally has not been well represented in pedagogy and educational research in Denmark, but gained a prominent role in recent years (Jensen, 2017a). The following section sketches out central research-based arguments for introducing more movement into everyday school life. In doing so, the section draws on a review by Jørgensen (2017), and includes references from both conference reports, as well as other studies since published.

2.1.1. PHYSICAL ACTIVITY AND HEALTH

The first theme concerns the effect of physical activity[2] (PA) on health. Research within this area claims a causal relationship between the low amounts of PA and the risk of developing what is broadly referred to as life-style diseases, such as type-2 diabetes, obesity and cardiovascular diseases (Lee et al., 2012). Despite this knowledge, activity levels of children and young people are reported to be generally decreasing, which is a trend reinforced as children grow older (Strong et al., 2005), resulting in the older students being the most inactive in the school (Rasmussen & Due, 2010). Furthermore, studies show that girls are generally more inactive than boys (Nielsen, Pfister, & Andersen, 2011) and that there is an increasing divide between children and young people who are physically fit and those who are not (Wedderkopp, Froberg, Hansen, & Andersen, 2004).

A number of intervention studies focus on physical activity in schools have examined the effects of different parameters related to physical health. It is well documented that interventions with PA in schools can increase children's levels of PA and health (van Sluijs, Mcminn, & Griffin, 2008). This is the case, whether looking at interventions concerning an increase in the number of hours of physical education (Klakk, Andersen, Heidemann, Møller, & Wedderkopp, 2014), emphasized focus on moderate to high physical intensity in the existing physical education (Lonsdale et al., 2013), movement integrated into subjects (Bartholomew & Jowers, 2011), movement as breaks in the subjects (Goh, Hannon, Webster, Podlog, & Newton, 2016), or movement as breaks, planned active recess, and physical exercise outside school (Erwin, Beets, Centeio, & Morrow Jr., 2014). Reviews furthermore show that interventions with multiple components, i.e. considering PA in various schools contexts such as PA in class, leadership, transportation to and from school and so forth, show more compelling evidence in terms of demonstrating a positive relationship between implementation of PA and health outcome (Naylor et al., 2015).

[2] Physical activity is generally defined as any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a resting level (Physical Activity Guidelines Advisory Committee, 2008)

The underlying premise for many of the above-mentioned studies is a concern that children and young people are less and less active in their private and school life. Despite the recognition of the centrality of increasing children and young people's bone and muscle strength in relation to being healthy (B. K. Pedersen & Andersen, 2011), the interventions generally aim at increasing students' physical activity levels (Jørgensen, 2017). That is, students should be physically active for longer periods during the school day, at moderate to high intensity levels.

2.1.2. PHYSICAL ACTIVITY AND WELL-BEING

Studies in general (outside the context of schools) show that PA can improve self-confidence, self-esteem, and self-image (Biddle & Asare, 2011), and reduce anxiety and depression (Brown, Pearson, Braithwaite, Brown, & Biddle, 2013). Self-esteem is furthermore negatively associated with sedentary behavior in children and young people, when looking at high levels of screen time compared with scores in psychological well-being and perceived quality of life (Suchert, Hanewinkel, & Isensee, 2015).

Studies in schools similarly show that physical activities can promote student psychological health (Käll, Malmgren, Olsson, Lindén, & Nilsson, 2015), as well as contribute to students' feeling of joy, goal orientation, and motivation during instruction (Howie, Newman-Norlund, & Pate, 2014) and develop positive social relations and friendships (de la Haye, Robins, Mohr, & Wilson, 2011). Studies considering how classroom based physical activity affects academic motivation (i.e. interest/enjoyment, perceived competence, effort, value, and pressure) show how students feel more competent and try harder when physical activity is integrated into lessons (Vazou, Gavrilou, Mamalaki, Papanastasiou, & Sioumala, 2012). However, no reference to particular subjects were identified in the studies.

The studies mentioned in the above, which are used to substantiate the integration of more movement are primarily interested in the psychosocial dimensions of well-being by considering factors such as self-confidence, self-esteem, self-image, and depression. Yet, while a positive correlation between physical activity and learning, well-being, and health might incite the idea that participation in movement is per definition always positive, PA in school have also been reported to have negative effects if the teachers are not attentive to whether the physical activities are of an including or excluding nature (Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-Ntoumani, 2011). It seems that activities have a positive influence on the students' well-being and motivation when the physical activities are connected with success (Dishman, Saunders, Motl, Dowda, & Pate, 2009), opportunities for self-determination, positive social relations, and perceived competency (Standage, Gillison, Ntoumanis, & Treasure, 2012), and with learning and improvement in favor of competition and performance (Bryan & Solmon, 2012). Such research raises a central point in noting how the benefits of PA are dependent upon the manner in which it is organized and perceived. In an article concerning the influence of exercise and movement for students' psychosocial health, well-being, and comfort, Ommundsen (2018) points to two potential contextual difficulties concerning initiatives to implement more movement at school. Firstly, the experienced significance of different sources of physical self-image is particularly relevant for girls, who, to a higher degree than boys, use exterior physical aspects such as looks, weight, and body shape as basis for their self-image. For this reason, there is a marked chance that young girls will experience a reduction of self-esteem. For example, studies show that inadequate social accept as a result of the emphasis of unattainable body ideals amongst peers is connected with a psychological strain in the shape of anxiety and depression (Haugen, Johansen, & Ommundsen, 2014). Increased physical activities could in such cases lead to a negative self-perception and reduced motivation to participate in exercise and movement because of this. Secondly, Ommundsen points to the role of social acceptance in young people's general self-perception (2018). Students who do not conform to popular norms and values for appearances, body shape, and weight are often at risk (Evans, Rich, Davies, & Allwood, 2005; Evans et al., 2017; Storch et al., 2007). A central challenge is thus that physical activities in schools are not value-free, but significant to the students practicing them and students who do not conform run the risk of stigmatization and exclusion (Ommundsen, 2018).

2.1.3. PHYSICAL ACTIVITY AND LEARNING

The last and third area, the connection between physical activity and learning, is perhaps the most prominent of the three, and has attracted a lot of attention, which is evident in the increase of publications during the last 10-15 years (Jørgensen, 2017). Learning is in these types of studies measured through multiple parameters, which is indicative of the complexity of the concept. Learning is here generally conceptualized as either intelligence, cognition, or academic success and performance. Intelligence is measured typically using intelligence tests, while cognition is measured by testing e.g. executive functions such as inhibition or work memory, and long-term memory. Academic performance is accessed based on grades, standardized tests, and teacher evaluations (Jørgensen, 2017). With regards to PA, the research distinguishes between acute effects of PA, such as on-task behavior or concentration, and sustained effects associated with repeated PA, such as final grades.

Reviews show positive correlations between PA and students' academic performance (e.g. Esteban-Cornejo, Tejero-Gonzalez, Sallis, & Veiga, 2015; Rasberry et al., 2011). The positive correlation pertains both to the integration of additional weekly physical education classes (Ericsson & Karlsson, 2014; Ericsson & Karlsson, 2011), the integration of movement into subject teaching and learning (Mullender et al., 2015; Nielsen, 2016), and the implementation of exercise-breaks during teaching (Howie, Schatz, & Pate, 2015). Despite these findings, there are also studies that have not been able to show a positive correlation between PA and academic performance, and the results are therefore still considered ambiguous, although no studies show a negative correlation. Interestingly it has also been reported that academic performance does not suffer when time is allocated away from other subjects towards more PA (Trudeau & Shephard, 2008).

When measured in standardized tests, studies show that students generally perform poorer as the school day progresses, and that breaks of 20-30 minutes can counteract the mental fatigue that will impact on academic performances negatively (Sievertsen, Gino, & Piovesan, 2016). Physical activity has a positive effect on student behavior and their ability to work with and focus on a tasks (Kibbe et al., 2011). Positive correlations are also found in studies indicating positive effects of exercise breaks in lessons (Carlson et al., 2015), integrated exercise into subjects (Riley, Lubans, Morgan, & Young, 2015), and PA before class (e.g. physical education, PA, and controlled recess activities) (Budde, Voelcker-Rehage, Pietraßyk-Kendziorra, Ribeiro, & Tidow, 2008) on executive functions, which are an indicator for behavior and improvement in relation to children's school readiness.

Increase of physical activities is positively associated with learning and academic performance, and is a strong argument for mandating the integration of more movement. Despite a prevailing uncertainty concerning which types of activity, the intensity and frequency that best supports learning (Hillman, Erickson, & Kramer, 2008), studies indicate that activities of moderate to high intensity (C. H. Hillman et al., 2009), that challenges coordination (Budde et al., 2008), or require cooperation and strategic thinking (Pesce, Crova, Cereatti, Casella, & Bellucci, 2009) are particularly effective in promoting students' executive functions. Yet studies also indicate that classroom-based PA should have a duration of max. 10 minutes to be positively related to students' academic performance and executive functioning (Howie et al., 2015).

2.1.4. SUMMARY

As it appears in the review, research shows that physical activity in school has a number of positive effects related to health, well-being, and learning. Yet the research also reveals a complexity that is important in terms of how this is picked up by schools wanting to support their students. The choice of activity, in terms of i.e. its duration, the quality and intensity of movement, or how it is organized, is important in terms of what students are afforded. If the desired goal for example is for the students to become healthy, then findings indicate that the activities need to be completed with moderate to high intensity, where the students increase their pulse and in doing so become breathless. However, if the goal is to support well-being, the activities should focus on providing opportunities for experiencing success, self-determination, the feeling of belonging, and perceived competency, while competition should be downplayed. This calls for considerations about differentiation and inclusion. Finally, research indicates that if the aim is to strengthen students' learning, the activities should be characterized by moderate to high intensity, challenge motility, promote cooperation, and last no longer than 10 minutes.

This section has considered the research foundation for considering more movement into schools. Some of the studies in particular and the research field in general has been used to substantiate a push for the integration of increased movement into Danish schools. The following section turns to a concrete example of how an increased awareness of the potential benefits of physical activity and movement has inspired educational change in Denmark.

2.2. MANDATED MOVEMENT IN SCHOOLS

The growing body of research (see e.g. Howie & Pate, 2012) supporting a positive relation between physical activity and learning has inspired politicians and interest groups who are looking for new ways to improve the education sector. As early as 2006 a prominent Danish politician and later minister of education, Christine Antorini, advocated for a more physically active school day, as a measure against child obesity, and related lifestyle diseases such as diabetes and thrombocyte, which was experienced as an increasing issue in Denmark at the time (Byrne, 2006, August 23). In 2012, after becoming minister of education, her arguments had changed slightly, now emphasizing the benefits of PA for learning, and other side effects such as increased self-esteem, less victimization, and stronger social skills and motivation (Villadsen, 2012, August 22). Her change in argument should be seen in relation to the 2011 consensus conference as discussed previously, which was organized by the Ministry of Culture's committee for sports research (KIF) and various sports organizations. The conference produced a number of conclusions[3], and in the report that was released following the conference a central message was that these conclusions should impact on how primary school teachers amongst others conduct their teaching (Kunststyrelsen, 2011). The conference had thus granted new arguments to politicians seeking to change the educational system, from a health-based discourse to now also encompassing well-being and learning.

The heightened focus on the benefits of PA led to a mandate for more movement in primary, secondary, and vocational schools, and in the case of primary schools this was manifested as part of a new school reform implemented in August 2014. In the

[3] The conclusions released after the consensus conference of 2011 read that: PA improved cognition; that PA could serve as a tool for positive development of mental, emotional and social processes; that PA increase the formation of transmitters that are part of promoting structural and functional changes in the brain; that learning is improved if the physical activity is challenging, varied and involves the feeling of success; that PA increase the brain resistance against cognitive deterioration caused by age and disease; and that PA integrated into teaching other than PE has shown to improve learning (Kunststyrelsen, 2011, p. 5).

political agreement text[4] (Regeringen, 2013), which constituted the bedrock for the wording in the educational reform, the parties identified three goals which were envisioned as contributing to improved educational outcomes for all students (p. 2, authors' own translation):

1. Challenge all students, and enable them to become the best they can be
2. Decrease the significance of social background on academic achievement
3. Re-establish confidence and trust through respect for professional knowledge and practice

In order to achieve this, three overall focus areas were identified as central to accomplishing the above goals (Regeringen, 2013a, p. 2, authors' own translation):

1. Schools days had to be longer and should be more varied, to support improved education and learning outcomes
2. Competency boost for teachers, pedagogues[5] and school leaders
3. There should be fewer learning goals and school rules should be simplified

Following the implementation of the new reform framework, a wide range of initiatives were rolled out. In relation to the first focus area, one such initiative was the implementation of increased physical activities into the school day. This initiative brought with it changes in the regulations, and resulted in a mandate that *"all students participate in physical exercises and movement[6] corresponding to an average of 45*

[4] The agreement text was signed in 2013 by a majority of the Danish political parties, including the Social Democrats, the Social-Liberal Party, the Socialist People's Party, the Liberal Party, and the Danish People's Party

[5] In Denmark, the term 'pedagogues' refers to early years' teachers who teach in day care centers or social institutions but also in primary schools, here primarily the years 0-3.

[6] In this dissertation, I use the English terms "exercise" and "movement" as respective translations for the terms "motion" and "bevægelse". According to the Danish Dictionary, "motion" is regular physical activity with the intent to maintain physical health ("Motion," 2018). Similarly, the word "exercise" denotes bodily exertion for the sake of developing and maintaining physical fitness ("Exercise," 2018). "Motion" or "exercise" thus carry the connotation of a form of movement that is physically demanding and more energy taxing than e.g. walking around leisurely, and has scientifically, historically, in the civil society as well as in pedagogic contexts been used to signify bodily activities of a certain intensity and in particular cultural senses (Jensen, 2014b). The Danish word "bevægelse" signifies a change of position or movement of the body ("Bevægelse," 2018). This corresponds to the English term "movement", which similarly denotes a change of place or position or posture of the body ("Movement," 2018). Movement-like exercise denotes a physical process, but unlike exercise, it does not signify necessarily a particular amount or intensity of effort. It this sense, it is a more

minutes a day" (law no. 747, §15, authors' own translation). The mandate argues that increased exercise and movement promotes health in children and young people, and supports motivation and learning in school subjects (Regeringen, 2013a, p. 6). With this, the mandate focusses on the effects from an increase of exercise and movement in schools (Jensen, 2014a), and adopts what Jensen (2018) terms an "instrumentalization" of movement (p. 245f).

Exercise and movement is envisioned to be implemented across the entire school day, across all subjects. In the agreement text (Regeringen, 2013), it was thus suggested that exercise and movement could be both small scale physical activities such as ball games and running and larger scale physical activities in cooperation with sports- or culture clubs, inviting e.g. the local skating club into the school to organize various activities. They furthermore suggested that exercise and movement could be utilized in the subjects to support the pedagogical work with the content (p. 6).

While the argumentation for the mandate often was based on evidence-based research results (Jensen, 2017a), the mandate itself shows a semantic shift in how movement is conceptualized. As evident in the wording of the mandate, there is a change in terminology from 'physical activity', which is the concept used in the research used to underpin the mandate, to a more generic description of movement as 'exercise and movement'. The change in terminology indicates, according to Jensen (2017), a transformation and contextualization of physical activities that in the world of evidence-based research is relatively objectively described. He notes that there is a difference between 'physical activity' and 'exercise and movement', and that 'physical activity' is a theoretical operationalization amongst researchers, while 'exercise and movement' is a practice in the school (Jensen, 2017). The difference between theoretical operationalization and practice is furthered by the tendency for schools to primarily talk about 'exercise and movement' as *only* 'movement' (Jensen, 2017a). This marginalizes 'exercise', which denotes health and a conceptualization of the body as something one *has* in favor of 'movement', which connotes a more pedagogical and phenomenological understanding of the body (Jensen, 2014b). The concept of movement opens for a more humanistic interpretation of body and movement, where subjective experiences become meaningful in questions pertaining to the education of the student (Jensen, Jørgensen, & Volshøj, 2017).

Putting the mandate into practice and making it part of everyday teaching and learning is therefore not a simple matter. Since the integration of movement activities became mandated across all subjects, teachers' professional task changed as they faced pedagogical challenges that forced them to implement new teaching strategies they

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generic term that applies to all expressions or changes in the body. However, more than just refer to the motility of the body, movement contains a double meaning, in that a person can also be emotionally moved.

were unfamiliar with (Jensen, 2015). Teachers have a defining influence on what takes place in the classroom, including the degree to which physical activities become part of teaching and learning, and this is shaped by a number of different factors relating to the individual teacher (Jørgensen & Troelsen, 2017). This means that factors that may influence planning at one school may not be present at another school. Furthermore, education takes place across a number of settings and situations in schools, and physical activity/movement has to be adapted to fit these spaces. The development of different typologies as tools for conceptualizing and integrating exercise and movement reflect this (see e.g. Ottesen, 2017; Sønnichsen, 2015). However, as a result of these factors, the implementation of the mandate was shaped by local interpretations (by municipalities, schools, professionals, and parents) in order to become a dynamic part of school life (Moos, 2017).

2.2.1. THE STATUS OF IMPLEMENTING MANDATED MOVEMENT

Physical activities have become part of the professional tasks of teaching in Danish schools, and teachers are faced with the task of interpreting and transforming this initiative into their daily school life. Since the onset of the reform in 2014, various reports have described the status of the reform in general and the process of implementing more movement in particular. This section builds on 10 Danish reports and one PhD thesis to show how the mandate of more movement has impacted on everyday teaching and learning. Emerging themes were identified and analyzed in this process, and the significance of looking at those selected texts was that they all examined the impact of the school reform.

An outcome study published in 2017, documenting the effects of the reform three years after the its introduction, showed a positive correlation between the use of exercise and movement in teaching and learning and students' academic and general well-being, as well as learning in Year 6. Exercise and movement was as such the reform element, which at the time of the study, documented the most unequivocal correlation with student learning (Jacobsen et al., 2017). Previous studies showed that mandated movement is an area where some of the biggest changes have occurred after the reform (Jacobsen, Andersen, & Jordan, 2016).

Teachers' and students' reported experiences (Jacobsen et al., 2017, 2016) indicate that the utilization of exercise and movement in-class impact on their readiness and receptiveness to learning (Center for Ungdomsstudier, 2016; Jacobsen et al., 2017, 2016), as well as increased well-being and enhanced opportunities for differentiated teaching and learning (EVA, 2014). The significance of the utilization of exercise and movement on well-being and learning is reflected in the general positive sentiment amongst teachers and students, which has been increasing since the reform was implemented in 2014 (Jacobsen et al., 2017, 2016).

Different themes emerged in the reports that were described as key considerations to the process of implementing exercise and movement into the school day, and in particularly into teaching and learning. The age of the students figured as one of the most central and discussed factors across the material that affected how the integration of exercise and movement was experienced. Reports pointed to how the use of exercise and movement varied greatly across grades, and that there is a more extensive use of movement-based activities in the smaller grades compared to the higher grades (Center for Ungdomsstudier, 2016; Jacobsen et al., 2017, 2016; Ladekjær, 2016; Nielsen, Hansen, Jensen, & Arendt, 2015; Nielsen, Keilow, & Westergaard, 2017). A study conducted prior to the reform, showed that showed that students in lower and middle primary school were most physically active and enjoyed participating in physical activities, while students in higher primary school were less physically active and did not enjoy being physically active in school (Hansen, Friis-Hansen, & Jensen, 2015). These findings were echoed in a study one year into the reform, which indicated that teachers were less inclined to use physical activities in their classes with the older students (Jacobsen et al., 2015). The findings were explained by the experiences of the teachers, who found the experienced effects to be more evident with younger children (Jacobsen et al., 2015; Jacobsen et al., 2016) and that it became increasingly difficult to integrate movement-based activities into the more academically advanced content taught in upper primary (Jacobsen et al., 2017). Furthermore, one study also pointed to the lack of a culture of movement in upper primary, which went beyond explanations associated with the complexity of the content, but also pointing to the subjective feelings of awkwardness and embarrassment of students when asked to move as inhibiting factors. As a consequence of the findings in the reports concerning age as a central factor and challenge for teachers in following the mandate, a recent campaign was launched by the government called “Bevægelse i udskolingen” (“movement in upper primary school”, author’s own translation) (Undervisningsministeriet, 2018). As part of this campaign, the government published a memorandum explicating the importance of maintaining and encouraging increased movement in upper primary by arguing that an active childhood increases the likelihood for an active adulthood; the ministry reasoned that positive experiences with movement in school is beneficial both in the short and long term (Seelen, 2017).

A smaller but pronounced theme is variations across subjects. While none of the reports accounted for science education, they indicated that there are marked differences between the use of movement-based activities in Danish education versus mathematics education (Jacobsen et al., 2015; Jacobsen et al., 2016). Compared to teachers in mathematics, Danish teachers report a more frequent use of movement activities in class. A possible explanation for this is that Danish teachers typically are also homeroom teachers (Jacobsen et al., 2015), which may account for some of the reported difference, but this remains unknown.

A third theme is the question gender. One report showed that boys are clearly more physically active than girls in school, and that the difference became more pronounced with age (Nielsen, Hansen, Jensen, & Arendt, 2015). The reports do not only point out that gender matters but also that ethnicity (Nielsen et al., 2015) and mental disabilities (Nielsen et al., 2015, 2017) are over-represented in groups of children who are reported to be neither very physically active in or outside of school.

Finally, the reports also showed that teachers' and pedagogues' perceived lack of knowledge and know-how inhibited the integration of movement-based activities into teaching and learning (Jacobsen et al., 2017). Case studies in the reports showed that teachers experience a lack of competences when it comes to ensuring interesting activities that connect physicality and learning, as well as lack of time in preparing activities that are reported to take considerable time conceptualizing and planning (Jacobsen et al., 2017). This connects further to teachers being confused about the terminology used to talk about mandated movement (Jacobsen et al., 2017).

In summation, reports show that mandated movement has been a focus area in the process of implementing the reform, and that much effort has been put into this in practice, which is showing in outcome studies in terms of the benefits for learning and well-being. The positive benefits are reported to include readiness and receptiveness to learning, as well as potentials for differentiation, resulting in a general positive sentiment towards movement-based activities in school. However, the reports also indicate challenges. Age is a central factor, which affects the possibility of successful movement-based teaching and learning. Teachers perceive it as easier to engage younger students in being physically active, while the complexity of the content taught in upper primary as well as the increased self-awareness in the students challenge and constrain teachers in their efforts. Apart from age as a factor to be considered, the subject taught also provided different opportunities, along with factors such as gender, ethnicity, and mental disabilities. The reports showed that these factors combined with the perceived lack of competency and expertise, the lack of clarity of the concept of movement, and certainty about the purpose of movement for teaching and learning, were major inhibiting factors to the process of implementing more movement.

The following section considers how some of the challenges reported in the above studies may be related to the push for more movement grounded in evidence-based research.

2.3. THE NEED FOR BROADER PESPECTIVES ON MOVEMENT?

The above review shows that the integration of PA into the school promotes health, that physical education and movement can support well-being, and that exercise integrated into subjects supports and promotes learning. While the studies document different effects of being physically active, the research does not say anything or very little about the context into which movement and physical activity is introduced. As context, the school is both an enabler and inhibitor in the use of PA in health promotion (Eime, Young, Harvey, Charity, & Payne, 2013). In terms of providing an arena for doing physical activities, schools have great potential as they have at their disposal access to resources and a sound pedagogical structure. Yet on the other hand, the push for more movement also contests traditional ideas about the purpose of schooling, challenging skeptic school leaders, teachers, or parents who claim that initiatives such as mandated movement steal away valuable time, which could have been spent on raising academic achievements (Ommundsen, 2018), and they may be justified in their criticism. Because while research documents a relation between PA and learning, the research departs in paradigms removed from the practical pedagogical context in which they are used to substantiate change (Jensen, 2017a). Change that in part is justified by the effects of PA on learning, but which can also be coupled with a political interest in school-based sports and exercise as a solution to the growing problem of sedentary lifestyle in children and young people, and the side effects such as life-style diseases (Herskind & Rønholt, 2007). In addressing the purpose of movement in schools, there thus seems to be a challenge concerning legitimacy, and the question remains whether physical activities can be legitimized on the backdrop of research as presented above, or whether such purposes are negotiated contextually.

Positivism is claimed to have penetrated social life to the extent that it “saturates common sense arguments and supports oversimplified aspects/versions of scientism” (Kincheloe & Tobin, 2009, p. 6). This view is reflected in Jensen (2018), who raises his concerns that the narrow sense in which movement is conceptualized and researched runs the risk of reducing movement to a ‘social technology’ (Brinkmann & Tanggaard, 2008) without appreciation of the substantive, cultural, and social context into which it is introduced. He notes that, while not wanting to question the quality of the research supporting the correlation between PA and health, well-being, and learning, it is nonetheless vital to recognize the difference between a theoretical operationalization of movement amongst scientists and the practice in which it is enacted. The reason for this is that there is a potential slip in meaning when knowledge derived from research is transformed into practice. While research with increasing certainty can claim a correlation between PA and learning, this does not necessarily ensure that the interpretation and implementation of physical activities at a particular school promotes children’s learning (Jensen, 2018). What counts as valid knowledge in a research context cannot uncritically be transformed into knowledge that is useful in schools (Jensen, 2017a). Building on Biesta (2010), schools are conceptualized as open and complex fields, where the surroundings and human practice come together in unpredictable ways. Despite a correlation between PA and learning, there is no causality or determinism stating that any child who is physically active will experience increased learning (Jensen, 2017a). Instead, the complexity of human everyday life calls for the recognition of different knowledge forms (Berger & Luckmann, 2004), particularly when the goal is to create quality teaching (Jensen, 2017a). Professions draw on a heterogeneous foundations of knowledge (Grimen, 2008), and teacher professionals rely on theoretical pedagogic knowledge as well as knowledge about the subjects they teach in, not to mention knowledge of the practical dimension within which they act (Schön, 2001). Hence, recognizing that the practical realities of the school is complex and context dependent means that looking for answers in research may prove very difficult (Jørgensen, 2017). Instead Jensen (2018) argues for the introduction of a new concept of meaning, where the meaning of movement is not defined in the narrow sense of PA. Inspired by the works of sports-philosopher Kretchmar (2000), Jensen contends that the integration of movement into schools may be rationally meaningful to professionals and students when they consider the empirical studies and health scientific theories about the body that form the basis for recommendations and guidelines. As such, students may rationally understand why attaining a high pulse is important, if they understand the physiological knowledge underpinning such recommendation. Yet being able to see the rational meaning and perhaps even instrumental meaning of reaching a high pulse does not necessarily entail the desire to run. Despite understanding the purpose of running, they may not feel like it or find it attractive. Against this backdrop, Jensen talks about another kind of meaning that is of existential character (2018). Meaning as a subjective or intersubjective understanding, assessment, or attitude that is connected to identity and habitus (Jensen, 2018). Existential meaning is thus a question of personal and social values and what is defined as valuable by the student or groups of students. It is an affective kind of meaning (Kretchmar, 2000) that does not rely on empirical evidence, but embodied experiences. By pointing to concepts such as identity and habitus, Jensen is pointing to aspects of movement that lack in the research supporting a mandate for more movement, and which are central to how physical activities are perceived and made sense of (Kretchmar, 2000).

2.4. SUMMARY

The purpose of this chapter was to examine what an embodied pedagogy means in the broader context of education in Denmark. This was accomplished by addressing two overarching dimensions shaping how education professionals come to understand the role of the body, embodiment and movement in primary schools: 1) research-based arguments for introducing more movement into everyday school life, and 2) the political mandate for more movement as an example of the interest sparked by such research. What may be deduced from the research presented and the wording of the mandate, is that there was a strong political persuasion about the benefits of movement for academic life and achievement, and this was supported by a large body of primarily evidence-based research documenting positive correlations between PA and health, well-being, and learning. However, at the same time, the practical realities of schools are not comparable. The theoretical operationalization of movement amongst scientists is problematic when seeking to transform research into practice. It is problematic not only in terms of what counts as valid knowledge, but also in terms of how research might be transformed, interpreted and implemented as part of teaching and learning. These challenges are reflected in the reports, which despite positive sentiments from teachers and students towards the integration of more movement into everyday school life, also show very concrete challenges in particularly upper primary linked to e.g. the complexity of the content, the age of the students, and gender.

Apart from the Ph.D. dissertation referenced in section 2.2.1 **Fejl! Henvisningskilde ikke fundet.**that also builds on participant observations, the reports identify outcomes, attitudes, experiences and advices related to the implementation process through questionnaires and interviews. As such, little knowledge is made available in terms of how the implementation actually shapes teaching and learning, how the mandate is conceptualized by schools or teachers, and what it actually looks like in class. Consequently, researchers such as Jensen (2017, 2018) concerned with a contextual perspective on the implementation of movement, advocate for a more phenomenological, situated and contextually sensitive perspective if we are to understand how a movement-based curriculum might make sense within an educational framework where the purpose of movement is to support teaching and learning.

This chapter explored the push for more movement into Danish schools in general. The following chapter turns to science education specifically, to explore how movement links to the discipline of science by examining how science education research has positioned the body.

CHAPTER 3. BODIES IN SCIENCE EDUCATION RESEARCH

This dissertation is about a pedagogy of embodiment for science education – a kind of pedagogy, the foundation of which has been strengthened and made relevant not only by a growing body of research underlining the potential benefits of increased movement in schools, but also the heightened attention this has generated as noted in chapter 2. Yet despite the growing awareness of the benefits of increased movement, it remains unclear why movement should be part of subject particular teaching and learning including science education.

This chapter sets out to examine the arguments for an embodied science pedagogy in order to begin to understand how the Danish push for more movement into subjects may support learning in science. In order to do this, science education research concerned with the role of the body for teaching and learning is reviewed. It is not a systematic review, but instead a presentation of different fields encountered during the span of this dissertation. The fields encountered are *embodied cognition, materialist phenomenology, sociocultural perspectives on the body, pragmatist perspectives,* and *gendered perspectives*. In what follows, these different fields are presented together with their conceptualization of the body and its role for science learning. Selected studies are used to represent overarching arguments for each field. The relevance of each field in relation to this dissertation is also discussed.

3.1. INTRODUCTION – LOCATING A BODY IN SCIENCE EDUCATION

Science education is a particular arena for learning in schools that is influenced by its long history and central position in society. Science education has been identified as a school subject that is of economic importance, and closely coupled with increasing scientific literacy, a thinking competency, to address the needs of technologically driven economy (Hodson, 2003). The implication of this is that science education emphasizes a very specific scientific knowledge and skills development (Hodson, 2003). The training of a scientific reasoning (American Association for the Advancement of Science, 2001) or 'scientific habit of mind' in students has been promoted as the way forward – a worldview in which logical thinking, quantitative analysis, deductive reasoning, proper questioning, and reliance on sound evidence (Dewey, 2008) are central to the practice of science. Science education is thus a system of inquiry that calls for the application of all of the above habits. Despite a pragmatic framing of science as a system of inquiry, where knowing science is *doing* science, science also 'suffers' from the long standing Cartesian tradition of separation that divorces and polarizes mind and body, reason and feeling (Alsop, 2014; Alsop &

Watts, 2003). This has meant the framing of science as a “rhetoric of conclusion” (Schwab 1962, p. 24), where science is looked upon as an accumulation of facts and thus reducing science education to content rather than process. Reducing scientific knowledge to content renders the body *hidden* and *contained* (Pillow, 2000), which in turn suggests that learning is non-corporeal and rational tasks (Ross, 2004). Zembylas (2007) characterizes this kind of education when writing, “There are *specters* haunting the classrooms – *bodies* and *affects*. Yet, teachers and students are often *not supposed* to have bodies and affects because education should be the acquisition of knowledge” (p. 19). Reducing science to formulaic knowledge has meant the elimination of bodies in thinking, doing, and understanding science, where bodies are to be used, but not noted, and where students learn to distrust their bodies, valuing what they read over what they can sense (Alsop, 2011).

Yet in educational practices students and teachers continuously use their bodies when they talk, write, listen, smell, see, work with different artefacts, communicate with facial expressions, stances or gestures, or walk around in the classroom. Despite this, science education at large is treated as dis-embodied in didactical research and subject particular didactics (Almqvist & Quennerstedt, 2015), as studies tend to focus on students’ concept development rather than their bodies as content for consideration in teaching and learning. There are, however, notable exceptions to this tendency and below, key pockets of studies dealing with the question of the body in their research of science teaching and learning are identified and discussed in relation to this dissertation.

3.2. THE BODY IN COGNITIVE APPROACHES TO SCIENCE EDUCATION – EMBODIED COGNITION

Research in cognition has traditionally looked at the mind as an abstract information processing system, where the body as our sensory-motor system was only recognized as a conveyer of stimuli and responses to a cognitive processor where higher-level abstract thinking took place. The specifics of human physiology and interactions with a surrounding material and social world were largely neglected until the 1980s, when research started to reformulate this kind of research from the assumption that cognition is embodied (Amin, Jeppsson, & Haglund, 2015). Since then, the role of the body in shaping the mind has been granted a central position in the cognitive sciences (Niebert & Gropengießer, 2015). Research in embodied cognition seeks to develop models of cognition that attend to the features of bodies, human brains, and material contexts where thought takes place. While this area has received much attention in the area of mathematics education research, it is only more recently that science education research has begun to venture into this field, examining how language, gesture, and objects support scientific conceptualization and reasoning in abstract domains (Amin et al., 2015). Despite the relatively late emergence of this field, it represents perhaps the largest field of embodied research in science education. This is apparent in the attention it has received in recent years. For instance, in 2015 two special issues of the

International Journal of Science Education (issue 5-6) were dedicated to embodied cognition, numbering 12 articles in total, in comparison to e.g. a special issue on the topic of affect in 2003, which only figured four articles.

Connecting the body with science is, according to Niebert, Marsch, & Treagust (2012), particularly pertinent to science educators, because teaching and thinking about science without metaphors and analogies grounded in embodied experiences is simply not possible. This argument taps into the central view of embodied cognition, namely a view of understanding as ultimately grounded in our bodily experience with our physical and social environment, which is inspired by the work on conceptual metaphors by linguists Lakoff and Johnson (1980). Exploring how abstract concepts are habitually based on bodily experiences, they found that many of the concepts employed in everyday life are not understood literally, but metaphorically; that is, based on different domains of knowledge. According to Lakoff and Johnson, this reflects “general principles of understanding” (1980, p. 116), where we come to know a new domain on knowledge by metaphorically projecting an existing (embodied) source domain to the target domain. When inferential logic is passed from one domain to another, this is regarded as a conceptual metaphor. Conceptual metaphor is thus defined as “a unidirectional mapping of entities form a concrete conceptual domain to what is usually more abstract conceptual domain”, and the ability of metaphorical thought “makes abstract scientific theorizing generally possible” (Niebert & Gropengießer, 2015, p. 905). In Lakoff and Johnson’s theory they acknowledge the embodied sources of metaphors, and call them “image schemas” (1980). An image schema is a recurring structure within our cognitive processes, which establishes patterns of understanding and reasoning. For example, the container schema arises from recurrent experiences that are the interactions of our sensory-motor system with the environment. According to Niebert and Gropengießer (2015), the container schema emerges from experiences of the body as three-dimensional being, into which we put things, such as water, food, and air. Image schemas provide structure and consistency to the way we see the world, and help up orientate in the physical and social world. We furthermore use these schemas to understand abstract ideas that we cannot directly sense, such as the structure of atoms or the solar system.

As seen in the above, embodied cognition conceptualizes the body in terms of the foundational role bodily experiences has for the ability to understand, reason and talk about the world. Yet it is not the body per se that is of interest in the field of research, but rather how embodiment conceptualized as external representations becomes a resource for conceptual change. Conceptual change is difficult in science education because scientific evidence and theories often exceed what can be experienced in the mesocosm (Niebert & Gropengießer, 2015). The mesocosm is the world we as humans have adapted our perceptions, experiences, and actions to (Vollmer, 1984); that is, the dimension of the world, which is tangible and perceivable to us using our human sensory abilities. Learning in science calls for the ability to transgress and connect experiences in the mesocosm to abstract ideas rooted in microcosmic (e.g.

cells or molecules) and macrocosmic (e.g. the solar system or biosphere) entities. Didactical research in embodied cognition looks at how (embodied) experiences can support the design of external representations. For example, Riemeier and Gropengießer (2008) show in a study how students' conceptual understanding of microbial growth can be supported by use of an external representation such as tearing of paper. The physical action provide an experience in the mesocosm, which acts as a resource for the students to inquire or reflect on conceptions of cell division. In their study, they showed that students when provided with this experience were able to form conceptual metaphors that lead to refined conceptual understandings of microbial growth, and avoid alternative conceptions. Experiences can also be promoted using mixed reality, such as in a study by Lindgren, Tscholl, Wang, and Johnson (2016), who manipulated embodied experiences using digital objects. They demonstrated how immersive whole-body interactive simulations strengthened middle school students' conceptual learning about gravity and planetary motion. In a Danish context, Bruun and Christiansen (2016) provided examples of how kinaesthetic activities afforded useful entry points for students' construction of physics conceptions. Providing students with physical activities that enabled them to kinesthetically experience the feel of force, students were able to reflect and connect experiences to abstract ideas such as Newton's first, second and third law.

Research in embodied cognition is perhaps the most developed field presented in this review and provides foundational knowledge about the centrality of the body for the development of conceptual metaphors. However, in terms of conceptualizing a body in science education, the strong focus on cognition arguably positions the body as a kind of objective vehicle or starting point for abstract thinking. As such, research in this field does not provide entry points into understanding how the introduction of movement-based learning activities become meaningful, other than from a conceptual perspective. Such contextualized and situational perspectives are at large absent or only indirectly present in the research as considerations and reflections about how the formation of conceptual metaphors are not a straightforward process and why students often struggle to make and interpret scientific experiments in the classroom (Hofstein & Lunetta, 1982). For example, Niebert and Gropengießer note that "it seems that providing experiences to students does not always produce the intended motivation and understanding" (2015, p. 925). While it is not the project of the cognitive sciences to pursue these matters, such reflections inform this dissertation, as evidence of the subjective ways in which students make sense of activities, including movement-based activities.

3.3. INCARNATE PERSPECTIVE ON BODIES – MATERIALIST PHENOMENOLOGY

A different approach to understanding the centrality of bodies for learning is found in the works of Michael Wolff-Roth termed "incarnation" (Roth, 2010). The interest of this approach is a conceptual one, to ground mathematical knowledge in the body. In opposition to embodied cognition, knowing is not viewed as stemming from intellectual forms of consciousness, as e.g. sensorimotor image schemas (Johnson, 1987; Lakoff & Johnson, 1980). Instead, knowing is proposed as stemming from "incarnate" ways of being (Roth, 2010, p. 9): one of these being the ability of our lived body to kinetically move. Drawing on materialist phenomenology, for example Maurice Merleau-Ponty, Roth and colleagues seek to go beyond traditional mind/body dichotomies to conceptualize knowing and learning in terms of mind/body as indistinguishable and irreducible structures (Bautista, Roth, & Thom, 2011).

The incarnate approach differs from classic approaches to embodied cognition, because it distinguishes between the material body and the flesh. In contrast to traditional conceptions of body as something that is confined to myself, the flesh places the knowing subject in a mutual relation with the world. The shift in terminology is of central theoretical importance, because it is used to distinguish between bodies that can and cannot develop intentionality and incarnate memory. Incarnate memory and intentionality are forms of knowing and being that precede consciousness or schemas, and which are integral to learning because "only a body that knows how to move the arm and hand can point, reach, or gesture (Brinkmann & Tanggaard, 2010)" (Bautista et al., 2011, p. 367). Kinetic movement is at the core of incarnate memory and intentionality, and in its originary form arises from incarnate capacities of the living body involuntarily and without the mediation of mental schemas. Bautista, Roth, and Thom (2011) see this as a sign that the flesh is inaccessible by verbal consciousness, and therefore argue for corporeal-kinetic forms as the ground for all knowing. They propose that

> "Based on this line of reasoning, mathematics is not embodied/enacted with the conscious mind "as master." Practical comprehension of mathematics means knowing in the flesh, and is developed through the flesh. The most relevant senses for the constitution of mathematics are the senses of sight, touch, and hearing. By means of the expressive and perceptive capabilities of these senses, human beings come to make mathematical sense of our surrounding environment. In performing gestures, bodily movements, verbal utterances, or distinctions in our prosody, the flesh as a whole becomes an expression of the mathematical world to which we are exposed. In our theory, therefore, the human body is understood as the semiotic signifier of mathematics par excellence, as it is the material ground of any mathematical idea we can express and convey to others (Thom & Roth, 2011)." (Bautista et al., 2011, p. 367-368)

Rather than the body as a backdrop to the research of knowing and learning as the case of research in embodied cognition, Roth and colleagues thus propose to look at bodies as the *signifiers* of learning by considering gestures, movements, utterances, prosody, and so forth. Although this approach was developed with an interest in mathematics education (Roth, 2011), it has since been applied to science education research, where Hwang and Roth (2011) have examined how physics lectures can be understood as more than just talk plus notes. They problematize that students can have a clear sense of understanding during the lecture, but then fail to understand their own notes or even textbooks when preparing for exams. What they found was that this informational gap can be explained by the "informational more" that becomes evident when looking at concepts as heterogeneous performances, where meaning is synonymous with the "synergistic and irreducible transactions of many different communicative modes", which are made up of body movements, positions, prosody, and so on (Hwang & Roth, 2011. p. 461).

An incarnate perspective is of interest to the dissertation because it affords a different entry point into considering the role of movement for science education. As argued in chapter 2, the introduction of more movement loses its relevancy to subjects such as science, because the individual and social value of movement in science is different from the rational meaning of becoming healthier, stronger, and so forth. An incarnate perspective instead associates movement with meaning making, where movement in science education becomes evidences of knowing in the flesh. Examining movement from this perspective thus opens up for considerations about how the movement embodied by the students in different tasks become meaningful as ways of knowing science.

However, at the same time this approach may be critiqued for its perspective from nowhere (cf. Harraway, 1991). In meticulously describing kinetic and verbal actions of participants to show how concepts are heterogeneously performed through the bodily work (gesture, talk, body orientation, gaze, and prosody) in lectures, sight is lost of *who* moves, the incentives and feelings surrounding the movement and how this shapes the affordances of movement. I thus turned to the studies below, to consider frameworks adopting a more subjective approach to the question of movement.

3.4. AFFECTIVE BODIES IN SCIENCE EDUCATION – SOCIOCULTURAL PERSPECTIVES

In the search for more subjective approaches to the question of the role of movement in science education, the field of affect or *emotion* was considered. Questions may be raised about why studies dealing with *emotions* are included in this review concerned with movement and an embodied pedagogy for science. If emotion is somehow more about the body than cognition. In answer to this question, I turn to Roth (2007), who in an article concerned with identity in scientific literacy argued that scientific knowledge cannot be separated from everything else in our everyday lives; instead it must be seen in light of the emotional-volitional dimensions of our actions. When doing science, many different actions are possible within the same activity, but their sense changes when the activity is realized. As I will come to show in chapter seven, waving can, in an activity concerned with dramatization of the formation of ions, lead to the construction of theoretical knowledge about charges, whereas in an activity concerned with the speed of sound, it just marks the readiness of the participants. The same activity realizes different goals, and as such, these goals constitute possibilities that are realized in and through human bodies. Actions are suspended between the activity as a collective motive that mediates their sense and the concrete operations realizing them through bodily performance. As such, an action is never just directed towards the self that realizes that action, but also always the other – as part of a particular culture in which that action is valued. However, while goals may express a volitional dimension they cannot account for why some actions are realized while others are not – why we do as we do. Instead, we have to look at emotions as a driver and context for satisfying needs. Roth writes that emotions are

> "integral to performance, to every instant of praxis, rather than being an external variable that can be added from the outside after the fact. By noting its integrality I mean to highlight that it is a constitutive moment without which actual performances (and therefore cognition and consciousness) cannot be understood" (2007, p. 168).

As humans generally strive for goals that lead to positive emotional valence (Turner, 2002), in the context of learners this means choosing goals (actions) that increase agency and control over their environment (Roth, 2007). For this reason, emotions and affect may be said to be of great importance, not only in everyday lives, but also in educational settings.

Research on affect is a burgeoning field, which includes a very diverse body of research, spanning from research in emotions, to aesthetic experience, and wellbeing. The field is not defined by a set of theories or research methods, but gets a body from the contrast it presents to approaches that prizes apart the body and mind, by polarizing reason from feeling. It is argued that emotions and wellbeing play a key role in everyday lives, including educational settings (Bellocchi, Quigley, & Otrel-Cass, 2017). Despite the centrality, the field is still underrepresented in academic journals (Fortus, 2014) potentially because there has been a history of valuing cognitive skills over emotional and expressive aspects of learning (Ingold, 2011). The Cartesian dualism has and still shape educational institutions, technologies, language and sociocultural practices (Alsop, 2017). A Cartesian mindset calls for teaching to take place only between minds, and have manifested itself in particular bodily habits for teachers and students alike. Examples of this can be seen in the way lecture halls are structured to restrain bodies and focus the gaze (Brook, 2000); in how students were punished if they could not conform to the bodily requirements of e.g. sitting still for longer periods of time (Håkan Larsson & Fagrell, 2010), or how teachers should not touch students or express vivid displays of emotions (Zembylas, 2007). Zembylas writes "such bodily/affective habits are determined by institutional and cultural norms that see bodies and affects as fundamentally shaped and disciplined by reason" (Zembylas, 2007, p. 20). Such institutionalized and cultural norms regulate actions, and shape how teachers and students act, but also how to conceptualize teaching and learning. In an article about the sociocultural turn in science education research, Kenneth Tobin recollects how mainstream perspectives of what counts as science over time has and still does marginalize emerging sociocultural discourses (such as the recognition of the role of affect) that are at times regarded as non-scientific (2015). To him this is problematic because the marginalization impoverishes the domain of science education, as it fails to connect with the everyday life experiences of the stakeholders, as these do not get a voice in the kind of research shaping policy. With issues such as sustainability and climate change affecting our lives, getting young people engaged and instilling positive attitudes towards science has perhaps never been more important. Yet doing so means expanding what counts as science and opening up for emic perspectives to shape what and how science is taught (Tobin, 2015).

Research on affect in science education has been criticized for focusing on making students feel good rather than becoming educated (Alsop & Watts, 2003). Proponents, however, argue that affect surrounds learning (Alsop & Watts, 2003), and that knowledge is never just understood; it is felt, and "responded to emotionally and corporeally" (Zembylas, 2007, p. 20). Studies on affect in science education have captured the role and importance of considering affect in different ways from post-event rationalizations to situated daily-lived situations. While there seems to be an inherent tendency to value post-event rationalizations of emotions (Alsop, 2014), new and more cutting-edge perspectives are being applied, which accordingly call for more complex perspectives on the body. In what follows I engage with a selected few to show what I find to be dominant approaches.

One on the most predominant approaches to emotions in science education is found in the works on *attitudes towards science*, where quantitative measures are the most common way of obtaining data (Osborne, Simon, & Collins, 2003). Within this approach, the body is predominantly conceptualized through post-event rationalizations of emotions. The concept of attitude towards science is "somewhat nebulous" (Osborne et al., 2003, p. 1049), and suffers from lack of clarity about what is meant by attitudes towards science. Different elaborations have provided different focus, but in general studies of students' attitudes towards science seek to shed light on the subjects expressed feelings and preferences towards an object, here science education. This is done by looking at a range of different components, such as perception of teacher, anxiety towards science, value of science, motivation, attitudes of peers and friends towards science, attitudes of parents, fear of failure, nature of the classroom, self-esteem, enjoyment, and so forth. Yet the problem with such self-reported feelings and preferences is that it is unclear whether they connect to the behaviors actually exhibited by the student. Behavior may be influenced by other attitudes held by the student, anticipated consequences of behavior, motivation to behave in different ways than the expressed attitude, and so forth (Osborne et al., 2003). An outcome of this has been the distinction between attitudes and behavior, and subsequent theoretical developments such as the theory of reasoned action. Ajzen and Fishbein's (1980) theory of reasoned action distinguishes between attitudes towards an object and attitudes towards the action to be performed toward that object, and argues that it is the latter kind of attitude that best predicts behavior. As such, they pose a relationship between attitude→intention→behavior that has guided further research to consider behavioral aspects as central to attitudes towards science and the need for stronger demarcation between school science and science in society (Osborne et al., 2003).

Much more contextualized and sensitive to the dynamic relationship between participants and environment are the studies of emotion by e.g. Flávia Maria and Mortimer (2003). In their study, they (2003) seek to remedy the tendency to neglect dimensions of feeling and emotion in learning science, something they argue “tend to be diluted in the more general considerations of attitudes and values, with little attention on their effects of teacher-student and student-student interactions” (p. 1096). They do so, by investigating how the relations between students and student-teacher contribute to the emergence of primary and secondary emotions and feelings in science classroom. Following the work of Antonio Damasio on emotions, they build on a conceptualization of emotions as unique adaptations that integrate the mechanisms used by the organism to regulate their social and organic survival, positioning emotions as key in interactive processes. Emotions are seen as providing patterns of behavior that are connected with ideas and feelings, such as pleasure and pain, or personal advantages or disadvantages. By means of an ethnographic study, they examine how emotions emerge in the classroom by looking at physiognomic aspects of posture, gesture, facial expressions, as well as expressive intonation in relation to talk.

Milne and Rubin (2011) and Orlander and Wickman (2011) push us to consider a perspective on the affective body that goes beyond the acceptance of emotions as something that can be expressed or that emerges in social situations, to recognizing that emotions are social phenomena, “instantiated in a relationship of the moment” (Milne & Rubin, 2011, p. 626). Milne and Rubin (2011) consequently employ the notion of “emoting”, as a way of stressing how emotions represent ways of engaging with the world, in the strive for change or maintenance of relationships. To emote is therefore to embody a way of being in the world, a strategy or goal so to speak, in a dynamic world. Through the recollections of Rubin, who is a science teacher, the authors show how curriculum and companion meanings[7] can be fused through explicit focus on the emotions and bodily experiences that emerge in learning activities. Thereby Milne and Rubin show the importance and value of aesthetic experience to

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[7] *Companion meanings* are the understandings associated with what is learnt in classrooms, or the ‘extra’ meanings of science education (Roberts & Östman, 1998). Companion meanings may have possible consequences for the way in which students come to make sense of the matter other than curricular purposes, shaping e.g. how they come to view what is worth knowing and whether they can master it (Arvola Orlander & Wickman, 2011).

science learning, contrary to the example provided by Orlander and Wickman, where the emotional responses from the students emerge as elements of disturbance. Orlander and Wickman (2011), like Milne and Rubin, place body, mind, and world in a dynamic relationship enacted through interactions, where learning is not about learning facts, but about how we interact with our environment in creating meaning – in living. Orlander and Wickman consider bodily experiences in secondary school biology and their importance to meaning-making. Rather than trying to conceptualize, the body in terms of what it is or is not, they conceptualize it in terms of how it is transacted during the work performed in class. By considering students' bodily encounters with conducting a calf-eye and learning about sex, they show how the students as learners are actively involved in negotiations of bodily experiences as learning science, but also how encounters between bodies have importance for meaning-making and the kind of content that is afforded in the activity. They build on a theoretical framework proposed by Sullivan (2001), who utilizes Dewey and Bentley's concept of "transaction" (1949/1975) to move the focus away from a body as a substance, and instead understand it as a set of patterned activities. Sullivan notes that "thinking of bodies as transactional construes bodies as *patterns of behavior* or actions that occur *across and by means of* or trans- various environments, hence bodies as transactional" (2001, p. 3, original emphases). To think about bodies in this way, is to recognize that bodies and environments co-constitute each other in the process of growing and learning, not as completely separate entities, nor as one and the same. By adopting this approach, attention remains on "the lived experiences of bodies, on the activities in which the students' bodies are involved and what meanings are constituted in them, and not on the body as an isolated object" (Orlander & Wickman, 2011, p. 575).

A completely different approach to the role of affect and bodies in science education is adopted by Perrier and Nsengiyumva (2003) and Tobin, King, Henderson, Bellocchi, and Ritchie (2016) although in very different ways. While both studies consider emotions from a wellness perspective, Perrier and Nsengiyumva consider how hands-on, inquiry based science activities may have curative potential to victims of violence and war, whereas Tobin and colleagues are interested in the expression of emotions and physiological changes during teaching, and how such emotions may be ameliorated using various tools. Perrier and Nsengiyumva (2003) push against the boundaries for what might be considered normal science education (Alsop & Watts, 2003), as they examine how training hands-on inquiry methods with children in war-torn Rwanda can not only lead to the experience of the joy of learning, but that engaging in science can restore a sound connection to the natural world. Such a connection may provide children with the feeling that the surroundings can be made meaningful again, and thus acted upon. This is something that could contribute significantly to improved mental health. Perrier and Nsengiyumva (2003) only briefly touch upon the theoretical foundation for linking hands-on activities with development of learning. Yet in their study and the way in which they approach the theme of science as stage for therapeutic change, there is a recognition of the intertwinement on psychomotor, affective, and cognitive domains as they explain how the children handled the activities and how their engagement reflected interest, joy and a sense of meaning. It is an active, feeling, growing body they describe, but it is also a body whose materiality and situatedness is taken for granted and not reflected on specifically. In contrast, Tobin and colleagues (2016) adopt an approach that goes beyond the previously mentioned studies in exploring the body. Basing their study on polyvagal theory, they connect emotion to measurable changes in blood oxygenation and heart rate to examine how these are expressed during teaching, and subsequently how awareness of bodily states and changes assist teachers in approaching classes more relaxed and focused.

The above approaches to an affective body in science education are very different in terms of their theoretical orientation, and methods for capturing and examining expressions of emotions. In terms of their relevance to this dissertation, which seeks to examine what an embodied pedagogy looks like, research on attitudes, while foregrounding affect, is too far removed from the practice that unfolds in the classroom. The body that emerges in this kind of research seems to be a construct of discursive practices, where explanations are based on constructs such as gender, personality, curriculum, classroom, or socio-economic class. The materiality and lived experience of bodily work as central to how we feel about and perceive science education is lost in such explanations, where general statements and overviews produced by subject preference studies, attitude scales, interest inventories or subject enrolment become the major source of information about how young people feel about science (Osborne et al., 2003). Consequently, studies like that of Flávia Maria and Mortimer (2003) are much more relevant to this dissertation. Although research on facial expressions is not without its critics (see e.g. Fridlund, 1994), the visceral perspective on the psychology of emotions offers a perspective on the body, as a body with substance, a body that feels, changes, and responds to the social and physical environment that it is located in. It is a perspective that prompts consideration about the learning environment that emerges in tasks including movement, but also the kind of emotional responses experienced by the students in having to participate in such tasks.

As supplement to the recognition of the centrality of emotions shaping how students experience science education, the transactional approach adopted in studies like that of Milne and Rubin, or Orlander and Wickman, directs consideration to the implications such emotions have for what is learnt and who learns it. For this dissertation, this prompts considerations about how students through movement in science education interact with materials in different environments and with different bodies in the process of solving tasks.

While considerations about emotions may link to the notion of wellbeing, it is not within the scope of this dissertation to consider wellbeing. However, using biological markers as suggested by Tobin et al. (2016) as a means to capture and identify heightened emotions in relation to participation in movement-based learning tasks would be an interesting approach in intervention studies concerned with body consciousness and changing how students react in situations where they have to use their bodies actively while learning.

3.5. KNOWING AS ACTION – PRAGMATIST PERSPECTIVE

Echoing the studies in the above section by Milne and Rubin, and Orlander and Wickman, pragmatist arguments for considering an embodied pedagogy may also be seen in relation to how scientific literacy is conceptualized. Scientific literacy, as argued by Wickman and Ligozat (2010), is about acquiring habits of action that enable coping with reality. That is, science is not mainly about learning the correct explanations, but rather "learning to deal with nature and the material world in socially fruitful ways" (p. 147). Building on Ludwig Wittgenstein's idea that the meaning of a word is in its use, Wickman and Ligozat discuss how learning a scientific concept does not start by learning definitions, but rather experiencing the social activities that the concept forms part of. This means that the basic level of learning is not remembering definitions, but using words in social activities that accomplish certain purposes. As action is per definition bodily, the pragmatic approach to scientific literacy proposed here is an argument for increased sensitivity towards embodied human practice and habits in learning and teaching science. They write,

> "Dewey maintain that to know how to make our concepts clearer, we need a human practice in which it is used to evaluate how good they are in attaining what we intend. We grow up and live in a society that is already full of customary ways of doing and communicating things. Typically we acquire habits that are part of the customs of society, not because we think that they are necessarily the best ones, but simply because that is how we do things. Many of these customs and habits are beyond the immediate volition of individuals as we grow up and in our life. It is within these customs and habits that individual differences and reflection works; habits can be slowly transformed to achieve things better only within the frames set by culture. The meanings of concepts are entwined and grow out of settings that involve such habits and customs of communication and of the material artifacts that we use." (Wickman & Ligozat, 2010, p. 155)

The implications of the role of culture for habits and customs are an approach to science where teaching and learning takes a point of departure in what is relevant to the students and the activities are experienced as having ends-in-view. That is, developing activities that students see the meaning and purpose of in the sense that they can act purposefully in a way where the scientific skills and concepts can be used for enhanced competence in solving problems both inside and outside the classroom.

In terms of understanding the role of movement in science education, inspiration may thus also be found in pragmatist perspectives. Looking at movement as action, where students engage in particular ways of moving to accomplish curricular goals prompts consideration about whether and how movement is experienced by the students as having purpose. Yet, also, consideration about the affordances developed through movement-based learning activities and how such affordances can be made explicit to the students.

3.6. BODY POLITICS IN SCIENCE EDUCATION – GENDERED PERSPECTIVES

Finally, the issue of gender as a way of conceptualizing bodies in science education is touched upon. Feminist and gender studies present a strong, yet relatively small, voice into research in science education (Hussénius, 2014), despite gender having been identified as e.g. one of the "most significant factors related to students' attitudes towards science" (Osborne et al., 2003, p. 1062). While, the work done on this topic is by no means of one piece, there are major commonalities in the way such research addresses issues related to subjectivity, the nature of social life, and their consequences for educational processes (O'Loughlin, 1997). What can be said in general is that such research focus on the forms of subjectivities that throughout history have been treasured and upheld; male bodies over female bodies, and normal bodies over queer bodies. While such bodies have been enshrined during history and are still at work today, there are societal transformations taking place (Hussénius, 2014) changing how we view gender. Gender and feminist studies are at the core of this transformation, pushing for the rejection of a prior unity of the subject by adopting a view of subjectivity as something to be struggled for, but never arrived at, merely recreated (O'Loughlin, 1997).

Examples of such research in science education are seen in the works of Due (2014) who, based on an interest in power relations, examines the how the construction and reconstruction of notions of the skilled physics student shapes students' experience of inclusion or exclusion from the practice of doing physics. Viewing gender as both a process and a discourse, she shows how traditional gender positions were reconstructed (boys as more competent than girls), but also that such positions were challenged and resisted. Conceptualizations of the body appear in this research in terms of typical gender dichotomies (men versus women) and associated properties of the two genders: males as rational, hard, and objective, and women as emotional, soft, and irrational. As such, gender becomes an analytical category used to consider how masculinity and femininity are constructed in social interaction and discourse, and how such categories structure social life. Due investigates gender through students' talk in group discussions and individual interviews, noting how they position themselves and are positioned by others. In terms of conceptualizing a discursive body, similar tenets can be identified in an article by Orlander (2014), who examines the encounters between heteronormative sexual education in secondary school (particularly learning about the human genitals) and 15-year-old students. Aiming to shed light on how meanings are constructed in classrooms, Orlander builds on Foucault's understanding of discursive practices, as a way of discussing normality. Normality includes social and moral rules of human behavior, which people sustain, disturb, or change through their actions in encounters. Such encounters create patterns of activities that correspond with the context of knowledge the students are positioned in, and render some discourses accepted and others impossible. Through close readings of transcribed recordings, her analysis shows how companion meanings arise in the discussion about seemingly value-neutral facts, underlining students' attempts to relate the content to their own experiences. She problematizes that the companion meanings that emerge are not treated as explicit content in teaching as the tacit gendered relations that are established becomes part of knowing about the genitals.

Gendered and feminist studies on the body in science education, like the examples above, direct attention towards the many ways in which we are our bodies (Alsop, 2014), and thus contribute with diversity to a field heavily influenced by cognitive approaches. However, a focus on gender would neglect aspects of movement such as physiology, sensation and affect, which are central concerns in this dissertation. O'Loughlin notes that the "gender dimension though crucial, *does not exhaust the discussion*" (1997, p. 22, original emphases). A critique, which is also reflected in Alsop (2014), who citing Rebecca Solnit (2001, p. 28) writes that body politics is "… 'sensually' thin, it is left underdeveloped as a 'theoretical body' that 'never aches' or suffers under the elements', or 'experiences fear', 'exhilaration' or 'muscle strain'" (p. 211). O'Loughlin (1997) urges us to look instead beyond gender differences towards that which unite us, which, building on Merleau-Ponty, is the embodied subject's first-hand involvement in the world, and their intimate connection to the spaces inhabited. That is how the body-subject knows, moves, and inhabits a place without prior consciousness: a perspective that is seeks to understand the body's capacity to act intelligibly, but which is not consumed by gender. I seek to follow this advice in this dissertation.

3.7. SUMMARY

The purpose of this chapter was to identify research arguing for an increased sensitivity towards embodied dimensions in science education in order begin to understand how the Danish push for more movement into subjects may support learning in science. Different approaches to the body in science education were examined, and their key concepts, central arguments, and conceptualizations of the body summarized in Table 1 below.

Table 1: Summarizing table - arguments for an embodied pedagogy

Theoretical approach	Key concepts	Central arguments for an embodied pedagogy	Notions of the body
Embodied cognition	Embodied cognition	Abstract concepts in science are based on bodily experiences	Embodiment is conceptualized as external representations
Materialist phenomenology	Incarnate intention and memory	Practical comprehension of science means knowing through the flesh	Bodies as signifiers Knowing e.g. science is expressed through gestures, movement, utterances and prosody
Various sociocultural approaches	Attitudes Behavior Emotions Wellbeing Emoting Transactions	Scientific knowledge is not just understood, it is felt and responded to corporeally and emotionally	Emotions are expressed through physiognomy (posture, gesture, facial expression or prosody) Cognitive, psychomotor, and affective domains are intertwined Emotions are a way of engaging with the world Bodily experiences are important to meaning-making
Pragmatist approach	Action	Knowing is situated action	Action is per definition embodied, but is also shaped by culture
Feminist and gender theory	Discourse Power relations Normality	Gender structure social life and shape what students are afforded to learn	Differences in biological body as categories for analysis of social interaction

Looking at the table from the perspective of this dissertation, there is a paucity of research concerned with movement in itself. Movement is seen as an inherent quality of the body, which shapes how the world is made sense of through interaction, but it is not the object of interest. As such, there is a space for this dissertation that seeks to examine how a pedagogy that foregrounds movement becomes meaningful in science education. This dissertation finds inspiration in several of the above approaches in terms of conceptualizing a moving body in science education, in particular materialist phenomenology for its recognition of the incarnate intentionality and memory of the body expressed through movement. Inspiration is also found in sociocultural and pragmatist approaches for drawing attention to the livedness of movement, highlighting how movement is a way of emoting, of managing the world, and knowing the world. These ideas inform the following chapter, which proposes a theoretical framework for thinking about what it means to be and think through the body.

CHAPTER 4. THEORETICAL FRAMEWORK

Chapter 4 presents the theoretical framework with a focus on what it means to be and think through our moving bodies. The framework consists of three dimensions named *embodied identity*, *body-consciousness*, and *body legitimacy*. In what follows, each of these dimensions are introduced, their relevance, as well as the central concepts that guide the chapters to come.

4.1. EMBODIED IDENTITY

In entering the classroom, students come with different embodied experiences of the world. These experiences are embedded in an on their bodies as e.g. scars, ways of comporting themselves, or habits, and these shape how they make sense of and react to their surroundings. Capturing this idea, this section named *embodied identity* represents the argument that learning is not a disembodied acquisition of knowledge, but rather the result of the experiences of an individual body (Hwang & Roth, 2011a).

A focus on the role of an (embodied) identity is particularly interesting in science education since it goes against the notion that "scientific knowledge can be separated from everything else of everyday life, taught in special rooms at a particular time of the day" (Roth, 2007, p. 154). It implies that there is no space for an embodied science identity since traditional science education is a place where young people are educated based on an acontextualized pipeline model that is supposed to produce future scientists (Fensham, 2006). Recently, however, science education has adopted a more humanistic perspective (Fensham, 2006) and has taken an interest in understanding identity and human experiences and what this means in the science classroom (Roth & Tobin, 2007). For example, Hwang and Roth (2011) write:

> "For students who do not yet grasp a concept, who do not even know what the intended concept involves, there is no magical solution for learning scientific concepts such as inertia. They can only engage in talking with and about these concrete objects (e.g., seeing, hearing, and touching) and in letting sense appear to them from this everyday (ordinary) experience of the world. Thus, students doing an experiment in a science laboratory grapple with mathematical equations and scientific equipment, and thereby evolve a better sense of some scientific phenomenon. In this way, learning science and mathematics occurs in their everyday lifeworlds rather than in some metaphysical conceptual netherworld abstracted from reality. Students' powers to act knowledgeably in their familiar world is inseparably intertwined with their everyday experiences. Everydayness,

> which refers to the condition that real people (embodied creatures) inhabit in and for their everyday practice, constitutes both the context of and resource for expanding the sense of the world and therefore for learning science and mathematics." (p. 2)

In this passage, Hwang and Roth draw attention to the body as a necessary condition for knowing and learning. It is through our everyday (embodied) encounters and transactions with these objects that the students come to know and be familiar with these objects. Knowledge, as such, is not an abstract construct, but instead the "power to act knowledgeably" around these objects in a particular context. Through a process of interacting with the environment, the students thus come to know the world, and expand the possibility for entering into new relationships with the objects that were not accessible to them before the encounter. This rationale builds on a phenomenological reasoning found in the works of French philosopher Maurice Merleau-Ponty (1908-1961), who argued for the body as our "primary subjectivity" (Shusterman, 2008, p. 151), where the living body – the body that is capable of moving, hurting, being affected, of affect – is the source of sense (Hwang & Roth, 2011a). In this dissertation, Merleau-Ponty's concept of *the lived body* was as significant influence in terms of conceptualizing the body, and in what follows selected key ideas from his seminal work Phenomenology of Perception are presented under the headings *permanence* and *spatiality.*

4.1.1. THE LIVED BODY

Merleau-Ponty is known by many as the philosopher of the body. His work examines how embodiment comes to matter in our perception of phenomena in the world, where he looks at the body, not as an isolated phenomena, but rather in terms of what an embodied presence in the world means, connecting the body to phenomena such as perception, space, and sense making. The concept of the lived body takes on a central position in Merleau-Ponty's ontology of the body because it is with this concept that he seeks to overcome dualism. Dualism comes from the Latin *dualis*, which means *that, which contains two*, in this case object and subject. Dualism use this distinction to contemplate the body as an outer objective phenomenon and the mind as an inner subjective phenomenon, and in doing so position man in an external relation to the world. In doing so, dualism expresses a mindset where the subjective human stands at a distance from an objectively existing world (Thøgersen, 2004). Merleau-Ponty objects to this distinction between the subjective and objective body, as he argues that it is our very embodiment, which allows humans to perceive of a world, and as such, we are already in the world. Consequently, the concept of the lived body becomes pivotal in pointing towards the simultaneously subjective and objective body (Thøgersen, 2004). The lived body is a phenomenal body. It is *my own* body as I *experience* it. It is thus the body that the individual human is, not only an impersonal, biological body that sustains us, nor a sentient object that is governed by a directive mind (Hangaard, 1996). Rather, a body that by means of its very embodiment makes it possible to experience, sense and act in the world. The concept of the lived body is the body as it appears in everyday experiences. To Merleau-Ponty, this means that the lived body is not accessible through objective scientific studies, but can only be studied from a phenomenological perspective focusing on the *experience of the body* (Thøgersen, 2004).

4.1.1.1 Permanence

The lived body is characterized by its permanence. Permanence can be explained with reference to ideas such as stability, materiality, or solidity, and refers to the idea that the body has permanence because we cannot separate ourselves from our body. My body is always there, shaping how I come to see and understand the world. Merleau-Ponty writes:

> Its permanence is not a permanence in the world, but a permanence on my side. To say that my body is always near to me or always there for me is to say that it is never truly in front of me, that I cannot spread it out under my gaze, that it remains on the margins of all my perceptions, and that it is with me. *(Merleau-Ponty, 2012, p. 93)*

The permanence of the body is unlike that of objects. The permanence of objects is established by exploring it from different perspectives in space and time, to determine whether it perseveres through that exploration. Moreover, an object can be removed from our perceptual field by turning around, closing our eyes, or walking away. We cannot detach ourselves from the body. We cannot take up different perspectives on it, nor remove it from our perceptual field. The body is permanently present to us, without us ever being able to observe it like an object, as the angle we observe it from is unalterable (Langer, 1989). We can see those parts of the body that are furthest away from the eyes, and the visual body seems like an object. But as our gaze moves up and approach the eyes, this relationship change and refers me back to my original body that is seeing, not seen (Merleau-Ponty, 2012). In much the same manner, we cannot perceive our body perceiving. We can touch one hand, while the other touches something else, but “the activity of touching cannot itself be touched” (Langer, 1989, p. 37). This is what Merleau-Ponty refers to as double sensations, and notes how we can watch part of our body as an object, but its active being escapes us. As such, the body places us in a dialectical relationship between freedom and dependence. We are free to choose and vary our perspectives on objects, but on the condition that we cannot do the same to our body. It is only as a kind of reflection thematizing my experienced relation to the body that the visual body may take on the appearance of an object. In our everyday being, the body is there as a precondition for experiencing the world. It is there, as the most abiding and inescapable presence. We need not look for the body in order to move. We move it immediately without conscious thought or effort, and as such, it remains mostly characterized by absence. That is, it is seldom the thematic object of experience (Leder, 1990).

While the permanence of the body is primordial in the sense that it is a constant in our perception of the world, similarly it shapes our perspective on the world and becomes our bond with the world (Langer, 1989). To explain this Merleau-Ponty provides the example of a church steeple. I see a church tower from my window, but I cannot see the rest of the church. The window forces a particular perspective of the church, because the body already forces an incarnate perspective. An incarnate perspective means that the world is seen from a perspective, where we are present as embodied intentional beings (Thøgersen, 2004). The body, as such, is an ontological necessity because it enables actual situations where I can perceive the objects of the world. It is a necessity of my being. Yet it is not only the exterior body that shapes perception, but also the inner visceral organs. Drew Leder (1990) notes how the "structure of my perceptual organs shapes that which I apprehend" (p. 1) and in doing so, move beyond Merleau-Ponty's primary concern with motility, to also consider the inner body. The inner body is characterized by experiential absence. Experiential absence refers to the notion that the inner workings of our body are often neglected in phenomenological accounts of the body because they remain absent from our attention when functioning as desired. Leder (1990) explains this by noting that the experience of our inner body relies on an interoceptive[8] vocabulary, which is not as well developed as our vocabulary to talk about our experience of the world through our exteroceptive[9] and proprioceptive[10] senses. Sensations of the internal organs often do not appear to us as discernable sensations. Instead the "visceral grip me from within, often exerting an emotional insistence", which becomes most clear at times of dysfunction (i.e. a stomach cramp, a headache, or the unrelenting need for defecation), where "an insistence and aversive call is needed to compel reparatory action" (Leder, 1990, p. 40). Hence, the inner body, like motility, becomes significant to perception as the condition that allows us to experience the world. Bengtsson (2013b) sums up this notion eloquently by writing that: "If something happens to our body, the world changes correspondingly. When we have a headache, the world is not accessible in the same way as it usually is, and if we lose our sight or an arm, the world changes in several respects" (p. 6).

4.1.1.2 Spatiality

With permanence also comes the occupancy of space. The body takes up space and moves in space. Yet the way in which the body extends in space is different from an object since the body is not an object, but rather the medium whereby the world comes

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[8] Interoceptive refers to all sensations of the internal organs of the body (the viscera) that are is capable of entering conscious experience (Leder, 1990)

[9] Exteroceptive senses refers to our five senses: touch, hearing, sight, smell, and taste (Leder, 1990)

[10] Proprioceptive senses refers to the sense of balance, position, and muscular tension (Leder, 1990)

into existence (Merleau-Ponty, 1963). Merleau-Ponty provides us with the following explanation:

> "If my arm is resting on the table, I will never think to say that it is *next* to the ashtray in the same way that the ashtray is next to the telephone. The contour of my body is a border that ordinary spatial relations do not cross. This is because the body's parts relate to each other in a peculiar way: they are not laid out side by side, but rather envelop each other […]. Likewise, my entire body is not for me an assemblage of organs juxtaposed in space. I hold my body as an indivisible possession and I know the position of each of my limbs through a *body schema* [un schema corporel] that envelops them all." *(Merleau-Ponty, 2012, p. 100-101)*

What Merleau-Ponty directs our attention to in the above passage is that the way we come to know the body is not as separate parts that are positioned next to each other like objects, for example, my hand next to my arm, or my toes next to my foot. My body parts enclose each other in a unity, and it is this unity that Merleau-Ponty calls *body schema*. Traditionally, *body schema* has been used to denote "a summary" of my bodily experience, or "center of images" that provides me with a global plan over my body (Thøgersen, 2004, p. 111, author's own translation of concepts). Merleau-Ponty disagrees with this conceptualization, and holds that a body schema is not a schema, which tells me the location of my limbs in relation to each other and the world. The schema is instead an expression of an integration of limbs and organs, where the unity proceeds the parts and where the unity becomes valuable in relation to the actions of the body in particular situations. This means that my body appears to me, not as a collection of limbs, but rather as a "posture toward a certain task, actual or possible" (Merleau-Ponty, 2012, p. 102). Therefore, the spatiality of our body can be characterized not a *spatiality of position*, but rather a *spatiality of situation*. While spatiality of position denotes that spatiality is based on a particular position in the room – that the body is here as opposed to there. Spatiality of situation on the other hand denotes a spatiality that is based on human participation in particular situations. That is, that the body is engaged with one task instead of another task in another situation. The spatiality of the lived body is a spatiality of situation, where our body appears to us as a posture or attitude towards an available or possible task. It is this attitude toward a task, which Merleau-Ponty calls body schema, where the body 'collects' itself in a unity in the effort to solve the task (Thøgersen, 2004). Over time, the manner in which the body collects itself to solve tasks can become habits. Habits are an expression of knowledge residing in the body and can be seen in how the body masters everyday situations. Habits ensure familiarity and the ability to act without conscious thought; for example, the students know where the tables are placed in the classroom, and act without further thought or consideration of the furniture. This familiarity is tacit or unreflective on an everyday basis, but if they came to class to one day to find it changed, then they would have to rebuild familiarity with the fact that the tables were regrouped. Yet, this familiarity would not concern the spatial position of the table, but familiarity with the situations the table forms part of, e.g. where to sit, who to sit next to, and the kind of work expected of them.

The above notion also extends to the general space we are situated in. We inhabit space and come to know it through the projects (desires/goals/necessities) that we thrust ourselves into (Merleau-Ponty, 2012). Therefore, a classroom is not a container for objects of experience (white board, tables, chairs, lab stations), but instead an “organic relation” based on embodiment (Thøgersen, 2004, p. 131, author's own translation). What this means is that a classroom, from an embodied perspective, is projected as a space because it provides me with a place where I can perform certain actions: I can watch the teacher at the white board, write, read, do experiments, and so forth. It is the possibility of all these actions, which extend the classroom as a human space, where I can move, learn, and express myself without thinking about my concrete position in the space. From a phenomenological perspective, the classroom is not a box that contains a collection of objects, but it is a unity of functions, which present me with possible actions (Thøgersen, 2004).

4.1.2. SUMMARY

I introduced section 4.1 by drawing attention to embodied identity *as representative of the argument that learning science is not a matter of disembodied acquisition of knowledge, but rather the experiences of individual bodies (Hwang & Roth, 2011a). Building on Merleau-Ponty’s ontology of the body, I have highlighted two different dimensions to show how embodiment shapes how we experience and understand the world. The concepts of permanency and spatiality show how having and being a body means being anchored in the world from a unique position where spaces and events in the world is perceived and experienced differently from others. Perceiving the world from a body that is my own, which is physically different from others and having lived through different experiences that reside in the body as habits, means I become familiar with the world in individual ways. This individual familiarity is not only a thought, felt or spoken way of understanding the world, but is visible in our very embodied actions (see article A for a more detailed discussion about the visibility of emotion in conduct). Through action, I come to be confronted with others, and in the confrontation with the other than the same come form an identity. Understanding the body from the perspective of Merleau-Ponty, is thus a matter of looking at the body as* somebody *rather than a view from nowhere (Shapiro, 1994) where bodies become a generic mass. In*

Table 2 below, I have summarized the central ideas of the first dimension.

Table 2: Embodied identity - Central ideas

Embodied pedagogy theme/ element	Underpinning concepts	Central idea
Body identity	**Permanency**	The body responds (enables and constrains) the perspectives about the world Bodies are different and different bodies grant different perceptions
	Spatiality	We come to know spaces such as classrooms through the projects that we engage in, for example writing, sitting down or doing experiments Spaces are characterized by particular routines and habits embedded in the body

4.2. BODY CONSCIOUSNESS

When participating in class, most actions that take place are based on habits and the familiarity of the spaces and situations that define the classroom. However, teaching and learning through and with the body necessarily entails foregrounding the body in ways where the body becomes the object of attention. Where the students must address their own embodiment, something which is often absent from consciousness (Leder, 1990). In this section, I elaborate on Merleau-Ponty's notion of *motor intentionality*, and building on American pragmatist philosopher Richard Shusterman identify another kind of intentionality, that is more distinctively cognitive and explicit, and which I talk about as *body consciousness*.

Although phenomenology and pragmatism have different outlooks (the study of metaphysics versus the study of practice), they do not exclude each other (Jordan, 2010). The two traditions hold similar views on experience, and Dewey (as a proponent for pragmatism and a great inspiration to Shusterman) and Merleau-Ponty share common understandings of the self. They see the self as intimately connected to the world, a self that cannot be defined in the abstract but who must be understood in its relation to the objective world. Merleau-Ponty's analysis of the self is explored through its immediate presence in the world, and the rootedness of being in the world and it is on this point that Merleau-Ponty and Dewey differ. For Dewey, the self is not a static metaphysical entity, something that is given and can be said to be possessed. It is something that you achieve through your actions in the world (Good, 2006). As such, Dewey was interested not in the immediate presence of the body (self), but in the process of growth, which can be characterized as a process of alienation where the Self encounters a problem (disruption), overcomes this encounter, and returns to a normal flow (Good & Garrison, 2010). In this process, the self experiences growth as he/she restructures his/her habits, which enable new perspectives on the problem. The self is thus constituted through these habits, yet not reducible to them as they rather determine the nature of the activity through which we present the Self (Good & Garrison, 2010; Good, 2006). It is this tradition that Shusterman comes from and against which his concept of body consciousness has to be understood.

Shusterman terms *somaesthetics* in 1996 (Shusterman, 2012), in search of an approach that examines the body as a site for developing awareness and through this, enhance one's quality of life (Jordan, 2010). It is a field that is "concerned with the critical study and meliorative cultivation of how we experience and use the living body (soma) as a site of sensory appreciation (aesthesis) and creative self-fashioning" (Shusterman, 2008, p. 1). As such, somaesthetics comprises both theory and practice, and aims to advance the practical utility of higher-level somatic[11] awareness and in doing so improve "one's cognition and capacities for virtue and happiness" (Shusterman, 2008, p. xii). Connecting to Merleau-Ponty, Shusterman argues that the body constitutes a fundamental dimension of our identity in forming the primal perspective or mode through which we come to engage in the world. It (the body) determines (often unconsciously) our "choice of ends and means by structuring the very needs, habits, interests, pleasures, and capacities on which those ends and means rely for their significance" (Shusterman, 2008, p. 3). While the body is mostly transparent and not an object of awareness, in times of difficulty the character of our experience of the body changes from an experience of something than I *am* to something that I *have* and *use* (Shusterman, 2008, p. 3). In such situations where the body fails to perform (dysfunctionality in its broadest sense)[12] and where it no longer functions effortless but must be commanded, the body becomes thematized.

[11] Shusterman uses the word *soma* rather than *body* to "emphasize the living, feeling, sentient, purposive body, rather than a mere physical corpus of flesh and bones" (Shusterman, 2008, p. xii)

[12] While Shusterman is primarily interested in dysfunction from the perspective of somatic rehabilitation, where dysfunctions appears as misconceptions in body image, e.g. the belief that I am sitting up straight, when in fact my back is rounded (Shusterman, 2008). This thesis adopts an understanding of dysfunction in relation to science education, where dysfunction is seen as the inability (physical or perceived) of performing a particular task connected to the learning activity.

Merleau-Ponty does not linger over the thematized body. He argues that expressive reflections on the body hinder further exploration of the lived body (Merleau-Ponty, 1964b). The argument for this ties back to the concept of body schema. In the body schema, Merleau-Ponty finds a collective attitude or orientation of the body towards a task. Tasks are everyday actions such as biking, writing, or reading that we are not consciously aware of doing, but just do (c.f. habits). According to Merleau-Ponty, this shows that there is an intentionality connected to movement that is unconscious, even primordial, and this is what he refers to as *motor intentionality*. Motor intentionality is an embodied intentionality that highlights how we orient ourselves in the world from a situated praxis – acting here and now in response to the surroundings. It is not a conscious relationship (*I think*), but an embodied relationship (*I can*), which reflects a primordial form of intentionality – a precognitive encounter with the world. The precognitive intentionality of the body is exemplified by Merleau-Ponty in the example of a mosquito that bites my neck. When bitten I move my hand up to scratch the itching area. This movement is not a conscious act. It is a spontaneously experienced connection between my hand, which possesses the ability to scratch, and the place on my neck, which is the area for scratching. The operation of my hand takes place on a phenomenal level. Hence, the body and movement is not a vessel for a separate consciousness. Rather the body and movement are intermediaries that link consciousness and the world. In other words, the body is placed as the locus of intentionality, as a kind of pure presence in the world that is open to its possibilities. Through movement, the most primordial intentional act, is the orientation of the body to and movement within its surroundings. As such, there is a world for a subject in so far as the body as capacities can appropriate its surroundings as intended (Young, 1980). As Merleau-Ponty is interested in this primordial, unreflective experience, he does not grant reflective thinking space because such thinking "inevitably change our basic experience by introducing categories and conceptual distinctions that were not originally given" (Shusterman, 2008, p. 65). Shusterman on the other hand, while recognizing the centrality of primordial and unconscious intentionality, places the reflective, thematized, and categorized body at the heart of his works in seeking to revitalize the role of conscious somatic sensation. Conscious somatic sensations are explicit and experiential sensations of the body that include feelings, observations, visualizations, and metal representations of our body and its parts (inside and outside) (Shusterman, 2008). The explicit and/or represented character is what distinguishes this kind of sensation from the "primary consciousness" (Shusterman, 2008, p. 53) that Merleau-Ponty advocates. As such, sensation takes on a very broad connotation, as it denotes not only sensations such as hunger, pain or pleasure, but also perceptions of different bodily states that are, what Shusterman calls "distinctively cognitive" (2008, p. 53), which does not share the same affective character as the above mentioned sensations. An example of the latter could, for example, be a somatic attention towards the movement of a limb, the feel of force on a joint, or noting the quality of a sound that hits our body. Explicit body consciousness can be characterized in two distinct ways. On the one hand, this consciousness can be dominated by external and distal senses (e.g. hearing, seeing, smelling), and on the other hand by internal bodily senses such as proprioception and kinaesthetic feelings. For example, the location of my hand can be noted by looking at it and noting its orientation. Yet I can also close my eyes and try to proprioceptively feel the location of the hand in relation to my other body parts, and the pull of gravity in relation to other objects that are present in my field of experience such as the floor or table.

Shusterman lists four different kinds of consciousness (Shusterman, 2008, 54ff):

- The foundation of our being is made up of **primitive modes of grasping** that we are not consciously aware of, what Merleau-Ponty refers to as "corporeal intentionality" (Merleau-Ponty, 1964, p. 89). Shusterman provides us with the example of sleeping. While we sleep, if our mouth and nose comes to block our breathing, we would typically turn our head or push away the pillow or obstructing object. This is an unconscious adjustment of behavior, and although it may not seem like an act of perception, the action still demonstrates a purposive understanding and intentional action.
- A second level of bodily consciousness could be described as **conscious perception without explicit awareness**. This kind of consciousness is present in situations where I consciously perceive, but do not direct my perception at something particular; that, is my perception does not thematize a distinct object in my consciousness. This kind of marginal or recessive consciousness can be compared to the experience of tuning out. To tune out means to cease pay attention to something or someone, and is a state of consciousness where we are aware of perceiving, but do not hold a particular thing as the object of our perception.
- Perception can be raised to a third level, **conscious somatic perception with explicit awareness,** where I am conscious and explicitly aware of what I perceive. When in a state of excitement, I may experience a shortness of breath. At the second level of consciousness, I would be aware of the experience, but not make the shortness an explicit object of my awareness (both visually and proprioceptively) as I would at the third level. At this level, I might recognize the forced heaving of my chest, the pumping of my heart, or sound of my breath when inhaling and exhaling. Such explicit conscious somatic perception, would from the perspective of Merleau-Ponty be recognized as a level of mental representation (thematization) (Shusterman, 2008).
- While the first three layers can be recognized in the works of Merleau-Ponty, the fourth layer is proposed by Shusterman. In the fourth level of

consciousness, we are not only conscious of what we perceive as a distinct object in our awareness, we are furthermore "mindfully conscious of this focused consciousness as we monitor our awareness of the object of our awareness through its representations in our consciousness" (Shusterman, 2008, p. 55). This level is called **self-conscious** or **reflective somatic perception with explicit awareness**, and denotes that we in this level of consciousness are not only aware of the character of our breath and how we are breathing. Instead, we become aware of how our self-consciousness affects the act of breathing, attentive awareness and related feelings.

For Shusterman the purpose of distinguishing between different levels of somatic awareness is to draw attention to the last two higher or representational levels of consciousness. By honing and developing these two levels, he argues that we can become more mindful of our perception, which will help us perform better in our lives by e.g. adopting a better posture and relieve back pains, or feeling the onset of stress before we fall sick. In the context of education, Shusterman's different levels of consciousness affords a sensitivity to the different ways students are present in learning activities. It moves the focus from the relation between the perceiving student and the world, to the relation between the perceiving body and the body of the perceiving student.

4.2.1. SUMMARY

I introduced section 4.2. by drawing attention to body consciousness as a way to approach a body that learns and grows through experience with the surrounding world (Dewey, 1938). Body-consciousness represents the argument that learning calls for bodily states that are distinctively cognitive in comparison to the embodied, primordial intentionality heralded by Merleau-Ponty. Building on Shusterman's somaesthetics, four different kinds of body-consciousness have been sketched out to show the nuances in how we are conscious of ourselves. In

Table 3 below, I have summarized the central ideas of these dimensions.

Table 3: Body consciousness - Central ideas

Embodied pedagogy theme/ element	Underpinning concepts	Central idea
Body consciousness	**Primitive modes of consciousness**	Unconscious adjustment of behavior
	Conscious perception without explicit awareness	Consciously perception, but not directed at anything in particular/ tuning out
	Conscious somatic perception with explicit awareness	Conscious and explicit awareness of what is perceived/ explicit conscious somatic perception/ level of mental representation
	Self-conscious or reflective somatic perception with explicit awareness	Mindfully conscious of a focused consciousness/ awareness of how our self-consciousness affects our bodily state

4.3. BODY LEGITIMACY

Students may, for different reasons, fail to perform certain tasks. In some cases, their bodies may fail to perform. They may lack the necessary fine motor control to conduct experiments or suffer an injury that prevents them from running or jumping. However, in some cases it is not a failure of the body that inhibits participation, but rather an anticipated inability to perform according to the perceived expectations to the social rules, norms, and values in the environment. Bodies are always taught to behave in certain ways no matter the scene (Brook, 2000; O'Farrell, Meadmore, McWilliam, & Symes, 2000). This is no different in science education that suffers from the long standing Cartesian tradition separating reason and feeling (Alsop & Watts, 2003), where bodies are schooled in particular ways to become something that is present in order to "cognitively develop concepts" (Almqvist & Quennerstedt, 2015, p. 451). In what follows, I develop this line of reasoning to discuss why certain forms of movement are recognized as acceptable behavior, while others are deemed deviant. I build on French sociologist Marcel Mauss' (1872-1950) concept of *body techniques* and the broader works of Canadian sociologist Erving Goffman (1922-1982). In particular, Goffman's attention to how interaction is framed by social rules, norms and values is of central interest to this study, as he in many ways contributes with an operationalization of Merleau-Ponty, by extending the functionality of the body onto a social arena (Crossley, 1995).

4.3.1. 'BODY TECHNIQUES'

Mauss (1979) developed the concept of 'body techniques' from observations of mundane activities such as eating, talking, and walking. In his observations he noted how these practices varied for different groups of society, e.g. how women walk differently to men, or how British troops dug differently compared to the French military (Mauss, 1979). This led to the formulation of the concept of body techniques, which is defined as "the ways in which from society to society men [sic] know how to use their bodies" (Mauss, 1979, p. 97). Body techniques were described as specific sets of movements or forms acquired by means of *training* or *education* that serve a purpose or function. Mauss argued that even the most mundane of everyday activities, such as walking and sitting, are based on historically and culturally situated "corporeal-cultural techniques" (Crossley, 1995, p. 135). Mauss developed his definition on the following premises: (1) body techniques are social practices derived from collective life, and they are social in two respects. On the one hand, body techniques outlive the individual, as they are learned and passed on through generations, and on the other hand, they emerge out of interactions and are not inventions of the individual (Crossley, 2007). (2) Body techniques reflect the embodied, incarnate structure of our being (Merleau-Ponty, 2012). We dig the way we do, in part, because of the structure of our organs and the way in which they function in concert. Our physicality both constrains and potentiates particular exercises of the body (Crossley, 2007). (3) Body techniques are not a mindless matter of producing patterns of movement, but a way of understanding. To learn how to bike, is for example not reducible to mechanistic movements (Crossley, 2007), but also entails grasping the principles of balance and propulsion, and to apply them in innovative ways in particular situations. Following these premises, body techniques can be said to form part of practical reasoning, and embedded in cultural contexts where they are regulated through ideas of what counts as normal and rational (Crossley, 2007). In specific educational situations some body techniques are regarded as more legitimate than others, for example yelling or running is expected in physical education, while in other contexts such as science education this would seem an odd behavior (Almqvist & Quennerstedt, 2015; Larsson & Quennerstedt, 2012). Hence participating in physical education or science education can be seen as forms of practical understanding, and the study of body techniques can elucidate and grant insights into embodied understanding and meaning (Crossley, 2007).

While Mauss contributed to establishing the concept of 'body techniques' as a socially scientific concern, he is criticized for analyzing body techniques in the abstract independently of the circumstances of their exercise (Crossley, 1995). In failing to recognize the situations and conditions of exercise, he treated body techniques as "historical and biographical acquisitions (which they are) but not as on-going practices which accommodate the anticipated exigencies of a present and a future (which is also true)" (Crossley, 1995, p. 135). Walking, from the perspective of Mauss, is a body technique that is socially variable, and which express different social status, where gait and symbolic significance are key to the socialness of walking. However, from the perspective of Goffman, walking is not just a matter of demonstrating a particular technique of the body, but has to be considered within a situation where the activity of walking is acknowledged and reproduced in conjunction and coordination with others taking part in the same activity (for example pedestrians). As such, walking is not just walking, but can be seen as a particular kind of behavior (pedestrian behavior) shaped by the setting, rules and values, and the manner in which social occurrences are managed or avoided. According to Goffman, it is only in the abstract imagery of the human sciences that techniques such as walking can assume a generalized and decontextualized form. In everyday life, body techniques are dependent upon their exercise, which is always conditioned by particular circumstances they must accommodate in order to be competent actions (Crossley, 1995). As such, we can talk about walking (or any other technique of the body) as essentially *acting*, where the surroundings form a stage on which the person performs. In what follows, I develop this reasoning by drawing on Goffman's dramaturgy.

4.3.2. GOFFMAN AND THE THEATER METAPHOR

Goffman (1959) uses metaphors from dramaturgy (theatre metaphor) as a resource for understanding and talking about how and why people act in the way they do (everyday interaction). The theatre metaphor originates in the ascertainment that life often assumes the character of a theatre, where people put on a play, adopt facades, manipulate and display emotions with a certain purpose in mind (Jacobsen & Kristiansen, 2002, p. 88). Goffman was the first sociologist to assume this perspective. However, it is important to bear in mind that despite the theater metaphor, Goffman does not see the daily interactions of humans as acting. Instead, he uses dramaturgy as an analytical metaphor to analyze interaction, as was it a play. It is not the great actor's performance that occupies Goffman, but the minute staging of one self, while simultaneously supporting others in their impression management. He delineates as a basic principle that we all respectively act as both performer and audience, where the individual presentation and the reaction of the audience together constitutes the theatre of life (Goffman, 1959). This is known as microfunctionalism (Gouldner, 1970), where the individual performances of the actors, the collaboration of teams, and the reactions of the audience together underpin the theater of everyday life as a unity. When we act, we each do so on the basis or inclination of wanting to make a certain impression on those present in the social context, and that this impression is received in a particular way. The intention behind the desire to present oneself in a particular manner can be different, but the fact remains that this is the way in which we manage our impression and hence the identity we portray to the world. In the meeting between the teacher and the students, the students may intend to signal a high commitment, although this perhaps does not resonate with how they really feel about science education. Yet they seek to present themselves in a manner that aligns with the values in the subject in order to perform well. According to Goffman, the reasons are, regardless of intentions the performer wishes to display, to control the way in which others perceive oneself (Goffman, 1959). His use of dramaturgy as an analytical tool to examine everyday life does not indicate a perception of everyday life as particularly dramatic. On the contrary, like the interaction between teachers and students that occur many times on a daily basis, he describes everyday life in general as relatively undramatic, trivial and characterized by meaningless and fleeting social relations (Jacobsen & Kristiansen, 2002). Still, in their own subtle way, everyday (inter)actions can be characterized as small dramas where we struggle to maintain a particular impression, struggle to adhere to the norm and values of the particular society. Because action is *other* oriented (Goffman, 2010), and like identity can only be understood on the backdrop of the alterity it recognizes and informs (Crossley, 1995, p. 141), notions of deviance and normality also only come into being in conjunction with the *other*. The same can be said for the discussion in section 4.2 concerning dysfunctional bodies. When bodies are dysfunctional, there is a failure to perform in given situations due to impairment or abnormal functioning of the body or behavior ("Dysfunction," 2018). Yet, building on Goffman, dysfunction need not be limited to physical impairments as was the focus of Shusterman's works. Dysfunction can more broadly be seen as the inability to perform according to basic rules, norms, and values in society, where the notion or experience of dysfunction is created in the face of others. These basic rules, norms, and values are most often not explicated, but exist as underlying ideals in the particular society, and govern what we deem right and wrong, normal and deviant. As such, parallels can be drawn between the notions of dysfunction and Goffman's concept of stigmatization, which builds on the idea that persons with stigma, embody a characteristic or feature that is deeply discredited. Basic understandings of normality and deviance form part of the intersubjective foundation for our actions (Goffman, 2009), and thus constitute the (unconscious) paradigm on the basis of which e.g. students and teachers interact on. Following Goffman (1959), understandings of normality and deviation are thus central to how we interact in everyday life, which also comprises opinions about bodies as (il)legitimate and (ab)normal in given situations.

4.3.3. SUMMARY

Section 4.3 draws attention to the social and cultural circumstances that shape interaction, and which are key to how we come to experience our own bodies and the world. Mauss' concept of body techniques focuses on an understanding of movement as particular corporeal-cultural techniques that reflects social, physical and mental aspects of living. Goffman further develops this understanding by emphasizing how the use of body techniques are not just cultural and historical, but also conditioned by the particular circumstances they must accommodate to be competent actions.

Goffman uses the theater metaphor as a means to conceptualize interactions and to consider how embodied beings make sense the activities they are engaged in. In Table 4 below, I have summarized the central ideas of these dimensions.

Table 4: Body legitimacy - Central ideas

Embodied pedagogy theme/ element	**Underpinning concepts**	**Central idea**
Body legitimacy	**Body techniques**	Movement is culturally and historically variable, and learnt through training/education to meet certain purposes Movement can be seen as practical reasoning that is embedded in a cultural context, and thus regulated by what counts as right or wrong Movement is a way of regulating social interaction whereby social occurrences are managed or avoided
	Theater metaphor	Interaction is conceptualized as a stage on which people perform to maintain and manage the impression they give of
	Stigma	Society uses preferred/ desired ways of embodied being. People who embody these, and those who seem not to conform are deemed deviant Perceptions of embodied normality/deviancy shape how we see ourselves

4.4. SUMMARIZING THE DIMENSIONS

The purpose of this chapter was to arrive at a conceptualization of the body that sensitizes the researcher and provides a language for analyzing how embodied aspects of being *matters* to how we experience and act in the world. For this purpose, three dimensions were identified: *embodied identity*, *body consciousness*, and *body legitimacy*. These three dimensions serve as analytical categories, and, while stemming from distinct theoretical starting points (phenomenology, pragmatism, and sociology), they inform and enrich each other. Merleau-Ponty provides what may be termed the most 'basic' understanding of embodiment in his formulation of an ontology of the body. Shusterman supplements, deepens, and challenges Merleau-Ponty in arguing for more explicitly cognitive ways of being, while Goffman anchors our being in a social and cultural world.

Concerned with providing a framework that positions students as embodied, situated, and sensitive to the context in which they are placed in, this chapter does not consider science education specifically. This is done in chapter 6, which applies the theoretical framework in an analysis to identify how the body becomes meaningful in science education. The findings are discussed in chapter 7 and used to substantiate an expansion of the above tables to include science education in chapter 8.

CHAPTER 5. METHODOLOGICAL CONSIDERATIONS

In the previous chapters, I have introduced the study, its research questions, and the background. I have reviewed existing research on the role of the body for learning in science education, and introduced the theoretical concepts which inspire this study. The next question addressed is *how* to conduct research on how movement becomes meaningful in educational settings. In what follows, the methodological approach to the study is firstly presented. Key terms are interpretivism, snapshots, and sociocultural theory. Secondly, the data sources are discussed, which include video observations, interviews, and collection of written materials and field notes. Thirdly, the chapter presents the process of analysis. This section includes a summary of article C, which presents the methodological framework utilized in this study for analyzing video. The chapter concludes with a discussion of research validation and ethical considerations.

5.1. STUDY DESIGN: EXPLORATIVE AND INTERPRETIVE

Methodology is a general approach for studying a research topic that deals with the overall principles or axioms of the generation of new knowledge (Cohen, Manion, & Morrison, 2011; McGregor & Murnane, 2010), and forms the link between ontology, epistemology, and theory that informs the research and practice of researching (Hetherington, 2013). Consideration about ontology is central to research because it gives rise to the way in which we enquire and research the nature of reality and how these things appear to us (Hitchcock & Hughes, 1995). In the search for truth or the nature of the phenomena studied, two overarching conceptions of the nature of social sciences have been developed and honed. These are positivism and interpretivism. Spradley (1980) describes the differences between these approaches using the metaphor of a petroleum engineer and an explorer. He argues that most social scientists operate in a way that resembles a petroleum engineer. They are already in possession of in-depth knowledge and know where and how to look for what they are searching for, and they work in linear or sequential ways. This stands in contrast to the explorer, who is trying to map unchartered wilderness, building on little or no prior knowledge of the area. While the engineer works to discover oil, the explorer seeks to describe what is found (Hitchcock & Hughes, 1995; Spradley, 1980). In the dissertation, where I study how movement becomes meaningful in science education – a field lacking in research, as noted in chapter 3 – I identify with the explorer (interpretative paradigm) as described by Spradley below:

> “The ethnographer has much in common with the explorer trying to map a wilderness area. The explorer begins with a general problem, to identify

> the major features of the terrain; the ethnographer wants to describe the cultural terrain. Then the explorer begins gathering information, going first in one direction, then perhaps retracing that route, then starting out in a new direction. On discovering a lake in the middle of a large wooded area, the explorer would take frequent compass readings, check the angle of the sun, take notes about prominent landmarks, and use feedback from each observation to modify earlier information. After weeks of investigation, the explorer would probably find it difficult to answer the question, 'What did you find?' Like an ethnographer, the explorer is seeking to describe a wilderness area rather than trying to 'find' something." (Spradley, 1980, p. 26, emphasis added)

Adopting the role of the explorer has meant for this study that I approached the science classroom not knowing what to find, but rather, through the theoretical lenses described in chapter 4, seeking to document how movement becomes meaningful in a social reality (science education) that foregrounds an embodied pedagogy. As such, this study can be characterized as an ethnographic study, where I seek to portray events in subjects' terms, report multiple perspectives, and through description and explanation seek to understand specific situations (Cohen et al., 2011). An ethnographic study is of value to educational research because it has the potential to capture the "richness, complexity, connectedness, conjunctions and disjunctions" that characterize the social and educational world (Cohen et al., 2011, p. 219).

The meaning of movement in science education is studies through *snapshots*, which can be described as analysis of particular situations, events, or phenomena at a single point in time (Cohen et al., 2011, p. 223). Through snapshots, particular situations are identified where the body in different ways come into focus in the interactions that unfold, enabling an analysis of how students make sense of movement in these situations.

In this dissertation, interactions are understood within a sociocultural framework. A sociocultural approach concerns the way in which human action is intrinsically connected to the institutional and historical setting within which it takes place (Wertsch, 1994). Adopting a sociocultural perspective on science education seeks to understand and research science education as "human social activities conducted within institutional and cultural frameworks" (Lemke, 2001). From this perspective, there is a general assumption that multiple realities exist, and that the symbolic, social, temporal, historical, material, and cultural contextual resources that humans have access to shape the construction of reality (Wertsch, 1994). However, the attribution of meaning through shared resources is always engaging in a state of flux and is, as such, subject to change as actors take agency (Cohen et al., 2011; Sewell, 1999). As such, I rely on the definition of meaning-making provided by Lemke (2001). He argues that meaning making is a "material process, transactive between persons and things, that does not belong to an autonomous Cartesian parallel universe of purely mental realities", indicating an understanding of meaning making that is more than reasoning, but also an “aspect of total human activity that is also bodily and rich in affect” (p. 309). The significance of this understanding for the study is that the events and interactions studied, where the students’ bodies came into focus in different ways, cannot be separated from the setting that they occur in. They were co-constituent of the meaning making processes reflected in the actions of the students, in terms of not only their presence, but also how the students related to them. This means that the configuration of desks, layout of the room, the time of year, etc. may all potentially influence the interactions that took place.

In this dissertation, lending from interpretive approaches where interactions are thought of as “behavior-with-meaning” (Cohen et al., 2011, p. 17) in combination with a focus on embodiment led to a conceptualization of interactions as essentially movement-with-meaning. Movement-with-meaning (or action, which is used from here on forward) stands in opposition to positivist traditions where behavior refers to responses from the external (e.g. another person, demands of society) or internal environment (e.g. hunger or pain). Rather than trying to understand the stimuli that cause certain behaviors, I am interested in understanding how people interpret and make sense of the world around them (in this study science education), and how movement becomes central in this process. As such, actions are only meaningful to the extent that we are able to ascertain the intentions of actors to share their experiences (Cohen et al., 2011). This also means that not every action is considered relevant to the study, but only those actions where the intentions of the actors can be ascertained.

Ascertaining intentions rests on the premise that social actions can be understood from the point of view of the actor, from a subjective perspective (Cohen et al., 2011; Knoblauch, 2009). A subjective perspective does, however, not limit research to exploring subjective meaning, but also allows for the opportunity to access objective shared meanings (Knoblauch, 2009) that arise from the interaction of subjective meanings[13]. According to Knoblauch (2009), the study of visible social interaction, is

[13] Such an argument rests on the premises of a social construction of reality, which Berger and Luckmann (2004) describes as a dialectics of externalization, internalization, and objectivation. They argue that there is an institutional world, characterized by a “reciprocal typification of habitualized actions” (Berger & Luckmann, 1966, p. 72) by particular types of actors. The institutional world is experienced as an objective (externalized) reality. It is external to the individual regardless of acknowledgement. The normativity of the externalized world is a product of human interaction, and despite the objective or even ontological status that it might have, it cannot be set apart from the human activity that produced it. The relationship between the creators and the institutions as the product is ongoing, and externalization and objectivation are as such moments in a continuing dialectical process. In the process of socialization, the objectivated world finds its way back in to the individual through experience, and on the

foremost the study of actors objectifying their meanings and their coordination of actions and their meaning of these actions. For this reason, combined with the importance of studying the social phenomenon (movement) in its natural setting as context is heavily implicated in meaning (Cohen et al., 2011), video was chosen as the primary source of data.

Video captures visible social interaction and accounts for the fact that interaction cannot be reduced to just verbal exchange, but is also dependent on physical and temporal properties (Knoblauch, 2009). Supplementing video data with ethnographic data (interviews, field notes, and collection of teacher produced materials) helped to explain more fully the richness and complexity of the social phenomenon, and through this process of triangulation, increase the validity of the study (Cohen et al., 2011).

The following section introduces the data sources used to make visible and capture snapshots of interactions where the students' bodies come into focus.

5.2. DATA SOURCES

Different types of data were collected as part of this study. These included video data, interview data, and collection of written material and field notes. The particular approach adopted to each of these methods in this dissertation is described below.

5.2.1. VIDEO OBSERVATIONS

Video observation is often a part of ethnographic research (Raudaskoski, 2010), and was chosen in this study because it captures visible social interaction in ways that capture not just talk, but also physical and temporal properties (Knoblauch, 2009). Video embodies many merits in terms of enabling research, such as providing researchers with powerful 'microscopes' (Derry, 2007, p. 6) that capture and retain 'unfiltered' (Simpson & Tuson, 2003, p. 51) interaction in great detail, which facilitate comprehensive analysis and reanalysis by various researchers across fields. According to Heath and Hindmarsh (2002); video provides the resources to capture the "tacit, 'seen but unnoticed' character of human activity and social organization" (p. 8) that in many ways are at the heart of this study, where the body that is often absent from conscious thought (Leder, 1990; Merleau-Ponty, 2012; Shusterman, 2008) is in focus.

This study adopts a particular approach to working with video situated in a qualitative interpretive research paradigm, called *videography*. Videography was born out of the

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backdrop of the institionalized social world which s/he is a part of, interprets and finds personal meaning (internalization) (Berger & Luckmann, 1966).

realization that studies in the social sciences often augment or complement their video data collection and analysis with ethnographic data such as field studies and participant observation (Knoblauch, 2012). The central argument is that the habitualization, routinization, and institutionalization of actions make it possible for others to understand them as meaningful, yet, as objectified as meanings might be “they are always related to someone who needs to understand them” (Knoblauch, 2009, p. 185). Hence, ethnographic knowledge becomes a central resource in interpreting video data in fields where implicit and tacit knowledge of actors needs eliciting in order to understand the action at hand, or in fields where the visual is more prominent (Knoblauch, 2009, 2012). As such, videography combines video analysis with ethnography for an interpretive procedure for the analysis of communicative actions (Knoblauch, 2009, 2012; Knoblauch, Tuma, & Schnettler, 2015). In contrast to conventional ethnography, a focused ethnography (videography) typically does not aim to encompass large, locally distributed social structures such as schools or even villages, and is characterized by a shorter stay in the field, where particular situations are recorded and supplemented by other kinds of data (Knoblauch, 2012; Knoblauch et al., 2015). This type of ethnography has been critiqued to be superficial or quick and dirty, yet such criticism ignores the amount of data generated over a relatively short period, as well as the labor intensive and detailed analysis that is unprecedented in conventional ethnographies (Knoblauch, 2005; Knoblauch et al., 2015).

5.2.1.1 Videography

This study utilizes videography to capture the social reality in question, here the integration of movement into science education. The core of videography is formulated in a single sentence by Knoblauch, Tuma and Schnettler (2015) as: “Researchers go ‘to the field’ and focus the video camera on everyday situations in which actors act, and they analyze how they act” (p. 20). As such, videography is a holistic approach to working with video that encompasses considerations about the different stages of research (entering the field, focusing the camera, and analyzing data) as well as considerations about the role of the researcher. Different stages shape the conditions for capturing social reality and this is described next.

The first part of the above quote, *researchers go to the field*, indicates that the researcher physically enters into the location where the observation is to take place, and observes what takes place. A field is a place associated with a particular body of knowledge, communicative forms, rules, spaces, and so forth (Knoblauch et al., 2015). The observations are to some degree participatory, because the observer participates by experiencing the field, by talking with people, physically sensing the culture and environment, and seeing what takes place. The kind of expertise or knowledge developed by going into the field can in a general sense be referred to as ‘ethnography’. The ethnographic knowledge provides insights into implicit and tacit knowledge that is useful and necessary to understand the action in the video. This kind of knowledge is not to be equated with the audiovisual data generated by video, but as expertise that guide and qualify analysis (Heath & Hindmarsh, 2002; Knoblauch, 2012).

In order to participate actively without causing unnecessary disturbances, some initial considerations about how to act is called for. As this study was conducted at a primary school, consideration about how to act around the particular age group was called for. Fine and Sandstrom (1988) argue for an indexation of childhood into different age groups when portraying children as social actors. They divide children into three age groups: preschoolers, preadolescents, and adolescents. This study considers the integration of movement-based learning activities into adolescent classrooms. Adolescents as a group is characterized biologically as the physical transition marked by the beginning of puberty and termination of physical growth (Arnett, 2007). Physically, major changes include changes to height, weight, muscle mass, sex organs, and major changes in the brain structure and organization. Cognitively, adolescents mature, enabling them to understand themselves better, and with this also others (Arnett, 2015), while socially they enjoy what Arnett (2007) calls "their self-focused freedom from role obligations and restraints, and they take satisfaction in their progress toward self-sufficiency" (p. 70). With changes in age (i.e. the physical, cognitive and social changes age entails), the demands of and role held by the researcher changes accordingly. As children grow older the authority of the adult (researcher) is downplayed, which becomes visible in the levelling of physical height and their ability to orient themselves in the surrounding environment.

Video observation is described by Schubert (2006) as a way of *focusing*. What is captured on film as a result of a particular focus can be described as a product of the researcher's knowledge about a certain field, prior theoretical assumptions, the peculiarities of the context and situation, and the technology. In terms of using video observations in the classroom, there was a matter of the light, which affected the perspective of the camera. As shown in Figure 1 (right image) most of the back wall, which was opposite the teacher's desk and interactive board, was a section of windows. The light affected the quality of the image, which meant I had to adopt the

Figure 1: The back wall of the classroom (image to the right) and the camera angle when capturing the entire class (image to the left)

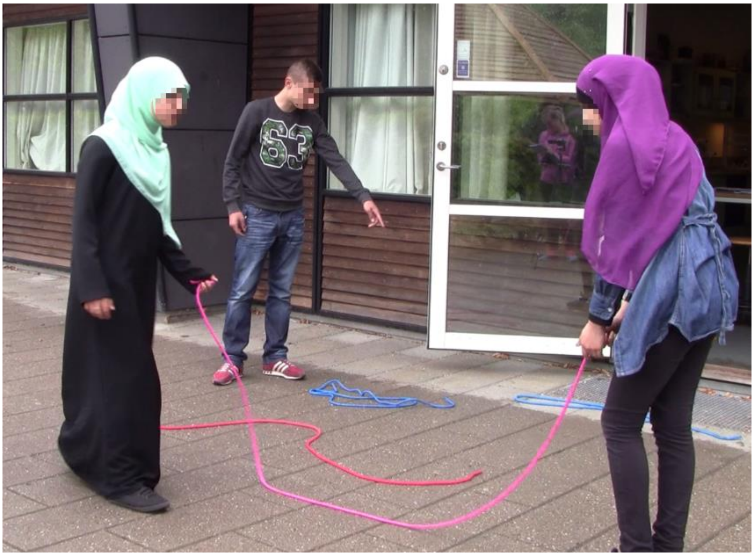
perspective of the students looking towards the interactive board. In order to capture the whole class I had to move quite far back in the room (Figure 1, left image), which meant that the sound quality decreased and the possibility for getting a clear image when zooming in on minor actions accordingly difficult.

Video observations of group work can be challenging since activities may be dispersed across the setting (Heath et al. 2010). In this study, the strategy adopted was to focus on the physical phenomena the students were asked to produce as the core of the activity was adopted. For example if the students were working on an experiment involving lab work, the camera would focus on the location at the lab station where the students were working with the experiment. In this case, I would use a narrow frame, and only capture e.g. the upper bodies of the students (see Figure 2).

Figure 2: Example of capturing interaction from a narrow angle

However, when the production of the phenomena involved more movement, the camera would use a wide frame and capture as much of their bodies as possible, and as many of the students as possible (see Figure 3).

Figure 3: Example of capturing interactions from a wide angle



Technology affects the way in which we collect, construct, analyze, and interpret data (Schnettler & Raab, 2008), and although technology is not considered an "autonomous actor" (Rammert & Schulz-Schaeffer, 2002 as cited in Schnettler & Raab, 2008). The camera contains a "built-in epistemology" (Knoblauch et al., 2015, p. 42), in its ability to record portions of what can be seen and heard. These recordings are the substance of video analysis, and are accessible in ways not possible in traditional participant observations, as they permit observers to view the event innumerable times, to alter temporally the speed of execution by viewing in slow motion or rapid winding. Such features allow fine grained analysis unavailable to the naked human eye (B. Jordan & Henderson, 1995; Knoblauch et al., 2015), yet they also frame what can be analyzed and how. As such, the camera limits what can be seen and heard. By pointing the equipment at one object and not another, by adjusting the angle, and setting audio levels a perspective is granted over others. This influences the record produced by the camera, and the interpretation available upon viewing the record.

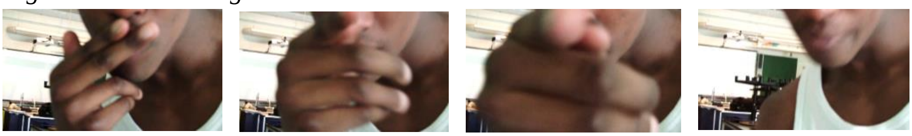
Videography focuses on capturing natural social situations, which are characterized as events in time that involve actors engaged in everyday life that would occur without the presence of an observer or camera (Knoblauch et al., 2015). The naturalness of data is concerned with the question of whether or not what is captured on video is an expression of everyday practice, or is influenced by the presence of the camera. In interpretative video analysis, natural data is not identical to data found by natural scientists, as it embodies an interpretative character (Schnettler & Raab, 2008). Natural data instead refers to recordings of social situations that were affected as little as possible by the researcher (Silverman, 2005). Since this study sought to record spontaneous activities that are unsolicited by the researcher , the socially constructed reality that was recorded during the video observation could be characterized as 'natural' (Lynch, 2002).

However, people react to the presence of a camera or observer, which is commonly described as 'reactivity'. This challenges the degree of naturalness of the data obtained (Laurier & Philo, 2012). Reactivity is not viewed as a problem per se in videography for several reasons. If participants react to the camera by glancing or showing discomfort, this too is an empirical observation that can inform the analysis. In addition, the camera record interactions, no matter the nature or orientation of these interactions (Knoblauch et al., 2015). What is recorded forms the basis for the analysis, and by considering the *actual*, rather than imagined (Heath, 1986), the focus is structured by the field and the actors in it (Knoblauch et al., 2015).

Heath notes that "If we are to make an empirical case for the effects of recording on interaction, then we need to demonstrate an orientation by the participants to the production of their action and activity to some aspect of the recording equipment" (Heath, 1986, p. 176, quoted in Lomax & Casey, 1998). Building on recordings of doctor-patient interactions, Heath (1986) explains how a child's shifts in gaze bring a disguised camera's presence into play. With this he shows us how the camera is omni-present, but not omni-relevant. Jordan and Henderson (1995) note how being filmed matters to the participants, but that people habituate to the camera as time passes by. They draw on examples of toddlers and police officers to note how there is an initial response to the camera, but that when play arises or when things heat up the camera is forgotten and participants turn to their everyday way of acting.

Such actions, where participants show overt reactivity towards the camera point to an incompleteness that, unlike much of the other activities present in the video material, is only made complete with the presence of the observer (the camera and indirectly the researcher) (see example in Figure 4).

Figure 4: Adi reacting to the camera



Laurier and Philo (2012) write how, in reverse, the records in which the participants do not show any signs of reacting to the presence of an observer are deemed complete because of the very lack of reactivity. Yet their completeness is also founded in the observer's presence in the daily work of analyzing video clips and sorting them, not through their being "self-contained, self-presenting or self-evident" (p. 189). Hence, the idea of capturing the 'natural' is in ways an illusion, as both the camera and the process of selecting footage shapes what is considered natural. I therefore turn to

Lomax and Casey's (1998) work; they consider the ways in which the video becomes part of the organization of fieldwork. By considering participants' displays of sensitivity to what is put on record, Lomax and Casey draw our attention to how such displays, rather than disrupt the naturalness of the records, instead inform the fieldwork in revealing how the participants see their status as objects of a particular record, which captures certain aspects and preserves for subsequent research.

5.2.2. INTERVIEWS

As noted above, videography entails supplementing video with ethnographic knowledge. One of the sources of ethnographic knowledge in this study is interviews. Interviews provide a key source of data in granting information about the meanings of social fields which the participant enter into a situation with. In the words of Knoblauch (2009) actions become "fixed patterns that are habitualized by actors, objectified in signs or culture and technical artifacts (and legitimized by those who want to keep them" (p. 184). Such actions are not easily accessible in visual data alone, and as such, interviews and conversations can aid in the process of uncovering the meanings of social fields. In this study, interviews granted emic perspectives on the interactional events witnessed during the participant observations and that were retained on video, as well as offering a legitimate space to inquire about seemingly taken for granted aspects of embodied actions.

As an overarching principle a semi-structured approach (Kvale & Brinkmann, 2008; Tanggaard & Brinkmann, 2010) was utilized, which seeks to gather information about the interviewees life world with the intent to interpret the meaning of the described phenomena. The semi-structured interviews used in this study adopted a phenomenological approach where the interviewer pursues elaborate emic perspectives on particular events and situations.

Interviews are interactional events, and the knowledge produced in the interview situation is constructed in collaboration between the interviewer and the interviewees (Holstein & Gubrium, 1995; Kvale & Brinkmann, 2015). Interviews differ from everyday conversations, because they are constructed conversations that are usually recorded, and the researcher is typically not only interested in what is said, but also in who says it (Kvale & Brinkmann, 2015). As such, the framing of the interview, including the atmosphere, the type of questions and the delivery of these are essential in providing for a productive and unhindered environment. Furthermore, it is central that the interview is dynamic in order to maintain a positive interplay, and stimulate the participants to talk about their experiences and feelings (Kvale & Brinkmann, 2008), and not constrained by procedure. This was the kind of interview I aimed at creating.

Furthermore, the interview situation necessarily involves different roles, and consequently the risk of creating what Bourdieu would call a kind of symbolic violence. Here the researcher adopts a more knowledgeable position in terms of linguistic mastery than the respondent, and in doing so produces unequal access to the interview situation (Bourdieu & Wacquant, 1992). Group interviews were chosen when working with the students as a way to level the inequality between the students and me as interviewer.

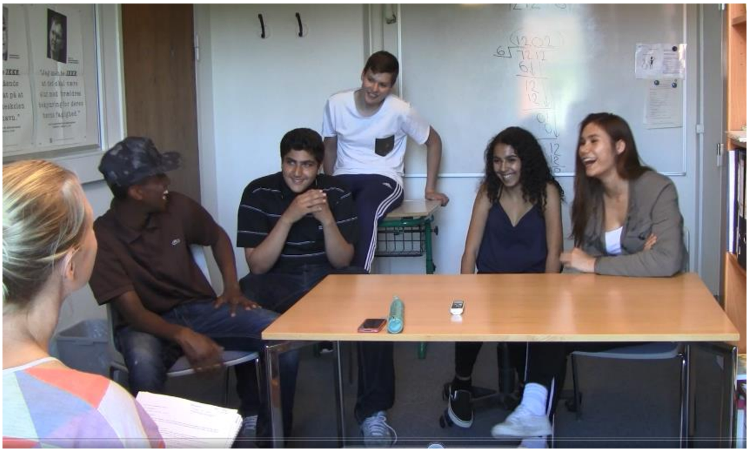
5.2.2.1 Group interviews

There are different advantages and disadvantages of working with group interviews in educational research. When pre-arranged they can be conducted with a minimum disruption to the class; they are often quicker than individual interviews, and can also bring people together with varied opinions. They may therefore yield a wider range of responses than in individual interview and be conducive to productive discussion (Cohen et al., 2011), particularly when a group of people have worked together for some time (Watts & Ebbutt, 1987). On the other hand, there are also disadvantages to group interviews, as noted by Arksey and Knight (1999). These include one person dominating the interview (particularly in the case of interviews with both males and females), stirring of antagonisms, and individuals adopting a reticent attitude in the presence of others, in particularly in the case of sensitive matters, where they suggest that a "public line" may be adopted rather than a personal line (Arksey & Knight, 1999, p. 76). Watts and Ebbutt (1987) expand on this, noting that group interviews as such are problematic when the interviewer looks for personal matters to emerge, or where a series of follow-up questions are needed. This is because a "group think" (Cohen et al., 2011, p. 432) may arise during such an interview situation, prompting a consensus discourse, rather than individual perspectives.

Group interviews were utilized in this study as a way of gaining emic perspectives on how the groups had made sense of the learning tasks they had engaged in during the observations. Through their shared recollection and discussion of the events, insights into the sentiments behind their actions and decisions were elucidated, and reflections about what they had learned in the activities enabled. This form of interviewing was also chosen in considering ways of making the students feel secure and safe in the situation, as well as accommodating practical issues such as time constraints (i.e. the students' had to be taken out of class to participate in the interviews, which meant looking for efficient ways of obtaining emic perspectives). However, there were also constraints in terms of the choice of group interviewing. The purpose of the interviews were to gain emic perspectives on the meaning of movement, and in this respect, group interviews were problematic because asking the students to reflect on their personal embodied experiences during the activities could potentially bring up sensitive matters or prompt a consensus discourse inhibiting such experiences to be told.

Finally, the interviews were video recorded. This served two purposes. Firstly, to create a backup if the voice recorder failed. Secondly, by characterizing the interview situation as an interactional *embodied* event, the construction of knowledge was viewed not only in terms of talk, but also in terms of the atmosphere surrounding the talk. Looking at how the students were positioned, their posture, use of gesture, and general facial expression, as seen in Figure 5, provided insights into the emotions connected to the topics discussed and were, as such, telling of the legitimacy of talking about these topics and their position in the group (subdue, boisterous, hesitant, shy, and so forth).

Figure 5: Still frame from a group interview



5.2.2.2 Video-stimulated recall interviews

Video stimulated recall dialogues (VSRD) with selected students also formed part of the data material. As noted above, it was included as a way to gain more personal perspectives on the activities than offered through group interviewing. In these interviews, selected footage was used to prompt a dialogue regarding the student's experiences of pre-selected situations. VRSD is argued to be a valuable tool for re-experiencing and re-collecting past interactions, while simultaneously allowing participants to reflect on and describe significant understandings (Raingruber, 2003). In studies of children, VRSD has been shown to develop further understanding of perception of learning in classroom (Morgan, 2007), while in studies of teachers' professional development, VSRD has been proved to enhance professional thinking (Moyles, Hargreaves, Merry, Paterson, & Esarte-Sarries, 2003).

Departing from the video recordings in which the students in question appeared, particular events were selected where the students' bodies in different ways came into focus. The student was then asked to watch the footage and encouraged to talk while watching the video. This was done as a way to open up a dialogue, but also as a means to identify specific events that were particularly meaningful to them. When the student would say something, I would stop the video and we would talk, or rewind to watch the scene again, asking him/her, what he/she experienced and why this scene caught his/her attention. During the dialogue, I aimed to listen, but also encouraged them to reflect both on the emotions they gave off during the activity, and how they felt when watching the activity again.

Like the group interviews, the VSRD were also video recorded for the same reasons as explained above. With the VSRD I made a particular effort to capture the screen of the computer, and as much of the students' faces and gestures as possible (see Figure 6).

Figure 6: Still frame from a video-stimulated recall interview with a student

5.2.3. COLLECTION OF WRITTEN MATERIALS AND FIELD NOTES

Video observations were supplemented with ethnographic fieldwork that consisted of collecting written materials from the teacher, as well as taking field notes. I was consistent in collecting materials produced by the teacher, as this formed a large part of his instructions to the students. However, due to my focus on the video observations, which often required my attention in terms of moving the tripod, zooming in or out to capture different body movements, and at times walking with the camera, there was a natural limit to how much attention could be paid to taking field notes. The field notes were either written down or recorded on a Dictaphone, and would often take the shape of post-event reflections. For this reason, the field notes were mainly reflections about the situations witnessed, rather than descriptions of these. The notes were used in the analysis of the recorded interactions, where they provided grounds for reflections and examination of different themes across the material.

5.3. THE PROCESS OF ANALYSIS

I have undertaken a number of steps to make the data accessible. The steps involve creating trace logs of the recorded data, transcribing the data, interpreting the material, and presenting the material (Knoblauch et al., 2015). Transcriptions, logging, and segmenting were performed using primarily the ELAN software. As this process builds on video technology, it is highly dependent on the capabilities of the particular software, which shapes not only what is recorded, but also the possibilities for transcription and representation.

The data analysis proceeded through iterative cycles of watching the video material, both alone and together with colleagues to build familiarity and shared interpretations of the material, and furthermore to identify particular events as critical incidents (Flanagan, 1954). In this dissertation, which focusses on how movement become meaningful in science education, the theory of “didactical annoyances” (Rønholt, 2003, author's own translation) became a guiding notion in identifying critical incidents. Didactical annoyances can be explained as an experienced phenomenon during class, manifested through embodied and verbal actions and expressions. Irritations during class are very common, as nothing rarely proceeds exactly as planned for by the teacher. Education as a social and academic situation is complex and alive, consisting of planned as well as randomly emerging intentions that both converge and diverge. This means that annoyances, problems, or disturbances arise and exist as a kind of general condition in classrooms. Some of these annoyances, however, gain critical bearing on the unfolding teaching and learning processes. Such annoyances are of particular didactical interest, hence the term *didactical annoyances*. In this dissertation, using didactical annoyances as a guiding notion meant identifying situations where explicit awareness of one’s own embodiment or way of comporting oneself shaped the unfolding events.

Once segments had been selected for examination, they were analyzed using the methodological framework presented in article C.

5.3.1.1 Summary of article C

Kristensen, L. K. (2018). “Peeling an onion”: layering as a methodology to promote embodied perspectives in video analysis. *Video Journal of Education and Pedagogy*, *3*. https://doi.org/https://doi.org/10.1186/s40990-018-0015-1

Article C proposes a methodological framework for analyzing video when adopting an embodied perspective. The article argues that in order to deal with the inherent complexity of human interaction that has been captured on video, analysis must adopt structured ways. For this purpose, the metaphor of *the onion* is utilized as a way to conceptualize the process of unpacking and reassembling the different layers of observed interaction. The different layers here referred to are the different kinds of visual, kinaesthetic or acoustic data obtained in video recordings, such as talk, gestures, or prosody.

The onion metaphor represents a particular approach to video data, where the process of peeling back layers simultaneously is an act of bringing together the layers. That is, to examine the onion, the layers must be laid open, and peeling back one layer at the time achieves this. When peeling back one layer at a time, what becomes important is that the second layer peeled back is not understood in isolation from the first layer. On the contrary, the way in which we come to talk about and understand the second layer, is shaped by what was brought forth in the first layer. Hence, each separate layer does not only provide a new vantage point, but adds depth to the growing interpretation.

The article identifies four layers (the visible, the audible, the material, and the emic) that presents different vantage points from which to understand embodied human activity, and argues that if embodied activity is to be understood holistically, the four layers need to be brought together. Building on the empirical data from this dissertation, the article exemplifies how these layers can be brought together in the above mentioned order by using the structured approach put forward in the onion metaphor.

The article concludes with a discussion concerning the order in which the different layers are analyzed, if the order shapes the findings, as well as issues regarding structural organization of the data and directionality (Bezemer & Mavers, 2011), agency of the reader (Heath, Hindmarsh, & Luff, 2010a), criterion of relevance (Schegloff, 1991), and questions of transparency in interpretation.

The article concludes that while the approach proposed is a laborious method for dealing with complex video data, the framework does provide a structured approach for dealing with complex video data, while enabling sensitivity towards embodied dimensions of interaction.

5.4. RESEARCH VALIDATION

The study presented here draws upon interpretative methodologies to investigate the emergence of students' bodies and the significance for science education. Interpretive research rests on the premise that reality as we know it is constructed intersubjectively through our actions in a social world, and because we cannot separate ourselves from our bodies and what we know, subjectivity is an integral part of understanding the world (Angen, 2000). Consequently, the research's subjectivity (values and moral) is an inherent part of all the phases of inquiry, which is also the case for this dissertation. Kvale and Brinkmann (2008) talk about this in terms of 'craftsmanlike quality' (p. 274f), as a way of bringing back the discussion of reliability and validity from philosophical abstractions to the daily scientific research practice. As such, validation is not a final evaluation of the product, but a continuous process that occurs at every step in the research. For this reason, in all the phases of the research I have incorporated validation processes, in order to work towards both ethical and substantive validation (Angen, 2000). Ethical validation involves doing research in a way where the knowledge that arises from the research has practical value, is generative, provides the possibility for transformation, and adopts a non-dogmatic approach in the way researchers communicate findings (Angen, 2000; Ellingson, 2013). According to Unger (1983, 1992), we have to adopt a reflexive approach by asking ourselves if the research is of value to the target population, if there are alternative explanations than the ones presented, and if the research contributes to an increased sensitivity or enlightenment about the human condition. Ethical validation thus urges the researcher to acknowledge and do justice to the object of study. Substantive validation concerns the way in which the research comes into being, where the researcher must show how she has done justice to the complexity of the field. Ways forward are to include multiple views to avoid a one-sided perspective (Ellingson, 2013), and to maintain a reflexive stance towards the researcher's own position and understandings relative to the study (Angen, 2000). In this dissertation, I interpret the integration of 'multiple views' both in terms of intersubjective consensus, but also as triangulation, which is the use of two or more methods of data collection in the study of human behavior (Cohen et al., 2011). Throughout the research presented in this dissertation, I reflect on the research process and its claims for validity and reliability. Furthermore, I elaborate on the substantive and ethical validation process in the discussion, chapter 8, in relation to the findings and understandings obtained in the study.

5.5. ETHICAL CONSIDERATIONS

I have sought to follow international best practices on ethical conduct, building in particular on the Danish Code of Research Integrity (*Danish Code of Conduct for Research Integrity*, 2014). These considerations are elaborated in Article B, where we also discuss how informed participants actually are despite informed consent. This discussion is particular pertinent to this study, as it involves young people in a school environment, who despite their coming of age, can be argued to be more vulnerable to persuasion, adverse influence, or even harm in research, than adults (Hill, 2005). It is therefore of central importance to take into consideration the ways in which research might place young people at a disadvantage. Valentine (1999) argues that more than informed consent as a way to protect the rights of the individual, we also have to take into consideration areas such as access and structures of compliance; privacy and confidentiality; methodologies and issues of power; and dissemination and advocacy when working with children and young people. In this study, I have aimed to account for these areas in the process of collecting data, and in terms of reporting, faces have been blurred except for images where students gave their explicit consent to the images shown. Showing their faces in those instances was important because I was able to express their emotions in those particular situations.

5.6. SUMMARY

In this section, I have discussed the methodology, data sources and process of analyzing data utilized in this study. Based in an interpretive paradigm, viewing reality as a social construction that we come to understand and make sense of through the social, cultural, institutional and historical relations we form part of (Berger & Luckmann, 1966), the role of an 'explorer' (Spradley, 1980) was adopted. In terms of methods, this has meant identifying ways of capturing the 'wilderness' (Spradley, 1980) of the field, not looking for answers, such as if particular types of movement are more conducive to science learning than others. Rather, I adopt approaches that enable me to capture the ways in which students' bodies come into focus through movement, to explore the meaning of these situations for science education.

For this reason, videography was chosen. Videography entails not only video observation, but also the simultaneous use of ethnographic work to deepen interpretation and analysis of captured interactions (Knoblauch, 2009, 2012; Knoblauch et al., 2015). As such, participant video observations and interviews functioned as the primary sources of data, supplemented by field notes, and collection of teacher produced materials. The data was logged, transcribed, and segmented using primarily ELAN, and proceeded through analysis based on a methodological framework of layering. The craftsmanship (Kvale & Brinkmann, 2008) placed into these methods, together with the other phases in the research process make up the quality of this study, which is defined by its interpretive and qualitative character.

CHAPTER 6. CONTEXT AND FINDINGS

This chapter presents the context of the study and the findings. The chapter begins by introducing the context, how the data was collected, and the particularities of the context that shaped the data collection process. The second part of the chapter presents the findings including summaries of articles A, B and D, and analysis of previously unpublished data.

6.1. THE CONTEXT

At the time of the study, the mandate for increased movement had not yet been effectuated. A school was thus selected that had, prior to the mandate, changed its profile from being an ordinary public school to adopting a sports profile[14]. This meant, amongst other things, that embodiment/movement had to be incorporated into teaching and learning in all subjects.

The principal identified Michael (pseudonym), an upper primary science teacher. Michael has a teaching degree where he majored in science and physical education and had at the time of the study 11 years' experience teaching upper primary science. During the school year of 2013/14 Michael taught Year 8 physics education. The Year 8 class consisted of 27 students: 12 boys and 15 girl between the ages of 14 and 16 years. All students gave their consent to participating in this study after having received information about the project and the nature of the data collection. The class had a mixed ethnic background, with only five ethnic Danish students. The remainder of the students were ethnically other, with a high number of students with African or Middle Eastern ethnicity.

Prior to the actual observations, the teacher was included in the preparations of the study. The intention was to build mutual trust and ownership over the process. This took place through meetings and email correspondence. Furthermore, preliminary

[14] Sports schools are made up of various concepts and models, and as such, it exists many different forms. However, there are three overall elements, which to different extents characterize sports schools. These are 1) the formation of sports talent classes (or what is also known as dual career programs, see Skrubbeltrang (2018) for further discussion). 2) A health profile, emphasizing recess activities, outdoor areas, healthy food, as well as increased hours of physical education or physically active hours every week. 3) An academic profile, where sport and physical activity is part of all subjects, recess, and so forth, with additional hours in physical education. (L. W. Pedersen, 2012)

observations of a science unit taught by the teacher were also conducted, in order for the researcher to become acquainted with the environment.

The empirical data collection took place in 2014. Video observations and pre- and post-interviews with Michael were conducted in April and May, where the class worked with a unit on light and sound and ions respectively. Group interviews with the students were conducted in June, and the video-stimulated recall interviews with three students in December.

During the study, I would meet with the teacher before each class to talk briefly about what he had planned for the day, any particular things he had considered, as well as his expectations. Once the students started to arrive, I would move to the back and remain behind the camera until the students would go to their respective workstations. At this point, I would move the camera, to capture what the students were working with. If the camera was in a fixed position, I would take notes and, when possible, photos of the phenomenon they were producing. When the students would finish with their assigned tasks, I would move to the back of the room, once again capturing the entire class and teacher. After each class, I would sit down with the teacher and talk about how the class went, if something unexpected had happened, and his reflections about including movement into the activities. I would also gather the handouts given to the students, and take pictures of the pages in the textbook they had been working with.

Once the observations were concluded, I met with each of the groups to talk about the tasks they had participated in, their experiences of these, how they had felt doing them, and what they thought about these activities as part of science education. One of these groups agreed to participate in stimulated-recall interviews. Upon participating in these interviews, students were asked to fill out a second letter of informed consent.

Further into the process of analyzing the data, two additional upper primary science teachers were interviewed regarding the conceptualization and implementation of movement into science education. The two other teachers, Rita and Louise (pseudonyms), also taught science education in upper primary, but at two different schools. Rita majored in Danish and science education, and had at the time of the study 7 years’ experience teaching upper primary science. Louise majored in Danish and science education, and had 6 years of experience. The reasons for conducting these interviews were to provide additional perspectives on the conceptualization of movement into science education, and to reflect on the process of implementing such a pedagogy. This interview took place in June 2017.

Table 5**Fejl! Henvisningskilde ikke fundet.** below provides an overview of the data collected during the study.

Table 5: Overview of data

Method	How data was collected	Purpose of collecting	Quantity
Video observations	One video camera following a selected student group around during the double lesson	To capture social practices within the science classroom	8 hrs. video
Interview	**Individual interviews with the teacher, before study, and before and after each class:** Semi-structured interviews, which took place in the classroom where the science unit took place	To understand how movement-based tasks in science education are conceptualized, planned for, anticipated, integrated, and reflected on	5 hrs. 29 min audio
	Group interviews with students: Semi-structured interviews which took place in an adjacent small room close to their homeroom	To gain insight into how students experience and reflect on teaching and learning implementations	1 hrs. 55 min video
	Group interview with teacher: Semi-structured interviews which took place at one of the teachers' workplace	To understand how physical activities in science education are conceptualized and made sense of	1 hrs. 7 min audio
	Video stimulated recall dialogues: Semi-structured video-prompted recall interviews, which took place in a meeting room at the school	To obtain emic perspectives on the students' experiences of and feelings about the tasks observed	2 hrs. 17 min. video
Field notes	Audio recordings of reflections following the observations, or when possible written notes and informal conversation during the observations	To reflect on what had been observed, and to capture situations not observed by the camera	30 min. audio of personal observations 20 pages written notes 12 min. audio of informal conversation with students during class
Collection of teacher produced materials	Collected after each class	To document the instructions of the teacher	7 handouts

Michael talked about the class as a group of students that could be very noisy, and use a language characteristic of a multiethnic group generally known as 'perkerdansk' (for a general discussion of the influence of immigrant communities on native languages see Nortier & Dorleijn, 2013). However, he also described the class as curious, willing to learn, and young people who wanted to do well in class, although this did not always show in their grades in physics. He commented that the girls in particular could be very shy and reticent, yet once I would get to know them and them me, they would be very forthcoming.

The science unit was organized as a workshop based science unit, and this format affected both what was recorded on video and how it was captured. Firstly, the workshop-based format meant that the students were divided into groups of 4-5, in which they had to stay for the duration of the unit. The teacher had assigned me to one group, which I was to follow during the entire unit. The reason for staying with one group was initially in consideration of the naturalness of the data (see section 5.2.1.1), because the participants' reactivity to video capture becomes quickly negligible after a phase of habituation (Schnettler & Raab, 2008). Following just one group would furthermore provide insights into how the same group of students acted across a number of assignments that entailed different kinds of physical activities. Yet, this plan had to be discarded as only one participant from the initial group turned up to class on the second day of observing. We (the teacher and I) did not know about this until the beginning of class, and therefore had to make a quick choice on where and who to focus on during the remainder of the unit. I chose to focus on the tasks, making sure that I would get recordings of all of the different science tasks the unit comprised of, although that meant observing different groups. Therefore, instead of having footage of only one group working with six different tasks, I got footage of three groups each working with two different tasks.

I conducted all the interviews with the students at the school to ensure a safe environment, but also as a way to open up for a productive talk, where stories can be told, interpreted, but also opposed (Tanggaard, 2008).

For all the interviews, templates were drawn up that organized the interviews thematically. A thematic organization supported the semi-structured approach as it enabled the students and teachers to shape the direction of the interview. Consequently, what was viewed as important to discuss varied in the interviews, but also the order in which the themes were discussed. In the group interviews, questions were primarily addressed to the group, but in some cases also individual students, primarily as a response to an issue or reflection raised by that student.

6.2. FINDINGS

This chapter presents the analysis of the data that was collected in this project. Some of this data has been presented in the following articles:

A. Kristensen, L. K., & Otrel-Cass, K. (2017). Emotions - connecting with the missing body. In A. Bellocchi, C. Quigley, & K. Otrel-Cass (Eds.), *Exploring Emotions, Aesthetics and Wellbeing in Science Education Research* (pp. 165–185). Springer International Publishing.

B. Otrel-Cass, K., & Kristensen, L. K. (2017). Troubling an embodied pedagogy in science education. In T. Vaahtera, A.-M. Niemi, S. Lappalainen, & D. Beach (Eds.), *Troubling educational cultures in the Nordic countries* (pp. 69–91). London: Tufnell Press.

D. Hardahl, L. K., Caiman, C., & Wickman, P. (2018). The body and the production of phenomena in the science laboratory: taking charge of a tacit science content. *In Process*.

In addition, I am also presenting data in this chapter that has not been previously published, and it includes the following kind of data:

- Video observations of classroom interactions
- Interviews with science teachers
- Video-stimulated recall interviews with students
- Group interviews with students

The analysis in this chapter looks across the above-mentioned articles and unpublished materials to address the two research questions, namely h*ow students experience an embodied pedagogy in science*, and h*ow teachers can work with an embodied pedagogy in science education*. The answers to the question are organized as themes that emerged through a process of inductive analysis (Patton, 2002), which focused on categorizing expressions of the phenomenon that is *students bodies* (as described in chapter four). Following the categorization into themes, the different segments were then closely examined to consider the causal conditions that brought about the particular expression, the context of the situation, how the actors reacted to the situation, and the consequences. This was accomplished using the layered approach proposed in article C, which builds on the principles of interaction analysis in a manner that emphasizes structured ways for unpacking and foregrounding the body. Themes 1-4 primarily address the first research question h*ow students' experience an embodied pedagogy in science*, while the fifth theme primarily addresses the second research question, *how can teachers work with an embodied pedagogy in science education*.

The chapter starts with a brief summary of the articles before presenting the themes. An overview of the data, findings and how the articles place in the themes are presented in Table 6 below:

Table 6: Overview of findings

Name of theme	Data	Key concepts	Findings	Article and/ or unpublis-hed data
Theme 1: Affective bodies	Video observations Group interviews Video stimulated recall interviews	Emotions	Emotions are central to meaning-making Cameras heightened the emotional atmosphere	Article A and Unpublished data
Theme 2: Productiv e bodies	Video observations	Educating bodies Bodily work Relations	Body plays a central role in the production of scientific phenomena Bodily work is a tacit content in science education Meanings associated with everyday habits are not readily available as meanings in science education The environment shapes the students premises for acting	Article D and Unpublished data
Theme 3: Frustrated bodies	Video observations Group interviews with students	Legitimacy Learning conceptions	Legitimacy of physical activities questioned when experiences included feelings of unproductiveness, futility, perceived likelihood of errors, and hindering of preferred ways of learning	Unpublished data
Theme 4: Performat ive bodies	Video observations Group interviews Video stimulated recall interviews Group interviews with students	Body consciousness Impression management Configuration	It is likely to be problematic in Year 8 to assume physical activities that carry high loads of performativity to be simple tasks Cultures of performativity may contribute to disengagements of students from teacher intended tasks Cultures of performativity configure students' understanding of tasks	Article B and Unpublished data
Theme 5: Complex bodies	Teacher interviews	Created dialogue Conceptuali-zing Implementing	Conceptualization of movement in science education is unclear to teachers The ambiguity of the concept of movement in science education inhibit the actualization of movement activities Bridging bodily experiences with concepts are viewed as central for an embodied pedagogy Prominent body consciousness amongst students in Year 8 pose a challenge for the implementation of physical activities Lack of resources become a stop block for the conceptualization and implementation process	Unpublished data

6.2.1. SUMMARIZING THE ARTICLES

6.2.1.1 Article A: “Emotions – connecting with the missing body”

The article prepared for the anthology, Exploring Emotions, Aesthetics and Wellbeing in Science Education Research (Bellocchi et al., 2017), takes a point of departure in the philosophy of Merleau-Ponty (1962, 1968) who argues that emotions are a way of taking up a position in the world, a kind of practical consciousness that is different and varies for individuals. Emotions are experienced with different intensities, but regardless of the intensity, they are always present as an atmosphere surrounding people’s actions, shaping how situations are experienced and made sense of. By paying attention to the connections between interactions and how people experience their emotion in a given situation, it becomes evident that certain actions are privileged.

The article presents worked vignettes of 14-16 year-old students experimenting with the Doppler Effect as part of their science unit. The teacher had deliberately incorporated experimentation that would involve some sort of physicality. In this particular experiment, running was part of the learning activity. The analysis showed that running in science was experienced by some of the students as a risky activity since it meant for those students that they had to present themselves in ways they did not desire. Yet for others, it was something fun to do – a way to show their physical attributes, and reinforce positive emotions since performativity brought about desired attention. While the task was not about who could run well and fast, public display paired with recording the activity on video (part of the experiment) foregrounded physical performance.

The findings suggest that there are different experiences of and emotional responses to activities that demand physical performance in science such as the task of running with a sound source as part of producing the Doppler phenomenon. The expectations of activities involving physical performance are shaped by the environment, which privileges certain meanings. The environment, in this case a hallway stylized as a running track, sets the tone for what to expect and how to physically operate within this environment.

6.2.1.2 Article B: “Troubling an embodied pedagogy in science education”

The second article takes a point of departure in a critical perspective on the Danish educational reform of 2014, in particular the mandate for increased movement and exercise during school day, and argues that the integration of physical activity into learning and teaching activities may not automatically lead to better learning as intended in the reform. While the mandate/reform signals on the one hand the realization that young people learn in complex embodied ways, it can also be viewed as a new form of governance where young people are expected to readily accept bodily activity as a productive and enjoyable condition for their learning. Focusing on science education, the article seeks to examine what this means to a subject, where there is a continued concern about the overall decline in student interest and engagement (Bybee & Mccrae, 2011; Fensham, 2006). The negative development may provide plausible arguments for initiatives such as the reform; nevertheless, research still needs do document what an embodied pedagogy in a subject such as science education that is known for having a very strong culture of its own (McKinley, 2005) entails, and how to create one. A focus on science education is particularly pertinent as student participation and achievement is a matter of equity and social justice, because of the role science plays in today's society.

Building on the ontology of Merleau-Ponty (1968, 2012), and in particular the notion of *the lived body* in understanding the role of the body for perception and experience, the article questions what this educational trend affords to the students' experiences at school. To do so, the article presents worked examples from a science activity, where a group of students in the age of 14-16 was working to produce the Doppler Effect had to run as part of the task.

Through microanalysis of discrete positive emotions, the analysis demonstrates how the students had slightly different bodily responses to the performance to two runners, who embodied very different styles of running. The different responses became interesting in the light of how the two runners managed their social identity in the hallway, which became a stage of actors and audience (Goffman, 1959), but also in terms of the kind of body-consciousness prompted by the activity. The analysis indicates that outside responses (by the group) to the performances of one particular runner reflected the social identity created in the situation, an identity that was managed by the runner himself through his actions, and read by the others on the backdrop of the hallway as a collective representation. As such, the group and the runner co-shaped the boundaries for what was proper performance in the hallway, and in doing so, defined the boundaries for participation and contribution in the Doppler Effect activity to go beyond the problem solving process.

Moreover, the hallway, the activity and the presence of recording devices shaped the students' willingness as runners and public performers. While microanalysis showed how there was more at stake than learning and accomplishing a task, further analysis of student interviews focusing on the students' embodied experiences and how these connected with learning science ideas and concepts, found a conspicuous tension between experiencing abstract concepts and the communication of embodied experiences.

The findings suggest that it is likely to be problematic with a class of 14-16 year olds to assume that embodied activities that carry a high load of performativity in science are simple tasks to be performed. An embodied pedagogy in science will require considering students' body-consciousness and how their lived bodies can support conditions for learning.

6.2.1.3 Article D: "The body and the production of phenomena in the science laboratory: taking charge of a tacit content"

Article D explores the role of the body in producing physical phenomena in the science laboratory, arguing that learning in science does not only entail conceptually distinguishing what is already there, but rather bit-by-bit embodied manipulation and tinkering with materials by the students to produce and stabilize physical phenomena. Such embodied work is at the heart of science, yet despite this, the body has received very little attention in empirical studies in science education.

By reviewing accounts from noted scientists on the production of physical phenomena, the article discusses that scientists and their inquiries are far from being only conceptual, but highly embodied. In these accounts, four ways in which the body is involved with materiality to produce physics are identified: firstly, labor is an indispensable part of physics inquiry. Secondly, the relation between body and materials produced need to be of a kind that stabilizes the production of the phenomenon so that it can be observed under specified conditions. Thirdly, some phenomena can be produced by a single scientist, but often collaboration is necessary, and fourthly, different categories of persons are deemed variously fit beforehand to carry out phenomena production. Moreover, the article also looks at how science education has discussed scientists' work of gathering information about the world to transform it into facts. Looking at major reviews during the last 30 years, the article that generally the role of the body for producing phenomena is not mentioned at all or just in the passing. If mentioned, the body is relegated to lower cognitive functions or secondary skills. The lack of attention to the pre-data process, how to get experiments going, stabilizing the phenomena, dividing the work, and its consequences for what students are afforded to learn, prompted an examination of how students utilize their bodies to manage equipment and register observations.

Adopting a theoretical framework inspired by Dewey (1958) and Merleau-Ponty (2012), and utilizing a pragmatic epistemological framework (Wickman, 2004; Wickman & Östman, 2002) the article examined how students bodily transacted with materials to produce physical phenomena. Through a process of tinkering, where students would test out different relations between themselves and the materials, they were able to produce and stabilize the phenomena to some extent. This was, however, not a straightforward process and they had to build new embodied understandings of what it meant to e.g. *see*. The study also indicated that the production of certain phenomena such as the Doppler Effect required multiple actors taking on different roles. The specialization of bodies (Knorr Cetina, 1999; Pettersson, 2011) occupying different roles produced different ways of experiencing the phenomena, and raised issues about who gets to do what.

The findings suggest that conducting and learning from experiments is not just a matter of using the senses to register particular properties. When tinkering, students draw on habits matured through a lifetime, using their eyes when asked to *see*. Yet, analyzing students' habits of "seeing" it is not always effective. Considering how important it is for physicists to be skillful at producing phenomena, suggests that the process of producing needs to be made an explicit and important content of science education.

While habits are essential to meaning making, the article raises the need to address whether prompting reflection on bodily ways may further deepen the students' understanding, and assist them in learning to tinker and communicate their findings regarding how to produce the phenomena. The article furthermore discusses the epistemological reasons to include producing the phenomena as an explicit and self-evident content in science education. The focus on the conceptual and theory-laden nature of science seems to have had the consequence that how scientific knowledge is produced from observing natural phenomena has been overlooked, although it is central for learning science and about the nature of science (Lederman, 2007). Furthermore, thinking about science and technology as a means to predict the workings of nature to accomplish technical control suggests an important role for science education in terms of not only teaching explanations, but also giving students a sense of control over their surroundings. This control cannot be gained without involving the body in technological transactions.

The next section will introduce the first theme, derived from the findings across the three articles as well as unpublished material.

6.2.2. THEME 1: SIGNIFICANCE OF EMOTIONS WHEN SCIENCE ACTIVITIES ARE BEING RECORDED – AFFECTIVE STUDENT BODIES

In increasingly technologically oriented science classrooms the digital recording of activities is becoming more and more commonplace including – for instance, the use of video recordings (Otrel-Cass, 2017). This theme presents findings that identify how emotions play out when embodied science activities include the use of recording devices. Article A (Kristensen & Otrel-Cass, 2017) focused particularly on this aspect to show how running and being recorded on video in the hallway became an emotional event. Some students expressed their reluctance to run in this activity, explaining that it would make them feel uncomfortable. This was in particular so because they ought to be recorded by their peers. To run was experienced as risky when it was captured on video, even though the students knew how to run fast. For other students, this activity was experienced in the opposite way. This was the case for those who felt physically capable and good at running. In that case, it became an opportunity to show physical capability and to get attention. A third kind of emotional experience was that of a student who knew that running would possibly result in public humiliation but who did it anyway.

A different observation data from previously unpublished material came from a different group of students working with the concepts of *wavelength* and *frequency*.

The activity took place in a secluded part of the schoolyard; however, younger students walked past occasionally on their way home. For their task, the students were asked to make a "perfect" wave using skipping ropes. The students had to place the rope on the ground in a manner portraying the perfect wave. They then had to return to their textbooks and read selected pages explaining the concept of wavelength and frequency, before producing a video where they would explain the concepts of *wavelength* and *frequency* using the ropes to support their explanations of the concepts.

The following excerpts (Figure 7) details an episode where the group (Lucas, Zara and Hafa) had just come back from the classroom where they had taken turns reading the assigned worksheet aloud to each other. Lucas had brought his chair with him to the outside area, and immediately positioned himself on a chair without much talk. Zara and Hafa each brought their hand-written notes with them. In the classroom, they had decided that Zara should talk first in the video, but once outside Zara changed her mind, and did not stay by the skipping rope shaped like a wave where the presentation was set to take place (turn 1). Instead, she followed Hafa back to Lucas. Hafa asked why she followed her, with an outstretched hand pointing towards the rope (turn 2-4). Zara replied that she did not want to be the first speaker, but Hafa disagreed. Zara followed Hafa back to Lucas, who was recording with the camera, pointing it towards Zara. She asked him to show what he had recorded so far (turn 5).

In the transcriptFigure 7 below, Zara did not want to be the first speaker. She indicated her reluctance verbally (turn 1) and by physically moving away from the rope. She evaded Hafa's question about why she was following her back to the position of the camera by Lucas (turn 4), by turning her attention towards Lucas and his recordings (turn 5). While maintaining a friendly tone and a big smile on her face, her jovial stance lightened the mood and made her actions seem like less of an evasion of a task that needed doing and more of a change of interest.

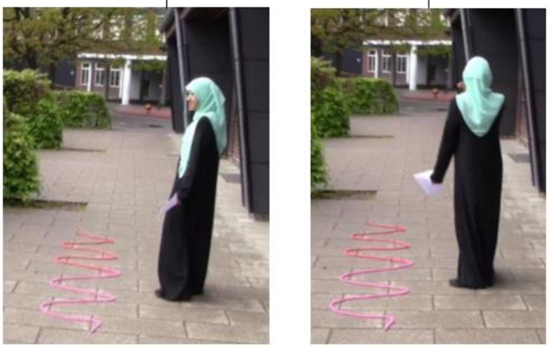
Figure 7: Zara, Lucas and Hafa working with waves

01	**Zara**:	Uhm… no, not me <Hafa walks away from the scene>. Okay, should I?
02	**Hafa**:	I'm not in first, it's you… what are you doing here?
03	**Zara**:	It's not!
04	**Hafa**:	It's you who say this… (Unclear) frequency. Why are you following me?
05	**Zara**:	Hey, wait wait wait <smiling broadly>. What do you think this is? Let me see your phone, no.

Standing next to Lucas, Hafa and Zara spent the next minute debating what to say on video and who should do it. They agreed that both should present in the video, but Zara said that she did not feel like it and did not make for the ropes, although she was the agreed first speaker. Hafa did not want to wait for Zara to get ready and walked back to the rope. Zara changed her mind again once Hafa took the initiative, and they changed positions again. Figure 8 below shows how when Zara approached the rope once again she expressed reluctance (turn 1), but she still positioned herself in front of the ropes, although not facing the camera. When asked if she was ready (turn 2), Zara first said no and kept her sideways position as if to turn away from the camera, and then suddenly walked away, loudly exclaiming "NO. NO" and that she could not do it (turn 3).

Figure 8: Zara, Lucas and Hafa recording their task

01	**Zara**:	(unclear) I hate to be filmed. Okay my turn? <walks to the rope, but stands with her side to the camera>
02	**Lucas**:	Are you ready?
03	**Zara**:	No, I'm not quite ready <Zara stands with her side to the camera for 5 seconds before turning to face the camera>.
		I hate having to (unclear) <when she turns to face the camera, she extends her hands away from her body to each side, palms facing the group>
		NO NO (hhh). I, I can't, I can't do it <walks away from the rope>
04	**Hafa**:	No, I do it then <change positions with Zara>
05	**Zara**:	Thanks



Like the girl Mira in Article A, Zara did not like being recorded on video. While Zara made no particular comment on this situation, she expressed through her actions that she was *not comfortable* with performing in front of a camera. Her *emotional response* manifested in movement away from the camera, both when she followed Hafa and when she turned her back to the group, and in her *use of gestures* to support her stance in turn 5, where her extended hands and palms facing forwards gave off a sense of despondency. In other observations of Zara, she appeared to be a poised and serious girl who did not shy away from a task. These observations are supported by an interview with her and Hafa, where she revealed her desire to be a good student, which was to be engaged and serious about the work they did in class. From this perspective, the observations strongly suggest that she struggled with completing the task and that doing it in front of the camera challenged her emotionally.

6.2.2.1 Summary

Theme 1 is concerned with the emergence of feelings and emotions that are central to meaning-making processes since affective experiences constitute the “very context in which meaning-making takes place” (Orlander & Wickman, 2011, p. 592). In the above examples, it appeared that video recording science activities heightened the emotional atmosphere. These devices allow for the capture and retaining of interactions and therefore permanently record the performances of the students. The findings point to how differently the science activity was experienced and that it resulted in different emotional responses that had to do with forecasting how one’s own physical appearance may be perceived by others and that this was potentially magnified through the recording.

6.2.3. THEME 2: THE ROLE OF BODIES FOR PRODUCING AND STABILIZING PHYSICAL PHENOMENA – PRODUCTIVE BODIES

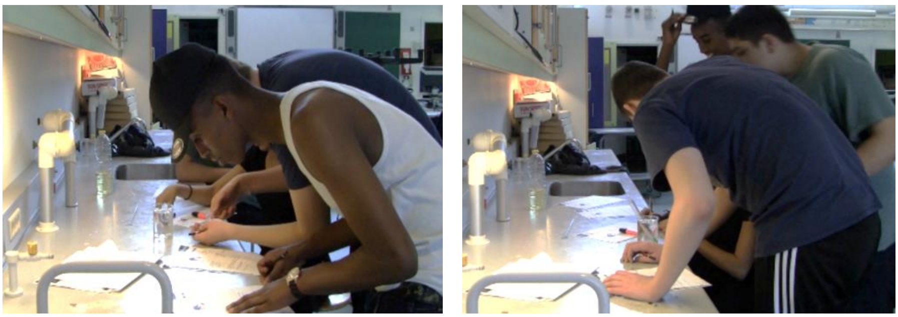
Open-ended processes of inquiry, such as tinkering in general (Bevan, Gutwill, Petrich, & Wilkinson, 2015; Maarten, Fons, & van der Putten, 2013) and laboratory work in particular (Hofstein & Lunetta, 2003) are recognized as central to learning in science. Often it is argued that the experiences gained in such work helps students understand phenomena, relationships, materials and so forth. This theme zooms in on the processes of producing physical phenomena, and presents findings that identify how 1) students engage bodily in processes of producing that is largely tacit, and 2) how this is a process shaped by the affordances of the environment. Article D (Hardahl, Wickman, & Caimann, n.d.) focused particularly on the first aspect in presenting an argument that sought to establish the importance of making the role of the body in producing scientific phenomena explicit in science education. Producing phenomena in science requires time and effort, manual labor, and embodied tinkering. That is, bodily labor is an indispensable part of science inquiry. The empirical data presented in the article showed how the students’ bodies were pivotal in managing equipment and making observations. They used their bodies to tinker and engage in transactions with equipment and substances to produce physical phenomena. Some phenomena also required a division of labor, and this became important for meaning making. Tinkering was automatic and easy for the students, as they drew on habits matured through their lifetime; however, the meanings associated with habits such as seeing, hearing, or running were not readily available as meanings in the context of science. Instead, students had to use and educate their bodies in particular ways to enable sensing in the right manner. Sometimes this involved tinkering with body positions and materials, and at other times dividing the work between them to produce the phenomena. In reporting on the physical phenomena, the students would use their bodies in particular ways representative of the work they had conducted. They would, for example, bend their bodies to gaze at a beaker from a certain angle or utilize a high-pitched voice to represent the concept of high frequency. Such actions indicated that the embodied knowledge gained in the process formed an essential even intimate part of knowing about phenomena.

While Article D highlights the tacit and un-reflective nature of bodily work in science education despite its centrality, a different analysis from previously unpublished data about the same group of students who were working with the two concepts presented in article D, identified how such bodily work was also shaped by the affordances of the environment and the physical phenomena in itself.

The following excerpts detail situations from each of the two activities set inside and outside the classroom respectively, illustrating the different ways in which the group consisting of Hai, Adi, Lucy, Alfons, and Mira, carried out the activities.

The first task was an experiment about the refraction of light. Figure 9 is exemplary of the embodied organization of the group during the activity. In the task concerning refraction, their movement was characterized by a high degree of alignment in their bodies. In much of the work, they adopted the same hunched forward shape in their upper bodies, leaning over the table, placing their hands on the table, gazing at and writing on the assignment sheet. The assignment sheets as well as the equipment and substances were placed on the table without question, and chairs were moved next to the table to form a small semi-circle around the equipment. Utilizing chairs limited their movement to primarily fine motor skills, which appeared contained, controlled and calm, indicating a bound flow (Konie, 2011), and they were very direct in their use of space, i.e. channeling their focus, honing in on the materials, and handling these in analogous ways. The students seemed engrossed in the task and did not comment on the way each person handled him or herself bodily during the task. Moreover, they were positioned in close proximity, their upper bodies and arms occasionally touching as they shared a confined space. Their talk revolved around a shared object, which was producing the phenomena and how to do this. Although they were enthusiastic and at times excited, their voices remained contained, never shouting.

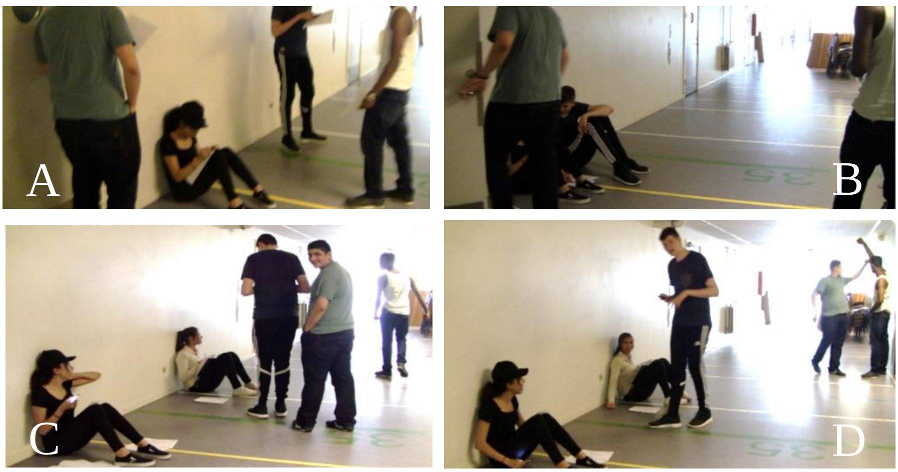
Figure 9: Coordinated bodies in bound flow



The manner in which the same students interacted changed markedly when they went into the hallway just outside the classroom to work on the Doppler Effect experiment. The difference between the two locations was prominent. The physics laboratory was set up with equipment, tables, chairs, and various chemical substances. The teacher was present in the room, as well as 2-3 other groups. The hallway did not contain any chairs, tables, equipment, nor chemical substances. The teacher rarely came out into the hallway, and the groups and other students who came by would only linger briefly. It is of course important to note that the nature of the science task was very different: in the classroom a close up observation of light waves, while the hallway activity involved understanding the nature of sound waves.

Figure 10 illustrates four different situations from the activity in the hallway. The students were spaced apart, directing their attention in different directions at different objects, which included the assignment sheet, each other, mobile phones, the adjacent classroom, and the observing camera (image A). The flow, which characterized the group interaction during the refraction task showed in the hallway little continuity and progression including through their actions and talk (Konie, 2011) as they were engrossed in different tasks (image B). Different from the activity in the classroom, the group was also much more attentive to the camera, which is captured in image C. Furthermore, there was also a heightened awareness of each other's movements, captured in image D, where Hai pulled Adi's arm down after Adi had displayed excitement about what they were in doing in physical education on that day. When asked about this, Hai explained that he found Adi acting inappropriately, and he was trying to be a good friend and help Adi behave in an acceptable way for a science class.

Figure 10: Scattered bodies (A), indirect flow (B), and consciousness of cameras (C) and of each other's movements (D)



The above images indicate a change in the behavior of the group from the refraction task to the Doppler Effect task. While the group remained the same, the location and nature of the physical phenomena changed. The bound flow characteristic of the group work in with the refraction task suggests, with reference to Merleau-Ponty's notion of spatiality (section 4.1.1.2), that the students shared an understanding of the classroom as a space where they performed certain actions, which in this case involved lab work. In contrast, the hallway became a much more ambiguous space that did not, to the same extent, represent a unity of functions (Thøgersen, 2004). Positioned in the hallway the students inhabited this space in different manners. There was not one set space to place the assignment sheet, nor natural place to gather (see image A, B and C), nor shared understandings about the hallway as part of science laboratory and consequently the actions linked to this space. The latter became evident in actions such as captured in image D, but also in the negotiations that took place in the hallway (reported on in article A and B), which consequently drew attention to individual attitudes as opposed to the task and how to go about this. Combined with the change in physical phenomena, which in contrast to the reflection task did not call for close-up scrutiny nor promoted close proximity between the students, the hallway task provided a setting that challenged the students in reaching a focused workflow.

This analysis suggests that the hallway was an alteration to what defined the science classroom, creating the need for the students to negotiate the meaning of this space and subsequently also indirectly what counted as natural movement (i.e. pulling down arm, how position one self, where to focus, and so forth). While article D discuss how students come to know science through bodily work, this latter analysis suggests that the idea of *producing bodies* is closely connected to the environment and how students understand the environment. In a classroom, where students are accustomed to working, a focus on the relation between bodies-machines-materials may be sufficient. However, positioning the students in unusual science settings such as the hallway alters the premises for participation compelling the students to reestablish the boundaries. From this perspective, the notion of *producing bodies* needs to be considered not only in terms of the relation between bodies-machines-materials, but also bodies-environment if we are to anticipate and support students in gaining a sense of control over their transactions (see article D for further discussion of this).

6.2.3.1 Summary

Hands-on work is recognized as a valuable tool for learning about science. Theme 2, which includes article D in combination with previously unpublished data, is about the role of bodies in hands-on work, or as the title indicates, *producing* bodies. Article D demonstrates how students' bodies form an integral part of doing and knowing about science through transactional processes with materials and machines. It highlights the tacit nature of the bodily work that goes into producing phenomena, and proposes that this be made explicit content in science education. The previously unpublished data showed how students' bodily work changes character when changed from familiar to unfamiliar settings. The analysis suggests that the classroom represents a shared unity of functions, which allows the students to focus on the task, while the hallway from a science education perspective is unfamiliar and thus lacks the shared understandings about functions as the classroom came to represent.

6.2.4. THEME 3: WHY SCIENCE LEARNING THROUGH THE BODY DOES NOT COME EASY – FRUSTRATED BODIES

Thinking about education and teaching often produces an image of children sitting at desks with the teacher near them, engrossed in reading, writing, or for the part of science education, also exploring physical phenomena through specialized equipment. While in a subject such as PE, the body is recognized in terms of its value to teaching and learning, an embodied perspective in science education is novel (Almqvist & Quennerstedt, 2015). This theme highlights how many students are challenged as their habits are broken or confronted with different ways of doing things resulting from a body-oriented pedagogy where they are tasked to learn with their bodies in more or less overtly ways. Science specific environments underpin this, especially the science laboratory, where children are expected to engage in experimentation in particular ways. Introducing an embodied pedagogy into science education potentially changes the way in which students are introduced to and learn about scientific concepts as opposed working inside the classroom and reading and writing. Such changes potentially become elements of frustration to those students with set preferences. In what follows, two observations from previously unpublished data are presented: first, a group task concerned with speed of sound, and second, a whole class activity learning about ions.

The first observation stems from the observations and interviews conducted in relation to a task called *The speed of sound*. The following excerpts detail discussions about the task, where Tom, Sean, and Zaida reflect upon their experiences on the following activity:

With a clapperboard (two makeshift pieces of wood used to make a loud piercing sound) or a gong, a stopwatch, and Google Earth app, the children had to measure the speed of sound. The task read:

> 1) Using Google Earth near the school, you have to find spots that are exactly 340 meters away from each other. Position yourselves in these spots. You have to be able to see and hear each other.
>
> 2) At one spot, one of the students have to use the clapperboard or gong. At the other spot, another student has to measure the time from seeing the

> clap/gong to hearing the clap/gong. Repeat and measure the test several times. Write the results in the table.
>
> 3) Another student uses the clapperboard and the measurement is repeated several times.
>
> 4) Since the speed of sound is 340 m/s, you should have measured exactly 1,0 s. Which average time did you measure?
>
> 5) Which speed did you find?
>
> 6) Normally you have a reaction time between 0,12 and 0,16. Does your reaction time mean anything for the measurements you took?"

In addition, the teacher had provided the students with a map of the spots he wanted them to use, and formulated instructions, which read:

> The one holding the clapperboard stands at the blue spot nearest the sports center [which was located 400 meters away from the school]. The one with the stopwatch stands at the orange spot located 340 meters away from the sports center. The one with the stopwatch stretches his/her arm up as a signal to signal (s)he is ready with the stopwatch, so that the one with the clapperboard can see when s(he) can clap. If the clapperboard cannot be heard by the one with the stopwatch, s(he) signals by covering both ears, which will result in another attempt. If the clap still cannot be heard by the one with stopwatch, the one with the clapperboard walks to the spot by the red line and repeats the experiment. You now have to take note of the change in distance from 340 m. to 170 m. Which average time should you get now?

This activity was characterized as part of an embodied pedagogy, since it required that the students had to walk between 800 and 1600 meters, use the sound instruments, and listen. During the activity, one of the students, Tom, was waiting for Sean and Zaida to get into position by the orange spot. He explained:

Tom: Normally we stay back in the classroom and do experiments

Researcher: Okay. So you're all gathered there?

Tom: Yes. Then half the class does experiments, and Michael talks to the other half. And then after one hour we switch

Researcher: Do you enjoy these kinds of activities <referring to the speed of sound task>? Or do you enjoy sitting in the classroom?

Tom: I like to sit in the classroom, because that way you get to do more experiments

Tom makes clear that he prefers to do activities in class. From his short comment above, two aspects can be identified. On the one hand, the activity breaks with what he considers ordinary classes, and on the other hand, he prefers to work inside the classroom as this is experienced as more efficient. It was having to walk some distance away from the school, the fact that they spent 17 minutes in the beginning getting organized, finding the place and getting the clapperboard, or having to run back and forth from the location and the classroom that prompted the feeling of ineffectiveness for Tom. The group shared his sentiments:

Tom: I like it best when you stand by, inside by the table and do experiments. Because that is what I'm really good at doing, and I also think that I get more out of it.

Researcher: Okay. Why? You said when I followed you that you didn't like that clapperboard task. It was a waste of time. Did you not learn anything there?

Tom: Well, it was because… No! I might as well have read how long time it took, well 180 meter a second for sound to transport.

Researcher: Okay

Tom: And, you don't get anything out of the clapperboard because it takes 1 second for the sound to come over to the one with the stopwatch, and then there's the thing with starting the stopwatch and the clapperboard, and the entire response time you have to…

Researcher: Okay, so you think it's too uncertain? What about you? <Addressed to Zaida>

Zaida: Well, it was the same as Tom. I think, well the one with the clapperboard that was kind of too much

Sean: Yeah. And there were also cars driving, and then, we couldn't hear that well

Researcher: So am I right to say that there was simply too many practical things, which were difficult that had to be solved?

Tom: Also because it took some time to get over there, and then we had less time to do the experiment

Researcher: Okay. So you said you would rather go through a lot of experiments in class? But. You would think that it would be fun to get outside and move around. It is nice and you get to walk and talk a bit. But isn't it that, I mean…

Sean: Well yes, but it is also nice to get

Tom: NO!

Sean: It's nice if you get something out of it, but we didn't get anything out of that clapperboard. It wasn't particularly…

Zaida: It was also too long, that is walk, I mean the walking was kind of a waste of time right.

The students voiced their frustrations with the task, identifying different aspects that added to this experience. The students kept coming back to and comparing the physical activities involved with what they imagined could have been accomplished had it done the more traditional way in class. From this perspective, the activity appeared to them less time effective (walking/ getting less done), futile (could have just read about it/ did not get anything out of doing it), and prone to errors (could not hear the sound properly/ reaction time). The teacher characterized this particular group as a group of strong students, who were viewed as some of the best in the class. Yet the teacher found that in particular the traditionally strong students sometimes struggled with activities that were more physical. He noted that "and then there are also strong students who have been used to 'oh well, we are not used to doing math in that way, we usually just sit at the table and draw, why do we have to do it outside?' They just don't see the connection between the two <referring to the connection between learning and movement>". The teacher's reflection seemed to echo the observations made about this group.

Another example was a classroom based dramatization of ions. Unlike the previously analyzed tasks, this task was a whole-class activity that took place inside the classroom. For this task, the students had to position themselves at the back of the science classroom. Michael, the teacher, then stood in front of the class from where he introduced the topic on acids and bases, and quickly moved on to discuss ions. They spend a short while talking about atoms, electrons and protons, and the charge each carry. Then, the teacher split the class into two, one group was assigned the role of positive ions, which had dropped one electron. To symbolize this charge, they were asked to raise one arm and wave with their hand as shown in Figure 12. The other group had to enact the role of negatively charged ions, which had gained one electron. To symbolize this charge, they were asked to raise one arm and make an upward pushing motion, as shown in Figure 11. The teacher supported his choice of embodied representation of the different charges by telling the students that:

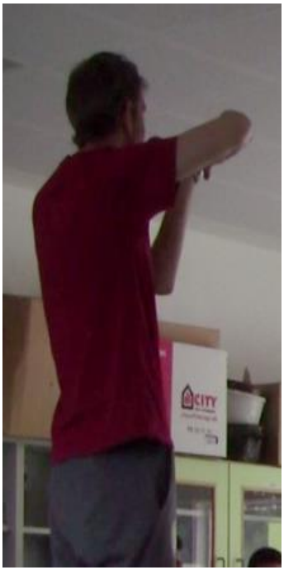
> “Over here, we have the negative ions. They have received an electron. And that’s why they are kind of heavy. Those <referring to the students embodying a positive ion>, they are free right. ‘Uhuuuuu, we are light, we have discarded something’. Over here <referring to the students embodying a negative ion>, ‘argh, we are a bit heavier, so we have something to carry’. So take one hand and hold it up a bit. You lift the roof with just one hand.”

Figure 11: Representing negatively charged ions

Figure 12: Representing positively charged ions

The teacher then told them that they had to imagine that they were dissolved in water, which meant that they had to walk around in and out between each other. He then climbed onto a table and the dramatization activity begun.

Figure 13: Interlocking of hands – positively and negatively charged ions combining into compounds



The teacher started by explaining, that when salt ions are dissolved in water they are free to move around, which was what they were doing. Then he asked them what would happen if the water had evaporated, and continued by explaining that one positively charged ion would combine with one negatively charged ion. He demonstrated the interlocking of the hands that ought to symbolize the bonding of the atoms to form ionic compounds to the students (see Figure 13). He then watched for the students to copy his movement. As a next step, he selected some students to be atoms with a positive charge of two ions, while the rest of the students stayed atoms with a negative charge of one ion. It took a few minutes to communicate the change in how to dramatize this change. While the teacher explained the activity, several questions concerning the charges emerged. This provided an opportunity for the teacher to explain, and to put names on the compounds the students were acting out by referring to a periodic table that was hanging on the wall in the classroom, which in the case of the first leg in the activity had been hydrogen and chloride atoms. In the second leg of the activity, the students were now asked to pretend being hydrogen and sulfate combining through evaporation, and following this magnesium and chloride. While the compounds changed, so did the chemical names and bonds. The combination of movement, coordination of actions between a group of students, the leaps between action, chemical name and formulas resulted in some confusion, explained briefly in the following.

Halfway into the dramatization exercise, Zara raised her hand and exclaimed, “Michael, I don’t get it”. At this point, the teacher had just started to refer to the periodic table, showing different atoms and their properties. The teacher responded to Zara, explaining that she belonged to the group of negative charged atoms with one negatively charged ion. Lucas, who was standing right next to her, grabbed her arm and said, “You just have to do like this”. Zara followed Lucas’ lead and minute later, they were asked to pair up. Zara paired up with a girl and asked the teacher if they had done it correctly, to which he nodded. This sequence of events can be seen in Figure 14 (see article C for discussion on this particular way of transcribing audio-visual data).

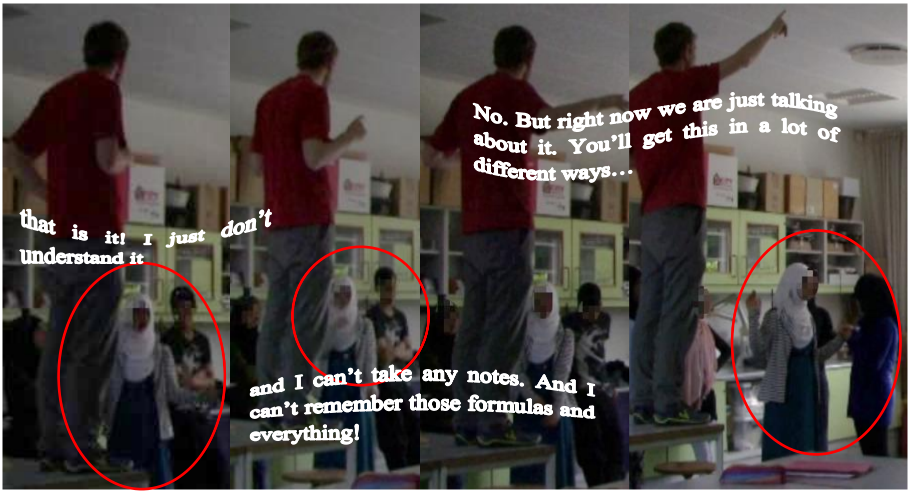
Figure 14: Zara unsure of the activity

Towards the end of the activity, Zara raised her hand and asked if she could say something. The teacher did not respond immediately and continued talking to the class. Another girl interrupted with no preamble, and said, "I don't completely get it". This prompted Zara to continue, who then said "that is it! I just don't understand it". She supported her stance by extending her arms away from her body in what could be interpreted as a resigned manner (see Figure 15). With this comment, she gained the teachers attention and continued by saying "and I can't take any notes. And I can't remember those formulas and everything!" Her outburst prompted the teacher to go into an explanation about the purpose of the dramatization activity, as shown in the transcript below:

> "No. But right now we're just talking about it. You'll be introduced to this in many different ways. But the main thing that you need to get from this, that is that you have to find together in way where there is nothing free. There are no plus ions available <waving with his right hand>. There are no minus ions available <pushing upwards with his right hand>. That is why the sulphuric acid here and our magnesium chloride a while back they become neutral. That is why, Ada now listen <referring to an earlier question>, you no longer say the charges that were there. You no longer say that it was H^{+} or $SO4^{2-}$. You no longer say that because the charges have been cancelled. Right."

Following his explanation, Zara did not say anything else, and he asked them to form a final compound, where Zara rightly joined hands with one other, although not linking both hands as they were supposed to do.

Figure 15: Zara voicing her frustration



When asked about the dramatization activity in a later interview, Zara explained that she found the activity confusing. When asked if it had anything to do with whether she could hear the teacher well enough in the at times noisy environment, she said:

Zara: No, it wasn't that. It wasn't difficult to hear. But I found it really confusing. Yes, I am more like. If I have to remember something, then I like it better if I can sit down and take notes and the write it down.

Researcher: Ahem

Zara: Like, like a normal class

Researcher: Yes lesson, yes

Zara: So that was it, I mean now I cannot remember all the formulas and everything he presented

Researcher: So, you've forgotten it already?

Zara: Yes

Similarly to Tom, she explained that her preferred learning style was a more traditional style and that this was a reason why the dramatization activity did not appeal to her. She associated learning with sitting down and taking notes, and commented that this was what happens in a "normal" classes. The teacher had deliberately tried to add a different way of conceptualizing ionic bonding and emphasized in an interview that it was important to "break the habit of thinking the truth is only found in books and that it is only by reading that you learn something". He wanted to teach the students that there are more ways of learning science than only from books, and that doing experiments has value beyond just testing what they can read in the book. This led him to *do* activities, such as the dramatization of ionic bonding. However, to Zara this was not clear so much so that this student was concerned that she was not able to explain about the chemical formulas they were presented with during the activity. This was something that she regarded as important as evidence of learning, and which she strived to achieve during classes. When asked what a good student is and when they see themselves as good students, Zara said that a good student participates actively in class, is quiet, asks questions, and in general demonstrates to the teacher what he or she is capable of doing. This was something that she aimed to be, and she explained that she used to consider her notes private, but decided to show them to the teacher to influence his assessment of her. As such, she seemed to be aware of how to maintain appearances (Goffman, 1959) as a good student.

6.2.4.1 Summary

Theme 3 was about the struggle of some students to make sense of learning science when movement became foregrounded through e.g. walking or using the body to represent abstract concepts. Two activities showed the associated frustrations with these activities. The experiences described included feelings of unproductiveness, futility, perceived likelihood of errors, and hindering of preferred ways of learning. Students who the teacher had identified as high achievers in particular reported these experiences. The act of being physically active, such as walking or acting out ions, was not experienced as problematic in itself but it represented a frustrating change to what usually takes place in science activities.

6.2.5. THEME 4: CULTURES OF PERFORMATIVITY AND STUDENT UNDERSTANDING – PERFORMATIVE BODIES

Cultures of performativity (for example emanating from sport or health) are very influential in 'determining' mindsets, pedagogic relations, and the actions of those working within schools (including students) and other pedagogic contexts (Evans, 2003; Gard & Wright, 2001). These cultures intersect with education, and find their way into classrooms where they impact upon the subjectivities of pupils (Evans et al., 2005). This theme presents findings that identify how such cultures come to privilege certain meanings and actions when working with embodied science activities. Article B focused in part on this aspect. The relevant findings from this article are briefly summarized before additional previously unpublished data from the observations are presented.

Article B questioned what the educational trend of movement integration affords to students' experiences at school, in particular what this meant for an embodied pedagogy in science education. Taking a point of departure in the observations of one group of 14-16 year-old students working with the Doppler Effect (described also in theme 1), the article presented a microanalysis of the students' responses to the performances of two runners, with different styles of running. The running performances were received by their groups as running performances, not science performances. Each runner had a different 'athletic profile', and shaped a particular culture of performativity. The findings suggested that in a class of 14-16 year old students, being physically activity carry a high load of performativity, which may present a risk for some, and for others an opportunity for others.

I expand this analysis now with previously unpublished data about another group working with the Doppler Effect. Their work with the task was not directly observed, but explored through subsequent group interviews. The group consisted of Hafa, Lucas, and Zara, yet at the interview, only Hafa and Zara were present. When asked about the activity and if they ran, they responded:

Zara: No… <shaking her head>

Hafa: It was Lucas

Researcher: So, only one from the group ran. Did not everyone have to run? How come only Lucas ran?

Hafa: Ahem… so, so it wasn't because… well I think that uhm…

Researcher: But why didn't one of you run instead of Lucas?

Hafa: Because he's the fastest <smiling broadly>

Researcher: Because he's the fastest?

Hafa: Yeah

Researcher: But speed didn't have anything to do with it. Did it?

Zara: Yes, actually it did

Researcher: Did it?

Zara: <nodding>

Hafa: So, so, or… well it didn't really, you only had to see what happened to the sound. So, actually it only needed to be something that passed by

Zara: No, it was because Michael [the teacher] said that we all had to run as fast as we could

Hafa: Yes

Zara: And then we thought that the fastest was Lucas, and therefore he should run

Researcher: So, it didn't have anything to do with you not wanting to run, or…

Hafa: I could have run

Zara: I don't really know. I hadn't thought much about it

Researcher: No, no. I'm just curious. So, it was simply because Lucas was the fastest?

Both girls: <nodding>

Similarly to the other group (Adi, Hai, Mira, Lucy, and Alfons), the girls both interpreted the task as one where it would be best to have the fastest runner run, and as a task that did not need all to run. Unlike Mira or Lucy, it did not seem here that they felt uncomfortable about running, but rather made a very pragmatic choice in sharing responsibilities for accomplishing a task, something that could be argued as typical in any kind of science experiment where group work is involved. They focussed on the result, the outcome of the experiment, which was the recording. From this perspective, the choice of only one runner seems only to indicate effective group work, where work is shared through differentiation of roles and tasks.

However, the division of roles (which is also discussed in article D and theme 2) in both groups showed that neither group understood the implicit intentions of the teacher. While the Doppler Effect could be produced by having only one person run, the person running would at the same time be the only person missing out on the 'real' Doppler experience. To note the difference, students thus had to experience the sound twofold, as a runner and as a listener, to be reminded that when the sound source is with you it always sounds the same yet when you are standing at a distance and the sound moves then the experience changes. While the teacher explained that this had been his intention, he did not mention this about the Doppler Effect experiment to the students, not in writing nor through verbal instructions, and as such it can be interpreted that it was only assumed to happen. This lack of understanding the reason for running in relation to learning about the Doppler Effect combined with the particular performative culture in running seemed to configure students' understandings of the task, and in turn privilege and promote the ability of being a fast and good runner as valuable to the task.

6.2.5.1 Summary

Theme 4 is about the influence of cultures of performativity on students' understandings and actions in science learning activities. In the above examples, it appeared that such cultures shape students' understandings and actions during science activities, particular when aspects of the task, such as running, opened up for different interpretations. The lack of clarity opened up for different interpretations of the purpose of running in the case of Hafa, Lucas, and Zara, while in the case of Adi, Hai, Lucy, Mira, and Alfons the hallway co-shaped the meaning of running to go beyond the problem solving process. Building on Zembylas (2003), who argues that teachers' and pupils' identities are continuously in a state of "becoming" in a context that is embedded in power relations, ideology, and culture (p. 213), questions may be raised as to what kind of subjectivities are privileged in activities where cultures of performativity are seemingly influential. The argument may even be made that an embodied pedagogy runs the risk of privileging such cultures to exert greater influence in subjects such as science education, and potentially situate students in a context where some bodies are experienced as more suited to physical performance than others.

6.2.6. THEME 5: THE COMPLEXITY OF INTEGRATING PHYSICAL ACTIVITIES INTO UPPER-PRIMARY SCIENCE EDUCATION – CONCEPTUALISING COMPLEX BODIES

Studies show that the integration of exercise and movement is used more in lower primary than upper primary (Rasmus Høibjerg Jacobsen et al., 2015). These findings echo other studies that ask the students how much they move during the day. The tendency is that the older the student, the less physically active he or she is (Center for Ungdomsstudier, 2016; C. P. Nielsen et al., 2015). International studies that have asked teachers about what influences their use of and willingness to integrate physical activity in teaching, have shown that teachers experience an increasing academic pressure concurrently with the age of the students (Jørgensen & Troelsen, 2017). IN particular, the experience of having to achieve curricular goals and prepare students for tests in the different subjects is one that figures strongly as an inhibiting factor (Allison et al., 2016; Gibson et al., 2008; Goh et al., 2013; Larsen, Samdal, & Tjomsland, 2012), as is the packed curriculum and lack of focus on physicality in testing (Gately, Curtis, & Hardaker, 2013; Langille & Rodgers, 2010). Whether these findings also pertain to teaching and learning in science education is unclear. This theme presents findings that detail three senior-primary science teachers' perspectives on the integration of movement into science education. As such, theme 5 differs from the above themes in that it takes a different perspective on the integration of movement into science education. Here it was important to foreground the teachers and to let them speak for themselves. The section includes the voices of Michael, the teacher who planned and taught the science course reported in the above findings, and Louise and Rita, two science teachers who work at different primary schools (see chapter

6.1). Sullivan's (2012) notion about "created dialogue" (p. 105-122) is utilized here to present the teachers' reflections in their own words concerning their work with conceptualizing and implementing an embodied pedagogy into science education. Created dialogue means that while the teachers were interviewed separately (Michael was interviewed alone, while Rita and Louise were interviewed together) a dialogue was created to give the impression that they had all sat together, breaching time and space. This created dialogue was possible because similar questions were discussed in the separate interviews. This section responds specifically to the sub-question of *how can teachers work with an embodied pedagogy in science education?*

6.2.6.1 Conceptualizing movement in science education

The analysis takes a point of departure in the conceptualization of movement in science education. For this part, teachers were asked to explain their understanding of exercise and movement, and elaborate on how this related to use of movement in science education. The created dialogue below presents ideas, values, and challenges associated with using movement as part of teaching. Like Sullivan (2012), I have added some text to make it more coherent. This is marked in bold print.

Michael: I see movement as the body being in motion. By that I mean that it is not just, uhm hand-arm coordination, but that the entire body is in motion, that gross motor skills are employed

Rita: Well, movement is really everything from going down **(to the back of the room)** to get the computer, every time they get up and walk around to get something done, when they have to write something on the interactive board and they take turns walking up, then that is actually also movement. But it isn't movement that strengthens teaching and learning. It is the kind of movement that is necessary for doing other things than sitting still.

Louise: It is a natural kind of movement

Rita: That is one kind of movement. The other kind of movement enters naturally into teaching and learning because you have to move in order to do an activity. And then there is what we plan for, which is movement for the sake of movement.

Louise: The kind of movement that has no learning, that is, the kind of movement that we occasionally are compelled to do because they have to move. However, you can't plan anything, and then it becomes a trip to the sports hall or whatever you can do, what's possible, **(for example)** the mandatory *rundbold*[15] because they need some kind of movement, but planning is not necessarily subject specific.

Michael: But I would still, I require of myself that the movement activity actually support the particular subject. That is, it is not just, let's say, "run around the track and field course and then come back" and then <produces a whistle sound> we have **(run).** No, I see movement as something that supports what they have to learn **(in science)**.

Rita: **(Yes)** like when we are teaching about the human body, exercising and pulse, or about the speed of wind, then I send them out for a run. That is, where it makes sense that I use movement. If it has anything at all to do with movement, then we make use of it. That is, where it makes sense I use movement. If it has anything at all to do with movement, then we make use of it. But I have stopped using movement where it does not make sense. **(Sometimes)** we go into the forest to collect 6- and 8-legged **(insects)** and snails, and I ask, "How many can you find", and then we make it into a competition about who is faster. In that way, it also makes sense, in a manner where they become motivated through competition.

Louise: Yes clearly, particularly when we have about the body and physiology, there the body comes into focus naturally. That is where it makes sense to them; they learn better when they have experienced it themselves learning about bones and joints. You remember it more easily when you have felt muscle tension on a classmate. But also when you've had theory on ponds and freshwater, that you are able to walk down **(to the ponds)** and examine it. It (**the inclusion of movement**), has to have a fairly precise academic focus for **(the students)** to find meaning in it. … If it is more ambiguous **(why they have to move)** then things don't make sense to them.

It was interesting to see how the conversation and thinking about movement in science made the teachers reflect that people move all the time and for different purposes and that much of the movement that occurs 'naturally' is just part of being a student at school. The difficulty teachers referred to is the planned movement that supports science learning, and what this looks like. Despite this uncertainty, the teachers wanted to *integrate movement* (Jørgensen, 2018), to support and promote student understanding of abstract concepts, without being the object of focus. Yet it was an

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[15] The Danish term "rundbold" refers to a ballgame traditionally played outdoor, which is very similar to the British game of "rounders" and hugely popular in Danish schools as a recreational game played across all years.

aspiration that was somewhat hazy when they were asked to explain what the role of movement for learning in science is.

Michael: I wanted to place **(my students)** in situations where they use their body, **(and I was provoked)** by a comment that there wasn't all that much movement in what I had planned. And I can see that, it's not like they [the students] moved around all the time. Not at all. It actually became rather static for many of them. When I imagine **(what I have planned)** as a general course facilitating movement, where I really thought that they would move a lot, and then they actually didn't. Then I need to reassess my perception of what movement in teaching and learning is. Because, in my mind, I had an idea that they would move around and actually get many things done, but when I came to it and I looked out over the classroom to see how many were actually doing something, and how many stood or sat down, then there weren't a whole lot who were moving. **(However)**, the question is if movement in teaching and learning is other things **(than being in motion)**. An embodied consciousness about light and sound **(for example)**, that is an embodied consciousness of the speed of sound by doing an experiment. This means that they have experienced the speed of sound with their senses. That is, they have experienced that light comes before sound, and be able to associate this with sound being slower than light.

Rita: I have just had something on the senses. That was exactly this thing with they remember what they did. Do they remember better? They also find it funny, "can we try again". This shows that they can use it when they have experienced it. There is no doubt about that, it makes better sense than when they've read about it or watched a movie about someone else doing it. We did something on reaction speed. It really made sense. They found it engaging, and I had to stop them. They were so absorbed in if they could improve, and if there were any differences when repeating it. They were so wrapped up in it, and they also get like that when measuring pulse, or going outside to run the speed of wind. I have good experiences doing that. Yes, it makes sense when they like it. Science education is in that sense really a gift because you go outside, as much of the content supports this.

Louise: **(Yes)** because it's a natural connection. Like when you introduce them to joints and muscles, and do like this <exploring the joints and muscles of her arm>. It is something that resides naturally in the content… you don't have to reinvent something.

Michael: I think you are completely right about that, this thing about the senses coming into play, but they also need to have an embodied consciousness about **(the content)**.

Rather than talk about movement, the teachers talk about “situations where they use their body”, “embodied consciousness”, “experience”, “senses” and “natural connection” as words that capture how a moving body comes to make sense in science education. In doing so, they adopt a working definition of movement that is perhaps more harmonious with teacher values and intentions about the purpose of their subjects. These findings are congruent with a recent study by (Jørgensen, 2018), who found that teachers shy away from using descriptions of movement such as physical activity or exercise, because these terms are viewed as rather incompatible with the purpose of teaching and the boundaries within which they have to work (p. 120).

In summary, it seems that the concept of movement in science education is ambiguous, even for teachers working with it in practice. There are different ways in which students move in class, and from the dialogues, it appears that there is a belief or idea that there are certain kinds of movement that are more right, or affording to learning than others. Yet it is unclear what this looks like, and when asked to conceptualize it, movement that is considered natural or supportive to science education becomes other things than a moving body, but rather a sentient, sensing body that learns through experience.

6.2.6.2 Implementing movement into upper primary science education

While integration of an embodied pedagogy into science education calls for considerations about how movement may be conceptualized to support learning, teachers also considered how to put these ideas into practice. Presenting three subheadings, the following dialogues seek to illustrate the issues raised by the teachers when discussing their experiences with implementing an embodied science pedagogy.

6.2.6.2.1 Meaningful experiences in science

The intentional promotion or support of meaningful experiences was an issue raised by the teachers when discussing their experiences with building bridges between the (embodied) experiences that arose from being physically active and the conceptual ideas the activities supported.

Louise: Like everything else, that needs following up it is of little use to move for the sake of moving. We continuously need to include the evaluation of why we did it.

Researcher: Are the students themselves able to evaluate the activities? **(That is)** do they reflect, or do you have to facilitate this?

Michael: It definitely does not occur automatically.

Louise: We have to be the initiators.

Rita: And then there are some who can do it and others who do not have a clue what we are talking about.

Louise: There are **(also**) some who enter into a dialogue with us and say what if or something… and then there are those who still need guiding questions.

Rita: It does not make sense if you do not first explain them [the students] what they are to gain from it [movement], **(whether integrated)** before or after **(the activity)**.

Michael: I have experienced that they sometimes completely forget that they are here to learn, and then suddenly arrive at the kind of understanding I had hoped they would. **(However, the opposite also happens, where they would say)** "Well yes, we had fun running, but what was the purpose?" That they do not necessarily see the link.

Researcher: So you as a teacher have a central role, or at least it sounds like you may have a central role **(when it comes to making that link)**?

Michael: Yes! **(Sometimes I fear)** that is the link has been a bit too elaborate on my part when I have tried to integrate movement into my subjects.

Researcher: What do you mean by elaborate?

Michael: That I have had an image **(of the link)** inside my head, which has not been properly explained to them

Rita: **(Students this age)** think very concretely and things need to be presented as concretely as possible before they can use it for anything.

It was interesting to see how the teachers reflected on the meaningfulness of movement as something that does not necessarily happen automatically, but as something that in many cases needs to be developed with support of the teacher. Although Louise noted elsewhere that the students who are academically strong enjoy movement, but would have learned all the same had they been taught on the whiteboard, the teachers still found it necessary to discuss how they can make the experiences gained through the body meaningful to the students.

6.2.6.2.2 Body consciousness in physical activities in science education

A second issue raised by the teachers related to the identities of the students; they noted the age group as a central consideration.

Louise: We are placed in upper primary, and **(at this stage)** a number of problems arise that we have no control over. I have a seventh class where many of the girls are struggling with themselves. There are some personal problems that we simultaneously have to take care of, and which actually also affects particularly **(how we do)** movement.

Rita: I have also had classes where the girls and boys could not socialize, not because they were mad at each other, but they just did not dare to touch each other, which is such teenage nonsense. It is really, really challenging to do movement with teenagers.

Michael: **(Activities)** where they have to touch each other is difficult for some even though they are in upper primary and should be over that

Louise: They are bodily frightened. We all have somebody sitting in the class who is particularly challenged, and they have an even harder time when they are pulled outside to do this movement. "See how strange I am, I can't do this"

Rita: To be stigmatized further, that is perhaps also a condition in all of this

Louise: They are certainly often challenged when moving. It takes them out of their comfort zone, where they do not always know what they have to do. **(But)** imagine you are in a class of 28 Year 8 students who have just played half an hour of rundbold… I would hate to be the teacher who goes into the class after that. Because when they are back in class, and if we do not open windows and doors straight away, phew! That has something to do with practical measures, in that if we really want their pulses raised and they sweat, and then there are some who do not want to do it and those who really smell bad for the rest of the day.

Rita: They don't say that it is embarrassing, but you can just see it on them that they don't want to, and it is very clear that they don't have enough self-esteem. The thing about the embarrassment factor you frequently encounter is something that is either too dumb or too embarrassing, or that' I do not want to run. Then they go somewhere else and do another thing. So, there are some who ruin it for the rest because it isn't cool enough.

From the dialogue, it becomes clear that one aspect of working with the particular age group concerns the physical transformation teenagers undergo, and that this affects teacher planning. On the one hand, they have to deal with the actual physical changes, such as the maturation of sweat glands, and how they affect the learning environment; on the other hand, they are confronted with resistance from students who seemingly feel that they are exposing themselves through being physically active. As such, integrating elements of physicality in upper primary seemingly is much more than pairing conceptual ideas with repertoires of movement, but simultaneously a matter of managing students' body consciousness.

On a different note, the teachers also expressed a growing independence in the age group.

Rita: I think there is a difference between what they experience as movement **(and what we see as movement)**. I think rundbold unfortunately was something that was mentioned quite a few times during the reform, and that is something they, **(the students)** have noticed. In my class, they complain that they do not get to play rundbold. No! I have many things planned for my classes, but I also think that I do other things **(that is movement)**. I can quote one of my students "we never get to do any movement in your classes", and that is not true. I do a lot of things and I mention everything that we have done, **(and the students reply)** "yes, but those are dull because that was working with conceptual ideas"

Louise: I had the same issue in my class, where at a parents' evening the parents told me that the students come home and tell them that they do not get to do any movement. I told them that "I can't understand this, I do x number **(of activities)**".

Rita: I think there is a difference between what they see as movement.

Louise: They just do not see **(what we do in class)** as movement. I did an activity just before the summer, where the students had to act out an emotion. Three teams got the task and went out into the room, placed the cards **(with the emotions)** on the floor and took turns picking a card and acting out the emotion. Then there were those students who sat down in front of each other, turned the card and smiled. You can say that was movement, but they did not bother to get up because they might as well do it seated. Yes, they could do that, but it was not the intention.

Michael: **(In particular students, who have very set conceptions about learning)** do not enter into the activities with an open mind. They have set expectations and explanations about what's going to happen **(when they learn in science)**, and when I start them out and suddenly their expectations do not fit with what I say, then they become confused.

It was interesting to learn of not only the different ways in which students resisted movement activities, i.e. challenging what counts as learning or as movement, but also that the teachers were working with young people who related to what they were doing and questioned both verbally and through their actions the necessity and purpose of moving. This premise for teaching adds to the complexity of integrating movement into upper secondary science. Rita and Louise elaborated, noting that:

Rita: **(We had)** a company that came **(to the school)** to propose and show how to integrate movement into teaching. Most of their proposals – and we tried them ourselves, were aimed at lower primary, middle primary, and a single one for upper primary. Then we were promised a course. Lower primary got one, middle primary got one, and then we were next, but they never came. It is too difficult! They cannot make anything that we are able to use. **(Integrating movement)** is just not the same as in lower primary school one could say; it is just something completely different. Movement in upper primary school is a format of its own.

Louise: I think we had that course at our school. **(I cannot remember)** if it was something we came up with ourselves, but you had to use 30 balls. Firstly, I do not have 30 balls, and secondly, all my girls would be standing at one end of the court because they would be afraid of the boys chucking tennis balls at them. Come on! Their sense of reality is way off.

Rita: That is the problem. If you find activities online, then you might find *Skolen i bevægelse*[16]. "Take a big dice", we have one right in there <pointing towards a cupboard> where you can insert all kinds of things. They [the students] throw it and then learns that all the assignments are hard work except for number one, and then they all throw one. It is this problem; it is difficult to do something that is conceptually relevant that everyone also wants, can do or dares to do.

[16] Skolen i Bevægelse is an official government website where you can find examples of physical activities integrated into the different subjects

In particular, Rita's last sentence captures the complexity that faces these teachers in their work, and the frustration they experience when trying to implement an embodied pedagogy. For while a physical activity may be conceptually relevant, it appears from the created dialogues that they are also facing a diverse group of students with very different basis for participating in physical learning activities. With the explicit mentioning of this premise, the findings seem to suggest that participation involving physicality calls for different considerations than what they would do in activities that are not physically active.

6.2.6.2.3 Planning for physical activities in science

Lastly, issues of resources were brought up by two of the three teachers. This was not something that had been a topic for the interviews, but was brought up as a central concern when discussing their experiences and reflections on integrating physical activities in science. The teachers articulated two major challenges: resources and tests. In relation to lack of resources as a challenge, the teachers noted,

Rita: I have always used movement, also before the reform. To me, it is a natural thing that you as a human being need to get up on your feet and play. We need to make room for this. I have never moved as little as I do now following the reform because I simply do not have the time to do it properly as I did before. There are high demands to knowing exactly what you want to do **(in upper primary)**, and that is a challenge. **(But)** it can be really difficult to integrate movement with conceptual ideas, or make it part of teaching. It calls for time to sit down and plan and we only have 14 minutes to prepare each lesson. And then you have to go forth and back to the classroom, and you have to take copies, and that leaves actually very little time **(to plan for movement)**. And when you have a course on genetics, then we could dance the DNA. There are things you could easily do if you didn't just have 14 minutes of preparation for each lesson.

Louise: I have also used games, and had my students make active games for each other with biology. They created a dodgeball game about virus and bacteria. It was really good! It showed that they had grasped the concepts and the different names. Nevertheless, it takes a long time to do it, to run it through and evaluate whether the other students got it. It is **(what I call)** the good activity, but it require of the students to stay in school past three o'clock if you had to do it more often.

Time was perceived as a central resource when working with physical activities in science, something that the teachers find they lack. In the conversations, it was interesting to see how the teachers expressed a wish to utilize movement as part of their teaching in contrast to other parts of the interviews, where they voiced perceived difficulties of conceptualizing and motivating their students to engage in these physical activities as pervasive to their planning. Part of the explanation for time being of central concern might be located in an implicit critique of a new working hour agreement, that was implemented simultaneously with the educational reform, and which meant that teachers' working hours are regulated by law. In principle, this means that they now have to be present in the school during the entire school day, whereas prior to the reform they were able to make preparations when and where they wanted. This has resulted in less flexibility and a stronger focus on how much time teachers have to prepare for each lesson.

Time was not the only resource that came to matter for their planning. Other aspects discussed were lack of equipment, and lack of spaces for moving. During the spring and summer, the teachers and their classes were able to utilize the outside areas, but during the rest of the year the teachers felt compelled to stay inside, which meant that running and other noisy physical activities were excluded as these might disturb adjacent classes. Moreover, Rita noted, that with 15 other classes in the upper school area, even if they were able to do activities inside, there was also the matter of getting access to spaces suited for doing physical activities. Furthermore, coordination was perceived as a challenge. Louise noted "we do not have the time to call all our colleagues or run around and ask 'what and when did you do it', to schedule and make plans for who does which activities". Across the timetable, students participated in different activities in different subjects. However, sometimes the teachers learned that the students had already done a particular activity the very day they were planning to use it. While the teacher could still ask the students to do it, they found that the students became demotivated when this happened and this affected the mood in the classroom.

Testing was brought up as another issue that affected the integration of physical activities in science.

Rita: As soon as grading comes into play in the beginning of Year 8 they start to want it, **(to do science)**. They still want the breaks, but I think it differs from Year 7, where they still care to play.

Louise: They don't want to **(play)** in Year 8.

Rita: No, a lot of the students stay seated as you say. When you initiate the game, a third of the class stay back, and I say 'get up on your feet, we have to do this', and you almost have to use energy to get them started. **(They will say)** 'I can sit over here'. 'No you can't – now we are moving'. It is a shift from what takes place in Year 7, where they are still happy to play.

Louise: And towards Year 9, they are very focused on the exams.

Rita: **(In Year 9)** we are so busy. **(In the new school year)** I am teaching Year 9 in biology. I have one lesson a week in biology with them, and if I have to include movement that does not count as valid knowledge to them, then I run out of time.

Louise: There is a long way from movement and learning in science to the product that is expected from them **(the policy makers)** higher up. It is something like that makes me question whether I should consider planning for movement or actually try to teach towards the absurd demands that are imposed on us.

Rita: As long as we have to answer to **(the learning)** goals **(for science education)** then we owe it to the students that they are actually capable of accomplishing those goals. It is a constant assessment where I have to evaluate what is best for these students. I would love to include more movement, but what do I have to take out in order to do that?

The conversation between Rita and Louise indicated a cross-pressure that the teachers found themselves in when trying to meet the different demands set by the policy-makers. On the one hand, they had to ensure that their students could pass the exam, and on the other hand, they had to integrate movement – elements that, when discussed in the context of testing, seemed incompatible, although they had also discussed how movement could support learning.

In summary, the teachers found that the implementation of physical activities into science education is a complex task that involves multifaceted considerations, involving consideration about how movement becomes meaningful to the students, how students feel about themselves and moving, and how resources and time are prioritized.

6.2.6.3 Summary

I have named this theme *Complex bodies* – a name that denotes how conceptualizing and teaching movement activities in upper-primary science class is as task that calls for multifaceted considerations about the circumstances surrounding and characterizing the (embodied) students in this particular segment of school. Presenting created dialogues, this theme portrayed how the process of conceptualizing and implementing movement activities was shaped by many uncertainties and challenges, which came to inhibit an actualization of integrated movement activities, which was viewed as the more meaningful way of integrating movement into science education. Such uncertainties and challenges were illustrated by the ambiguity surrounding the purpose and role of movement, the challenge of bridging different kinds of knowledge, the growing body consciousness and its consequences for social interaction, and the lack of resources for realizing physical activities. Despite having to manage such uncertainties and challenges on a daily basis, the teachers remained positive about the possibilities of an embodied pedagogy in science.

6.3. SUMMING UP

This chapter presented the findings for this dissertation. The findings were presented as summaries of articles, as well as analysis of unpublished data. The findings indicated that students' as embodied beings appear as complex learners, who are anything but machines to be optimized through movement. Rather, students are sentient and sensing beings, who when asked to be physically active in science education draw on their embodied dispositions in making sense of the activities. As such their emotions, physical competences, embodied identities and consciousness of their bodies all come to matter when responding to the tasks. The complexity of the students as embodied learners as well as the ambiguity of what counts as movement challenges teachers who seek to integrate physical activities into science education, and it becomes unclear what the purpose of movement is and how it supports (or is supposed to support) learning. This reality is furthermore framed by practical realities around the schools, where resources are not always readily available for this kind of work. In this way, the students' bodies become significant not only in terms of the consciousness surrounding their embodiment that an embodied pedagogy affords, but simultaneously also in terms of how an embodied pedagogy challenges understandings about what counts as learning and knowing in science education.

CHAPTER 7. DISCUSSION

This final chapter presents the response to the research questions. The discussion is organized along the three research questions of this thesis:

> *How do students experience an embodied pedagogy in science?*
>
> *How can teachers work with an embodied pedagogy in science education?*
>
> *How can an embodied pedagogy in science education be researched?*

Together, the discussion of these questions intends to contribute to a greater understanding of how movement becomes meaningful in the social reality of science classrooms when an embodied pedagogy is made part of the teaching and learning, and reflections about how such a reality may be captured and researched.

7.1. RESEARCH QUSTION 1: HOW DO STUDENTS EXPERIENCE AN EMBODIED PEDAGOGY IN SCIENCE?

Experiences are highly personal, and vary accordingly. This study is no exception, and the stories told and observed in the video data tell about those different experiences. The following synthesizes the findings when science education implicitly and explicitly foregrounds the body. Looking across the data presented in this dissertation, four overarching themes were identified in terms of how an embodied pedagogy comes to matter to students' experiences of science education. These are:

- Working with a tacit content
- Challenging notions about learning
- Emotions and performance
- Idea(l)s of performativity

Working with a tacit content. Students experience science through their bodies, which forms part of knowing science (Hardahl et al., n.d.). With an embodied pedagogy, this premise is emphasized when inviting students to see, hear, touch, move, or dramatize as part of the process of learning. This study found that students in many cases readily engaged in activities where using their bodies formed a central part of the learning, yet that they experienced the embodied dimensions of the tasks as *tacit content* where embodied knowledge could not be "explicitly stated" (Polanyi, 1966, p. 4, italics removed). Article D (*The body and the production of phenomena in the science laboratory: taking charge of a tacit science content*) presented an example where students sought to produce the phenomena of refraction. To do so they tested the effects of positioning their bodies and seeing the test tube from different angles according to instructions. The body positions were integral to knowing science, in this case refraction, yet remained an element of the activity that the students did not explicitly reflect on nor talk about in their report. Similarly, article B (*Troubling an embodied pedagogy in science education*) explains how the embodied experiences of students, when learning about the Doppler Effect, were remembered bodily, but were hard to transform into explicit scientific terminology. The knowledge the students gained through these embodied tasks may have been particularly difficult to express through language, since they were experienced in their complexity, meaning verbally and non-verbally including through kinesthetic, auditory, and visual modes (Clement, 2008; DiSessa, 2000). The ability of students to follow instructions, but without clear comprehension of the meaning of their actions, has been described as *discourse imitation* (Airey & Linder, 2009). Science education as a discourse can be characterized as a semiotic system of "… words, images, symbols, and actions" (Lemke, 1998, p. 4) in which the knowing is codified so to speak. While students may seemingly master one or more modes of the discourse, they can still fail to relate this to a teacher-intended disciplinary way of knowing (Airey & Linder, 2009). In the context of this study, *seeing, hearing, feeling*, and *sensing* were actions that occur in everyday situations, yet placed within a science education discourse, they were inaccessible as meanings. Such findings suggest difficulty in connecting embodied and disciplinary discursive ways of knowing. This may also be related to broader discussions about the gap between the understandings of expert scientists and students (see e.g. Brock, 2017; Sitaraman, 2017), where, according to Brock (2017), the difference between novices and experts is also a matter of tacit elements, including "knowledge related to the kind of contexts in which a particular approach will be successful, a sense of the related underlying structures of situations or kinaesthetic models of how particular systems will behave" (p. 135). Brock (2015) calls a greater awareness of the role of *intuition* and *insight* in terms of how they manifestation in practical work (p. 156) as a way to link the tacit and the explicit. This idea should be expanded to place emphasis on the role of embodied experiences and how they shape learning.

Challenging notions about learning. This study observed students engaging in seven different science tasks. The way how embodiment was part of the tasks was very different each time. Three activities concerned investigating properties of *light*, specifically the bending of light, refraction, and spectrometry. Three activities were about the concept of *sound*: the speed of sound, the Doppler Effect, and sound waves. The last activity focused on learning about ions. Of the seven tasks, students found in particular three tasks challenged their notions about learning in science. These were the speed of sound, Doppler Effect, and the ion activity. These activities either moved tasks away from the classroom, or included actions that utilized whole-body movement, which some students responded to with frustration and confusion when not explicitly explained about the purpose and background to learning also through embodied ways (chapter 6.2.4). In the context of secondary level teaching, Grauerholz

(2001) cautions that “not all students will respond well to holistic teaching methods. Those who have succeeded in traditional academic classrooms and systems may view holistic teaching as irrelevant and disorganized” (p. 45). While Grauerholz does not include embodiment in her definition of holistic teaching, which denotes students’ emotional, moral, spiritual, and intellectual concerns and struggles, this seems true also for this study when students, who had been identified by their teacher as high achievers, were frustrated with the activities. A science pedagogy that includes the body as a site for learning and source of knowledge may require explicit explanations.

Emotions and performance. An embodied pedagogy is also an emotional experience. As shown in article A (*Emotions: Connecting with the Missing Body*), students associated emotions with embodied activities. Affect is a central and important part of learning in and about science; for example, in shaping the choices students make about how or why to engage in science learning activities (Roth, 2007). The different emotions the students experienced in the Doppler task were of a different nature since they had to decide how much risk they were going to take performing publicly in front of others. Such findings point on the one hand to emotions as a central component of movement, and on the other hand emphasize the different experiences students have with movement and how these shape the affordances of such activities. As argued in chapter 2, the narrow sense in which movement is conceptualized and researched (Jensen, 2018) risks reducing movement to a social technology (Brinkmann & Tanggaard, 2008). In this study, there is evidence of such thinking in the way movement is used to support learning. The teacher was focused on how movement could support academic learning (e.g. *experiencing* the Doppler Effect) and did not consider the cultural and social context into which this kind of movement activity was introduced. It showed how the students’ experiences of running in the hallway were acts of communication (Goffman, 1959) that were perceived by one self *and* others.

Idea(l)s of performativity. Emotional experiences are situated in context (Goodwin, 2007; Goodwin, Cekaite, & Goodwin, 2012; Goodwin & Goodwin, 2000). Students experience the performativity of their bodies typically in sport classes (in and outside of school) that shape very specific ways about the role of the body. Article A (*Emotions: Connecting with the Missing Body*) and B (*Troubling an embodied pedagogy in science education*) showed how students transferred this experience into the context of the science activity of the Doppler Effect. The findings point towards physical capital some students had (while others did not) that legitimized physicality as a central competence. According to Evans, Rich, Davies, & Allwood (2005) there are very real risks involved for some students in displaying emotions (or affective dimensions of corporeality) when “cultures of ‘performativity’ dominate and prevail in schools” (p. 129). Such cultures influence how students think and learn about themselves and how they perform in front of others, for example in sport (Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-Ntoumani 2011). This applies also to an embodied science pedagogy, and demands careful consideration of the settings and instructions presented to students in order to create inclusive cultures of embodied learning in science rather than to perpetuate performative youth sports cultures.

7.2. RESEARCH QUESTION 2: HOW CAN TEACHERS WORK WITH AN EMBODIED PEDAGOGY IN SCIENCE EDUCATION?

Since Denmark has implemented a mandate asking teachers to integrate movement into their everyday teaching, teachers have to make a decision on how to go about this. Either they can interrupt the normal teaching to include brain breaks or they can opt for meaningful opportunities to include movement into their subject teaching. From the latter arises the need for an embodied pedagogy in subject specific teaching. An embodied pedagogy in subject specific teaching considers learning with and through the body, and as such seeks to join body and mind, physical and mental to fit ways of knowing in and the instructional methods of the subject. The conceptualization of an embodied pedagogy in science education thus calls for explicit considerations about how the body intertwines with the mind to support ways of knowing and teaching science.

However, the mandate in itself or the research used to underpin mandated movement does not inform subject specific teaching. As shown in chapter 2.1, the mandate builds on arguments for more movement that have been positioned in evidence-based research. However, this research is also signified by the lack of references made to subject specific pedagogical context (Jensen, 2017a). The findings in this study indicate that the rationalities of the mandate and the power it asserts on what happens in classrooms shape teachers' conceptualization of movement for their subject teaching. Here it is noteworthy to point out that the strong focus on the benefits of physical activity positions movement as a goal in itself. Teachers identified this as something important having to integrate:

> "…when we are teaching about the human body, exercising and pulse, or about the speed of wind, then I send them out for a run. That is, where it makes sense that I use movement. If it has anything at all to do with movement, then we make use of it." (Chapter 6.2.6.1).

While the application of the Ministry's mandate into school practice seems to manifest itself often in the idea that movement should be central, teachers also pointed out that this made them think about the affordances of movement within science and that it was not a simple thing to accomplish:

> "When I imagine **(what I have planned)** as a general course facilitating movement, where I really thought that they would move a lot, and then they actually didn't. Then I need to reassess my perception of what movement in teaching and learning is. Because, in my mind, I had an idea that they would move around and actually

> get many things done, but when I came to it and I looked out over the classroom to see how many were actually doing something, and how many stood or sat down, then there weren't a whole lot who were moving. **(However)**, the question is if movement in teaching and learning is other things **(than being in motion)**" (chapter 6.2.6.1)

While movement becomes the driving idea in the mandate, the faculty of movement is insufficient in terms of capturing what it means to conceptualize an embodied pedagogy for science education. This finding is consistent with arguments made by Jørgensen (2018), who found that the notion of movement takes on much broader meanings when implementing it into teaching and learning in general. This study has synthesized four different ideas as central to the formulation of an embodied pedagogy for science education:

1) An embodied pedagogy is more than thinking about movement.
2) A pedagogy utilizing the body needs to consider the individual ways in which people experience the world.
3) An embodied pedagogy needs to teach students how to learn through the body
4) Educating the body entails engaging students in explicit examinations of the consequences of their bodily actions for doing science.

An embodied pedagogy is more than thinking about movement. Teachers used expressions such as "embodied consciousness", "experience", and "senses" when talking about how movement becomes meaningful in science education (chapter 6.2.6.1). They noted how their students would learn better when being presented with the opportunity to e.g. touch the muscles to feel tension, hear the Doppler Effect, or see the refraction of light. While movement was enabling their students to experience the world, what movement exactly entailed was most times not pedagogically conceptualized. It was not movement in itself that provided meaningful entry points to experience science; rather, it was how such a pedagogy afforded new abstractions that allowed for embodied experiences. This suggests that an embodied pedagogy for science education becomes meaningful when it unpacks the details about the body encounters students may experience, to strengthen the sensory affordances and to build a language for talking about these experiences.

A pedagogy utilizing the body needs to consider the individual ways in which people experience the world. Focusing on the body and creating opportunities for the students to encounter physical phenomena through their senses, the teachers in this study displayed what an embodied science pedagogy could look like. In addition to the other research fields identified in chapter 3, sensory science pedagogy plays here an important role and is an underexposed field (Otrel-Cass, 2018). Sensory pedagogy acknowledges the role sensory experience plays for our perceptions of the world –

that is, how we structure space, define place and experience meaning (Johansson & Løkken, 2014). While the teachers in this study provided sensory opportunities for their students to experience and sense different physical phenomena, the findings showed that the students experienced the science phenomena differently in their encounters with various materials. This showed that meaning does not come ready made from an experience. Examples of this are presented in articles B and D. Article B found that students drew on embodied memory from experiences when asked to explain physical phenomena, and found it difficult to translate bodily experiences into conceptual ideas. Article D identified how the act of seeing can be accomplished in various ways as students adopt different bodily approaches resulting in dissimilar experiences of the refraction of light. The dissimilarity in their experiences produced negotiations about the notion of invisibility, and when something could be characterized as invisible. These observations suggest that objectifying bodily experiences in the classroom such as hearing, seeing, or sensing motion is problematic because students experience activities differently as the sensorial affordances afforded through participation is made sense of on individual backdrops. The inclination to objectify the senses is, according to Ingold (2000), a common flaw, which:

> "…lies in its naturalisation of the properties of seeing, hearing and other sensory modalities, leading to the mistaken belief that differences between cultures in the ways people perceive the world around them may be attributed to the relative balance, in each of a certain sense or senses over others" (p. 281).

This inclination to naturalize the senses is present in the written instructions for both the invisibility task (article D, chapter 7.1) and the Doppler Effect task (described in article B, and D, chapter 7.2), where the students are asked to *hear* or *see* without any further reflection about what this means. The implications is that a pedagogy utilizing the senses needs to consider the diverse ways in which people experience the world, as it is experienced emotionally and sensorially and evaluated on the backdrop of context and prior experiences (Otrel-Cass, 2018).

An embodied pedagogy needs to teach students how to learn through the body. This study finds that an embodied pedagogy needs to focus on educating the body as opposed to only educating the mind. What this means is that teachers and their students have to learn how to learn through the body. Embodied pedagogy for teachers means to consider getting the body actively involved in the learning process, for instance through including movement when learning about physical phenomena. This is important since bodily experiences do not automatically translate into conceptual learning and could also lead to confusions (Otrel-Cass, 2018), and must be therefore carefully mediated by the teacher to become meaningful for science learning (see findings in chapter 6.2.6.2.1). In this PhD project the teachers reflected on the need to make what they called "links" to ensure that students make additional learning experiences about scientific explanations through their bodies and with their senses.

The teachers found that the challenge of making links was a matter of rethinking communicating those intentions using various instructional methods, including improved presentation, feedback, or guiding questions. This is presented in article D, which show how students were largely unreflective about the position of the beaker or what it meant to *see* in the context of the experiment, suggesting that improved communication is also about making students reflect on the role of their body in relation to the activity. As argued in article D, “the acts necessary to produce certain stimuli do not come automatically. They need to be learned and educating the body is central in this learning.” (p. 15). Yet, neither in the reflections nor in the observations of the teachers and students have I encountered reflections on what it means to hear, see, feel, or position one’s body in a particular way in the context of science. Instead, such knowledge seems to be tacit, and understanding about what these things mean within science are taken for granted. The issue is that the supporting role that the body is attributed with undermines its value in how science could be experienced. This is perhaps not so surprising. Rogoff (2003) argues that people develop as participants in cultural communities, and that their development can only be understood in light of the cultural practice and the circumstances of their communities. Science education is, as argued in chapter 3.1 and article D, shaped by a strong focus on content rather than process, and the development of an embodied pedagogy must be seen in light of this. Learning how to learn through the body thus calls for a change in perspectives of the ways in which bodies are recognized in learning science by both teachers and students.

Educating the body entails engaging students in explicit examinations of the consequences of their bodily actions for doing science. Bodies are educated and taught to behave in certain ways in diverse settings (O’Farrell et al., 2000), including classrooms, where this is often done in implicit ways through the structuring and organization of the classroom (Brook, 2000). This is also the case in this study where students are expected to conform to a variety of particular forms of acting, such as listening, seeing, taking notes, moving their bodies in particular ways, and handling equipment according to detailed instructions. These bodily practices are often tacit, meaning that neither students nor teachers explicitly reflect on those practices. By neglecting the struggles on how bodily meaning making becomes relevant to science activities, there is a risk of reducing science activities to a kind of “theatrical practice that focuses on mimicking scientific activity” (Arvola Orlander & Wickman, 2011, p. 591). In article D, we suggest to address this issue by making the “absent body” (Leder, 1990) present through explicit examinations with the students of the consequences of their actions for producing physical phenomena. The value of explicitly addressing the role of the body as content in science education is also illustrated through the ideas of Shusterman (2008), who argues that by honing and developing conscious somatic perception with explicit awareness that may also be reflective/self-conscious, we can become more mindful of our perception (see chapter 4.2).

Science education holds many opportunities for including an embodied pedagogy. This was the case in this study, where the teacher, Michael, granted me insights into how he planned for this kind of teaching. He showed how a very common strategy of hands on (lab) work that is very engaging and motivating could be infused with movement. For example, utilizing the body to represent abstract concepts beyond our sensory abilities to witness ions, or moving a common approach to learn about waves outside. Using ropes rather than short strings as an in class activity may have added to the experiential value, in so far that the inquiry was not restraint anymore by adjusting your movement to the limited space inside. Based on the analysis of the observations and discussions, this study identified four aspects of utilizing an embodied that stood out as central to how teachers can develop an embodied pedagogy in science education. First, by identifying an embodied pedagogy that is more than including movement into teaching and learning. It involves careful considerations about the embodied experiences that can be experienced and created. Second, a pedagogy using the body needs to consider that people experience the world through the body in different ways, and this makes it very difficult to plan for the same kind of embodied learning. An embodied pedagogy approach will need to find opportunities to talk about these different experiences and what value they add. Third, an embodied pedagogy will require that teachers and students relearn how to learn through the body and what it adds to their experiences. Fourth, teachers need to integrate the earlier points in their planning, so they are better prepared to implement this into their everyday teaching and are prepared to explain this to their students since this is not how they have been taught to learn in science.

7.3. RESEARCH QUESTION 3: HOW CAN AN EMBODIED PEDAGOGY IN SCIENCE EDUCATION BE RESEARCHED?

Studying embodiment in the context of science education is a difficult endeavor. It entails shedding light on an existential aspect of our being that we take for granted, and which is often absent from conscious thought. The body grants us permanency in the world, and shapes the way we perceive the world, and how we come to know places (Merleau-Ponty, 2012). Its presence is permanent, always on the periphery of our perception, yet this very fundamental role simultaneously means that it eludes conscious thought (Leder, 1990). This is what Shusterman (2008) calls primitive or somatic modes of perception. In foregrounding the body in teaching and learning, an embodied pedagogy draws on a habitual body, but simultaneously prompts more explicit kinds of awareness of the body, where attention is directed towards the present state of the body and related feelings (Shusterman, 2008, p. 55). Such deeply personalized and contextualized meanings can be hard to access, as they are fleeting, situated in the moment. Finally, the study of embodiment is challenging because movement has multiple meanings and can only be understood against the context, culture and expectations of the person enacting the movement (Goffman, 1959, 2010). In relation to this, some ways of comporting oneself may be socially acceptable in some spaces, while unacceptable and stigmatized in others (Goffman, 2009). Research into this field thus also potentially involves sensitive situations, where the researcher on the one hand might witness acts of stigma, and simultaneously in the research provoke unnecessary awareness of such acts furthering discomfort in the informant. The following discusses how these challenges and ideas are transformed methodologically.

The study of an embodied pedagogy is essentially a study of situated practices. Teachers open up the world for the students through the body, and similarly, students explore and come to understand with their bodies. The movement that takes place in this kind of setting is not mindless (for example, a social technology, Brinkmann & Tanggaard, 2008), but instead meaningful behavior directed at particular experiences of the world in an actual setting. As such, it is not something that can be studied from afar. The processes that unfold are highly personal, situated, and responsive to the context. Consequently, it requires that the researcher goes into the field to explore how the teacher conceptualizes an embodied pedagogy and how this is transformed in the classroom, observe how the students are activated and engaged bodily in the tasks, and talk to them about how they experienced it.

Video observations are a valuable tool for this kind of research as they capture and retain the embodied actions that unfold during class, allowing review of interactions in detail (Knoblauch, Schnettler, & Raab, 2012), particularly non-verbal matters such as facial expressions, intonation, or stance-taking (Cohen et al., 2011; Derry et al., 2010; Knoblauch, 2009), which can otherwise be hard to document. For the study of embodied pedagogy, video observations are particularly valuable because they enable the researcher to develop an eye for seeing the body that otherwise evades conscious thought. For example, the empirical data presented in article B (*The body and the production of phenomena in the science laboratory: taking charge of a tacit science content*) shows how students gradually develop and refine the relation between their bodies and the materials they are working with. The capture and identification of this example and the resulting analysis would not have been possible without video data.

In terms of data analysis, video is a way to foreground the visible body in research, which tends to focus on talk. As argued in article C (*"Peeling an onion": layering as a methodology to promote embodied perspectives in video analysis*), there is a history and culture of writing in the scholarly community, and this form is better suited to publishing (although this is changing with the emergence of e.g. YouTube, and platforms for collaborative work on video such as V-note). This is problematic in terms of foregrounding the body, as writing has a way of reducing the visual, kinesthetic, and acoustic information into simple transcripts fit for journals. Video challenges this norm with the richness and complexity of the data generated. However, the very complexity of video data is simultaneously a challenge to researchers' as they need to find ways of communicating complex data in meaningful ways. The systematic framework presented in article C presents a way to foreground and become sensitive to embodied dimensions, by focusing on how each mode of data is interpreted and combined to inform understanding. The framework is inspired by Goffman (1959) in terms of conceptualizing and analyzing movement as essentially behavior with meaning, where actions are seen as ways of making sense of the world carrying significance and meaning in concrete social interactions. The work on embodiment in interaction analysis by, in particular, Goodwin (see e.g. Goodwin, 1993, 2000; Goodwin, Cekaite, & Goodwin, 2012) and multimodal transcripts by Norris (2004, 2012) propelled methodological consideration about how to foreground embodiment.

Key experiences gathered in the process of formulating the methodological framework concerned the merging of different modes of data, and the importance of gaining emic perspectives respectively. Regarding the process of merging different modes of data, the order of analysis seems to have an impact on the interpretations afforded through this framework. This study had a particular interest in foregrounding the role of movement for teaching and learning in science, and consequently utilized key ideas from LMA (Laban Movement Analysis) (Konie, 2011; Laban & Ullmann, 1975) to enable description of students' movement. Using this as basis for further analysis, privileged a focus on the manner in which students comported themselves, and in particular when one or more students deviated from the instructions provided by the teacher or from what seemed to be the norm. Other studies may want to take point of departure in other modes of data.

This study found that a key aspect of enabling learning through the body was also the ability of students to "link" bodily experiences to conceptual ideas. Research into such links may want to use emic perspectives as starting point, to give direction to how and when students feel they learn something through and with their bodies. In relation to the importance of gaining emic perspectives, the experience of developing the framework was that gaining the students voices became central in validating and/or correcting the interpretations made in the analysis. From an embodied perspective that recognizes how experiences are shaped by the body, research needs to open up for emic perspectives, as such personal insights (i.e. a stomach cramp or knee injury shapes how situations are perceived) can really only come from the owner of that body. Gaining emic perspectives in this study gave evidence of the different ways in which the students experienced an embodied pedagogy, how this was linked to how they felt in their bodies, and in some cases provided explanations to why the teacher-desired-experiences did not emerge. Article B (*Troubling an embodied pedagogy in science education*) showed how running for some students prompted a focus on speed as opposed to sound, while chapter 6 showed how a dramatization activity for one girl prompted a focus on doing things right, rather than how ions form. These examples show that the underpinning conceptual learning was somewhat overshadowed by how conscious the students became about the public nature of their embodied performances. In studies on embodied cognition in science education, Niebert and Gropengießer (2015) noted that proving experiences do not always result in intended understanding. Including emic perspectives may be a way forward to understand why this is not the case, and deepen our understanding about how the body mediates such experiences and what the students gain from them if not the intended learning.

CHAPTER 8. CONCLUSION

The diversity of data from this study provided rich information about the body in science education. The strong focus on taking a contextual perspective highlighted the significance that is conditioned by particular circumstances. The challenge in this research was to work within a not very clearly defined field and to approach the field systematically, but with the necessary sensitivity. The resulting approach was inspired by several fields to approach the concept of movement that does not take place as part of physical education but in science education, which has a tradition, culture, and history of separating the body and mind. I worked with a Year 8 physics class at a school that had mandated the integration of movement into all teaching including science, and science teachers who were trying to accommodate the government's then latest mandate. The project utilized an interpretative methodological framework, and used videography to combine video observations and ethnographic fieldwork in order to capture embodied science activities as they unfolded during class and reflections about these activities by the teachers and students.

While three dimensions of the body were identified in chapter 4 (embodied identity, body consciousness, and body legitimacy), as a way to conceptualize a situated and contextualized body in science learning, what increasingly became apparent during the study was the prominence of identity as an umbrella term for all three dimensions. Shedding light on the materiality and intentionality of the body, the different kinds of embodied conscious, and how embodied action always is part of a social and cultural context, all three dimensions contributed to examining how learning is not a disembodied acquisition of knowledge, but rather the result of experiences of an individual body. As such, identity was expressed not only by the students in having and being different bodies, with each their ways of making sense of the spaces they were positioned in. Identity was also affected by how the various science tasks foregrounded the body, making the students become very conscious about their own and others' embodiment. Moreover, because of these deliberate bodily performances (as opposed to the usual hidden embodied movements that are part of science activities) performative idea(l)s shaped how students came to view their own performance and others'. Resulting from the study is thus a refinement of the tables presented in chapter 4. Rather than three separate tables, these tables have, as shown in Table 7, been merged into one coherent table and the experiences from applying the framework to science education have been added in the shape of *emerging questions*.

Table 7: Embodied identity in science education

<table>
<tr><th colspan="4">Embodied identity in science education</th></tr>
<tr><th>Embodied science pedagogy element</th><th>Underpinning concept</th><th>Central ideas</th><th>Emerging questions</th></tr>
<tr><td rowspan="2">Body materiality</td><td>Permanency</td><td>The body responds (enables and constrains) the perspectives about the world

Bodies are different and different bodies grant different perceptions</td><td>How does the science learning activity position the students? What are the perspectives that each activity affords?

What kind of bodies are the learning activities designed for, and when do bodies become ‘dysfunctional’?</td></tr>
<tr><td>Spatiality</td><td>We come to know spaces such as classrooms through the projects that we engage in, for example writing, sitting down or doing experiments

Spaces are characterized by particular routines and habits embedded in the body</td><td>What actions characterize the science classroom?

What kind of habits/routines do the students have/associate with science activities?</td></tr>
<tr><td rowspan="3">Body consciousness</td><td>Primitive modes of consciousness</td><td>Unconscious adjustment of behavior</td><td rowspan="3">What kind of bodily consciousness is promoted in a task (written instruction) and how?

What kind of bodily consciousness is promoted in the task (verbal instruction) and for what purpose?

Does the task draw attention to the students’ own bodies in the enactment of it, and how do they become conscious of their own bodies and those of other students?</td></tr>
<tr><td>Conscious perception without explicit awareness</td><td>Consciously perception, but not directed at anything in particular/ tuning out</td></tr>
<tr><td>Conscious somatic perception with explicit awareness</td><td>Conscious and explicit awareness of what is perceived/ explicit conscious somatic perception/ level of mental representation</td></tr>
</table>

	Self-conscious or reflective somatic perception with explicit awareness	Mindfully conscious of a focused consciousness/ awareness of how our self-consciousness affects our bodily state	
Body legitimacy	**Body techniques**	Movement is culturally and historically variable, and learnt through training/education to meet certain purposes Movement can be seen as practical reasoning that is embedded in a cultural context, and thus regulated by what counts as right or wrong Movement is a way of regulating social interaction whereby social occurrences are managed or avoided	*Which body techniques are called for in the science tasks (e.g. seeing, hearing, walking, running, tinkering and so forth)?* *Are there any of the body techniques that are particularly 'scientific', that calls for very explicit grasping of conceptual ideas?* *Are there any body techniques that privileged particular status?*
	Theater metaphor	Interaction is conceptualized as a stage on which people perform to maintain and manage the impression they give of	*What kind of identities are managed and given of in the interactions?* *What characterizes the stage (interaction)?* *How do the students position themselves towards each other and the science activities?*
	Stigma	Society uses preferred/ desired ways of embodied being. People who embody these, and those who seem not to conform are deemed deviant Perceptions of embodied normality/deviancy shape how we see ourselves	*Are any of the students stigmatized?* *If so, what are the features they are discredited for?* *What is considered normal/deviant in the performance of the activity?* *Does the students feel at risk when engaging in the activities?*

Reflecting on my overarching question of what it looks like when movement become part of teaching and learning in science, I am reminded of dancing. An embodied pedagogy is about orchestrating multiple bodies in coordinated routines that activate and provide opportunities for completing certain kinds of bodily actions, all the while creating a space where the experiences resulting from these actions may be examined and expressed as ways of knowing science. However, while the scenes that emerged in this study showed groups of students moving into different spaces to perform series of movements intended to produce particular embodied experiences, performing these routines were not without difficulty. Every now and then, the dances were disrupted as students broke out of the intended movements, struggling to perform the movements and realize the intended experiences, or having trouble making sense of the movement. Hence, in the landscape of equipment, natural phenomena, science curricula, and sensing, moving and personal bodies, the major feature that materialized resulting from an emphasized sensitivity to embodied identity was the pedagogical complexity associated with foregrounding movement in teaching and learning.

8.1. IMPLICATIONS OF THIS STUDY

The intention of this study was to contribute with new insights that are relevant to policy makers, practitioners, and researchers.

This research identified the complexity associated with adopting and practicing an embodied pedagogy in science education. Since ***policy makers*** are instrumental to making significant changes to the educational practice landscape it seems that this mandate foregrounded in particular research that built its argument on a seemingly causal relationships between physical exercise and learning achievements. However, selecting such research ignores that teenagers in particular feel very sensitive about their embodied performances. It is important that policy makers consider how a systematic approach to increasing daily physical exercise can be promoted. An instrumentalizing approach to movement runs the risk of stigmatizing those who struggle to perform and/or alienating those who want to do science but cannot make sense of such an approach. Policy makers will need to consider what assistance and resources may be necessary for teachers or teacher educators to support a mandate that touches upon body sensitizing issues. Due to the sensitive nature of embodiment, taking note of students' voices may be crucial.

To ***practitioners***, specifically teachers but also teacher educators, this study suggests to be sensitive towards the embodied processes that takes place in the classroom when students *do* science. However, that said, the subjective and embodied experiences, feelings, and habits that surface during learning activities that foreground the body are often hard to anticipate, and arguably beyond what the teacher can be expected to accommodate a priori in his/her planning. Movement is inherently socially and culturally embedded. What will be fruitful is to broaden ideas and make space for a 'scientific body' that is more than just as a tool for objective reasoning. Science educators will need to remind themselves of the inherently personal and subjective nature of embodied experiences, to consider how such experiences inform and shape how students come to know about the world. Taking this approach means that learning through and with the body can be much more than making students move. One group of practitioners I haven't mentioned yet is students and it will be through their teachers that they can learn how they can experience their moving bodies. It means that teachers will need to provide them with the necessary explanations how to work with and understand their embodied experiences and what this means in the context of science education.

To the ***research community*** this study proposes that it is important to take more nuanced approaches to how we investigate and analyze embodied practices in education, especially science education. This research project adopted a few approaches to take note of the different layers that can be unfolded. Utilizing a videographic approach allowed for a deep investigation to look at micro and macro levels, at brief moments in time and over longer periods of science practices. The study also contributes with insights into how to conceptualize embodiment and embodied pedagogy, specifically in the context of science education research.

8.2. LIMITATIONS OF THE STUDY AND FUTURE DIRECTIONS

All research has its limitations, and this project is no exception. Decisions had to be made that shaped subsequently what can be learned. For example, there was little focus on quantity but rather on identifying the subtleties of human practices. Future research may wish to work with greater number of classes and teachers, perhaps over longer periods of time, to learn how an embodied pedagogy may build a stronger sense of how young people perceive the appropriateness of trusting their embodied experiences. In this research project, I did not intend to make an argument for or against movement in science but embraced subjectivity, both my own and the subjectivity of the students and teachers I was working with. Future research may wish to explore subjectivity through its entanglements with learning processes and concepts in science further – perhaps not necessarily to show how embodied subjectivity fools our perceptions of the world, which are research insights we have already explored (for example by looking at what is termed children's science or naive ideas in science). It will be more fruitful if future research examines further how we can teach and learn science in ways that are more in tune with our subjectivity that is generated through our bodies. Through the critical examination of a classroom that had adopted an embodied pedagogy, this study hopes to have contributed to the field of science education research. This field will require in the future even further expansions of understanding identity formation in science education, especially if the body and how it is affected by the nature of experiences we encounter, is to be taken more seriously.

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APPENDICES

Appendix A: Information letter to parents and students

Besøg på NN Skole

Kære forældre

Som en del af et Ph.d. projekt med fokus krop og bevægelse i faget fysik vil jeg, Liv, Institut for Medicin og Sundhedsteknologi, Aalborg Universitet, komme på besøg hos 8.u i fysiktimerne i uge 17 til 22.

Formålet med forskningsprojektet er at belyse hvordan krop og bevægelse tænkes ind i fysikfaget på en skole med en bred idrætsprofil, og hvilken betydning denne tilgang til undervisning har for elevernes læring i fysikfaget.

I forbindelse med projektforløbet vil jeg komme på besøg for at iagttage den måde, som krop og bevægelse iscenesættes på, og se på hvordan eleverne oplever undervisningsformen. For at jeg bedre kan få indblik i forløbet og elevernes oplevelser, ønsker jeg at tage billeder og videooptagelser af både elever og deres lære og det, de arbejder med, for efterfølgende at kunne gense hvad de gjorde i fysiktimerne. Enkelte elever vil også blive bedt om at bære en pulsmåler i timen for at måle hvor aktive de er i timerne. Jeg vil også meget gerne snakke med både elever og lærer om deres læring.

De indsamlede billeder og videooptagelser kommer til at indgå i undersøgelsen om den måde krop og bevægelse inddrages i fysikfaget på. De bliver udelukkende brugt i forskningsøjemed og bliver kun set af dem, der arbejder med projektet.

Ingen af billederne eller videooptagelserne bliver offentliggjort eller brugt i artikler uden at I som forældre er blevet spurgt om lov, men det er vigtigt, at I allerede nu siger fra, hvis I ikke er interesseret i at jeres barn/ børn indgår på de billeder/ videooptagelser, der i første omgang bliver foretaget i fysik-forløbet der begynder onsdag den 23. april. Meddel det til fysiklæreren, der så siger det videre til mig, når jeg kommer på besøg, og så vil jeg undgå at medtage dit/ jeres barn/børn når jeg optager.

Med venlig hilsen

For yderligere information om projektet kan I kontakte de projektansvarlige:

*Ph.d. stipendiat **Liv Kondrup Kristensen***

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Appendix B: Letter of informed consent

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AALBORG UNIVERSITET

København, 1 december 2014

Kære elev,

Vi, Liv Kondrup Kristensen og Kathrin Otrel-Cass fra Aalborg Universitet, arbejder sammen om et forskningsprojekt: *Including physical activity into primary science education: A (re)conceptualisation of the body in science.* Målet med undersøgelsen er at finde ud af, hvordan bevægelse og fysisk aktivitet kan inkluderes i den faglige undervisning i fysik, og hvilken betydning inklusionen har for læringsaktiviteterne i klasseværelset.

Derfor har jeg (Liv Kondrup Kristensen) tilbragt fire lektioner i dit klasseværelse i perioden 30. april til 21. maj, når der er blevet undervist i fysik sammen med din lærer. I løbet af de fire lektioner har jeg fulgt forskellige grupper i deres arbejde med de faglige læringsaktiviteter, og jeg har optaget mine observationer på video, taget billeder og lavet noter over de samtaler vi måske har haft. Derudover har talt med de forskellige grupper om deres erfaringer med læringsaktiviteterne ved et efterfølgende interview.

Et af de vigtigst mål for dette projekt er, at vi ønsker at se, hvordan brugen af bevægelse og fysisk aktivitet i læringsaktiviteter i klasseværelset opleves af eleverne, og til det formål vil vi gerne interviewe dig om dine personlige oplevelser i forbindelse med en udvalgt episode. Vi vil derfor vise dig et videoklip og bede dig om at fortælle os om din oplevelse af netop denne episode, og med dine egne ord forklare os hvad der sker, hvorfor det sker, og hvordan du følte under episoden. Interviewet vil blive optaget både på diktafon (audio) og på video, men bagfra således at vi kan se computerskærmen og måske dine bevægelse hvis du fx peger på skærmen.

Den videoepisode vi vil vise dig vil vi meget gerne bruge i vores forskning. Det betyder at vi gerne vil kunne vise den til forskere fra andre uddannelsesinstitutioner, så vi kan diskutere og reflektere over det vi ser. Vi vil også meget gerne kunne bruge video og billeder fra videoen i offentliggjorte artikler og konferencepræsentationer når vi rapporterer om vores resultater.

Bemærk venligst, at vi ikke vil bruge det rigtige navn på din skole. Vi vil ikke bruge de rigtige navne på deltagerne (lærer eller elever) i vores rapporter. Men vi vil gerne kunne bruge videomaterialet som du er blevet præsenteret for og har fået en kopi af, hvor du vil kunne identificeres. Hvis du ikke ønsker at kunne blive identificeret på videoen er det muligt at sløre dit ansigt, således at du ikke vil kunne genkendes.

Du kan naturligvis afslå denne invitation til at deltage i et personligt interview. Såfremt du gerne vil deltage, men ikke ønsker at kunne identificeres, kan du i det informerede samtykke i nedenstående indikerer i hvilket materiale vi må bruge og hvordan vi må bruge det.

Skole vil modtage en kopi af de artikler, præsentationer, mv. der måtte anvende det indsamlede data.

Hvis du har spørgsmål vedrørende undersøgelsen kan du kontakte Liv Kondrup Kristensen

(tlf: 22 90 58 98, e-mail: lkk@hst.aau.dk).

Med venlig hilsen

Liv Kondrup Kristensen

Informeret samtykke

(Sæt kryds i det felt du er enig med)

- ☐ Jeg giver fuld tilladelse til brug af videomaterialet. Det indebærer at video må anvendes usløret i forskningssammenhænge. Billeder fra videoen må også anvendes uden sløring. Det gælder for video optaget i:
    - ☐ Klasseværelset
    - ☐ Gruppeinterviewet
    - ☐ Det personlige interview

- ☐ Jeg giver delvis tilladelse til brug af videomaterialet. Det indebærer at video må anvendes i forskningssammenhænge, dog skal mit ansigt sløres så det ikke kan identificeres. Billeder fra videoen må ligeledes anvendes med sløring. Det gælder for video optaget i:
    - ☐ Klasseværelset
    - ☐ Gruppeinterviewet
    - ☐ Det personlige interview

Jeg er indforstået med, at ethvert visuelt materiale der måtte vise mig udelukkende må bruges i forsknings- og undervisningsmæssige sammenhænge. Datamaterialet vil blive opbevaret sikkert på en server på Aalborg Universitet og kun forskere underlagt Aalborg Universitets regler vil være i stand til at få adgang til materialet.

Jeg har læst oplysningerne i undersøgelsen

Dato:_______________________________

Navn (blokbogstaver): _____________________________

Underskrift: ___________________________

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