

What is fieldwork for? Exploring Roles of Fieldwork in Higher Education Earth Science

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Abstract

Fieldwork plays an important role in Higher Education Earth Science programmes. By taking students into the field, they gain access to observe and learn about geological phenomena in a natural environment. Fieldwork is perceived to be useful when introducing students to the scientific method, reasoning processes and applied fieldwork skills in geoscience. A persistent discourse in natural science education in general and earth science education in particular has been that 'fieldwork is good' for both social and academic purposes. The aim of this thesis is to nuance these perceptions by providing insights into fieldwork practices in Higher Education Earth Science and how these practices influence students' senses of belonging and their negotiations of geoscience identities.

In three empirical articles, this thesis explores how students' engagement in fieldwork practices in Higher Education Earth Science shape their senses of belonging and their negotiations of identity, as well as their possibilities for participation in the discipline. The fourth article outlines the changes in Earth's systems and the status of the educational landscape of Higher Education Earth Science in Norway, and discusses future avenues for teaching and learning Earth Science. Based on this, and the three empirical articles, this thesis discusses new possible roles of fieldwork for the future.

The first article investigates how values within the disciplinary culture and tacit knowledge intersect with students' sense of belonging and identity work. The article shows how these concepts are (re)produced and negotiated in learning situations and fieldwork settings. How field experiences become central the students' identity work is analysed, based on three empirical cases in which students negotiate the interpretive nature of geology, the embodied practice of fieldwork and how to 'see' like a geologist in the field.

The second article focuses on first year students' interactions with faculty, students' experiences in the field, and how these interactions and experiences influence students' negotiations of belonging in a geoscience study programme. By providing an empirical account of students' participation in different activities during the first year, this article illustrates how these interactions shape students' understandings of the discipline and their negotiations of how they (could) belong. The article furthermore shows how the activities legitimise particular ways of becoming a geoscientist.

The third article explores the fieldwork practices of students in their third year of an Earth Science bachelor's programme. It focuses on students' learning and geological reasoning processes in the field and how these processes influence students' identity negotiations of becoming geologists. The article discusses how the disciplinary fieldwork practice can create barriers for learning and belonging in Earth Science and possibilities of how to broaden participation by identifying multiple ways of belonging in Earth Science.

The work illustrates how the social practice of fieldwork reveals taken-for-granted ideas about students' engagement in and perception of fieldwork and their possibilities for learning. The thesis' empirical material in the form of observations and interviews enables investigations of fieldwork practices that go beyond seeing fieldwork as only an inherently 'good' teaching method but also as a practice with norms and values of disciplinary culture, as well as tacit knowledge. Furthermore, the work shows how disciplinary practices are negotiated and contested by students on their way to become Earth Scientists, which illuminates barriers for learning and participation.

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Prelude

The photograph in figure 1 shows a group of first-year students on their first field trip to Finse in Central Norway. A fieldtrip that is a reoccurring element in August every year as part of Earth Science students' introduction to their new study programme at the University of Oslo. This field encounter turns out to be significant for both the students and my research into fieldwork in Higher Education Earth Science.

When I first observed fieldwork in Finse, I saw dedicated and enthusiastic teachers; I saw an ambitious teaching plan with a high pace and I saw interested students. In the field, the students' task was to produce a map with classification of basement rocks and measurements of various ice directions carved into exposed basement rocks. I observed that this was a challenging task for first-year students who just entered the programme. Students were lagging behind, not being able to keep up and I started to question the intention of the exercise; why were they in the field if they were not given the time to observe and learn? When interviewing the students, some mentioned that the high pace made it difficult for them to gather all the information needed to produce the map. My observations and interviews with students on this trip provided insights into how the planning of teaching in the field influences students' possibilities for participation and learning.

The next year I returned to Finse with a new group of first-year students. That year, the teachers had changed the outline of the field trip. With additional funding, they took the students up on a glacier hike. At first, I thought it was an unnecessary addition to an already tight teaching schedule. Based on the observations from the year before, I reflected on how the time was spent in the field even more. It was during this trip, I took the photograph of students on the glacier in roped parties above a snow bridge (figure 1). This photograph has since then been part of my scientific presentations with an opening statement on Climate Change. However, the photograph holds a much richer story. A story about what I see, how I approach my research, how I have developed my thinking and how I now frame my work.

When I took the photograph, it was linked to ideas about how time was spent in the field and the teacher's decisions on what to show and tell the students about the glacier. The teachers' argument was that students need to see the environment early and recall it later during the semester. What I saw was an activity without any concrete assignments or a clear reflection on the learning outcome. Thus, the photograph became an illustration of a type of teaching that focuses on 'show and tell' in the field.

The next year, the glacier hike was again part of the teaching plan and the photograph changed its meaning. Observing the beauty and the colours, remembering the sound of the ice below the crampons, the view over the valley and the feeling of rope between us. Could the beautiful landscape provide a unique opportunity to inspire students to appreciate nature? Perhaps

being present on the glacier had a greater learning potential than I had seen earlier. Could this play an even more important role than only being linked to specific learning outcomes?

Now, when writing my thesis, the photograph represents change. How what I see has changed. How I have changed my focus and opened up towards exploring new aspects of fieldwork in Higher Education Earth Science. Realising and noticing change, being aware of my own thinking. This is important for understanding why and how my research came about. Understanding the fluidity of my research has been the greatest adventure of them all. The photograph now reminds me of this process.



Figure 1: First-year students during their first field experience at Finse in Central Norway. Photo: Rie Hjørnegaard Malm

1. Introduction

This thesis starts with the question: What is fieldwork for? The phrasing aims at opening up for explorations of a well-established element in Earth Science education: fieldwork. Posing the question what fieldwork is 'for', is a way of approaching the many ideas and stories about fieldwork in Higher Education Earth Science.

Sometimes, asking what something is 'for' can, if understood as an expository tactic, a starting-point rather than a ruling, be a means of helping us to clear away the discursive debris that accumulates around any widely used category.

(Collini 2012, p. I-II)

The discourses around fieldwork have, in my opinion, indeed been covered in 'debris'. We take for granted the positive and valuable notions about fieldwork and we maybe share a romanticised idea about all geologists loving fieldwork. With this thesis, I attempt to find nuances within and suggest more complexity for students' and our ideas about fieldwork, which for too long have been left unquestioned and embedded in this specific scientific and educational tradition.

Discourses around fieldwork are often connected to the strong belief in the inherent benefits of fieldwork for both research and learning. Learning and being in the field has been an established construct through time and is considered a fundamental element in Earth Science education (King 2008). In modern times, fieldwork has played a major role in the exploration of Earth, its processes, structures and resources. Along with the geographical expeditions to map the world, geological observations from the field were part of the voice that challenged the idea about Earth's age in the late 1600s and early 1700s (Dressen-Hammouda 2014). Later, the search for coal pushed the development for more scientific field skills in the 1800s and the potential economic gains of working for industry became important.

(...) geologists began to rival one another for recognition of their skills. To gain this recognition, however, they needed to 'prove' their field competence to other practicing geologists through field description and argumentation.

(Dressen-Hammouda 2014, pp. 5-6)

At the time, geologists would discuss scientific questions through writing and exchanging letters from their offices based on theoretical inferences. However, a new discourse developed in the 1800s, where the weight of the argument was considered to be stronger if the geologist presented field data to support their hypothesis (Young 2003). Documenting observations in the field has thus developed as a response to curiosity about Earth, economic interest and as part of an emerging scientific and disciplinary discourse.

A natural extension of this is taking students into the field as part of their training to become Earth Scientists (Raab and Frodeman 2002). In the field, students gain access to geological

phenomena, for instance processes taking place over geological time scales, and difficult threshold concepts such as spatial understanding (Kastens and Ishikawa 2006) and deep time (Kortz and Murray 2009). Fieldwork is perceived to be an effective learning arena introducing students to the scientific method and reasoning in geoscience (Mogk and Goodwin 2012). Overall, a persistent discourse in the educational literature is that 'fieldwork is good' for both social and academic purposes (i.e. Boyle et al. 2006; Orion and Ault 2007; Kastens and Manduca 2012).

The inclusion of students with disabilities has been part of this discourse, as a way of discussing how all students gain equal access to important learning opportunities in the field (Stokes et al. 2019). The literature on learning in the field also identifies challenges connected to the practical conditions and barriers occurring when running field trips or courses (e.g. Orion 1993; Orion and Hofstein 1994; Remmen and Frøyland 2014). However, the general assumption about fieldwork is linked to able-bodiedness and an implied value and necessity of fieldwork in Earth Science education.

In this thesis, I ask questions and aim to nuance established assumptions about fieldwork. I approach fieldwork by observing fieldwork situations, interpreting them and including students' perspectives to gain insights into what fieldwork means for their personal and professional development. More explicitly, this thesis explores roles fieldwork plays when students develop a sense of belonging in Earth Science and negotiate geoscience identities. Fieldwork contains implied notions, ideas and practices that students 'must learn' or even 'endure' (Dressen-Hammounda 2008, p. 239) in order to become part of the social practice of fieldwork. If Earth Science is considered a community of practice (Lave and Wenger 1991; Wenger 1998), then students are aspiring members to the practice. When Earth Science students enter university, they are introduced to the established practice around fieldwork when entering the field with their teachers.

Fieldwork is a specific practice within Earth Science that includes tacit knowledge of the discipline (Polanyi 1966) both in ways of thinking and doing (Raab and Frodeman 2002). As such, these practices and values of fieldwork create specific structures around students' possibilities for participation and learning. What counts as credible in science, in terms of what is recognised, is context dependent (Carlone and Johnson 2007) and it is therefore relevant to investigate the specificity of our socially constructed practices when we are interested in learning about students participation in science. This thesis therefore researches the practice of fieldwork in Higher Education Earth Science as an entrance to explore students' sense of belonging and their negotiations of geoscience identities. I understand identity in the framework of *science identity* defined by Heidi Carlone and Angela Johnson (2007) as the perception of oneself as a science person, shaped through performance, feeling of competence and recognition from others.

One cannot pull off being a particular kind of person (enacting a particular identity) unless one makes visible to (performs for) others one's competence in relevant practices, and, in response, others recognize one's performance as credible.

(Carlone and Johnson 2007, p. 1190)

The use of identity as a lens to explore a specific practice makes it possible to illuminate structures and ideas around that practice. This is particularly important because learning is linked to identity. Learning is here conceptualised as something more than obtaining knowledge, 'it is [a] matter of deciding what kind of person you are and want to be and engaging in those activities that make one part of the relevant communities' (Brickhouse 2001, p. 286). Learning is thus perceived to include notions of identity work, which means that students negotiate which activities they participate in and how this fit their idea about themselves and their future identities. The term identity can, however, also refer to and include many sub-identities e.g. cultural, gender, ethnic or national identities (Avraamidou 2020). As identities and identity work are strongly connected to sociocultural aspects and norms, it also means that students may be excluded from practices based on ideas, values and identities that more central participants hold.

The identity lens allows us to ask questions about the kinds of people promoted and marginalized by science teaching and learning practices; the ways students come to see science as a set of experiences, skills, knowledge, and beliefs worthy (or unworthy) of their engagement.

(Carlone and Johnson 2007, p. 1189)

Students entering university negotiate the practice they meet i.e. in the study programme and the discipline, and they will evaluate and negotiate if they can find a way to belong. Feeling a sense of belonging is a fundamental human need (Baumeister and Leary 1995) and students in the context of higher education will seek communities that fit their idea about themselves and who they want to become (Holmegaard et al. 2014; Ulriksen et al. 2017). Students' possibilities for creating a sense of belonging is thereby influenced by a wide range of factors within the institution (Tinto 1993; Tinto 2017) and can be understood as an interplay between students and the institution (Ulriksen et al. 2010). Consequently, feeling a sense of belonging is central in students' identity work when negotiating participation in Higher Education.

Angela Calabrese Barton and Kimberley Yang (2000) discuss how ideas about science practices define what 'good' science education is and call this 'the culture of power'. They show how this culture is reproduced through practice and how it creates structures that hinder the participation of students with e.g. a lower socioeconomic status. The practice is constituted in everything from instructional methods in school science to the implied aim of producing scientists in Higher Education instead of actually teaching science (Carlone 2004). This creates a narrow idea of what 'good' participation looks like which in turn excludes some students from participating (Brickhouse 2001). In this thesis, I explore how fieldwork practices produce and

reproduce a culture based on implied ideas about the scientific practice of fieldwork. Through analyses of students' experiences in the field I can make these normative structures visible and demonstrate how they influence students' negotiations of belonging and identity in Earth Science. Based on these insights, I then discuss what kind of students are encouraged to participate in Higher Education Earth Science and in what ways. With this, the aim of this thesis is to make explicit how the implicit reproduction of the 'culture of power' is constituted in fieldwork practices in Higher Education Earth Science.

1.1 Setting the scene

For geologists, fieldwork often evokes memories, stories and anecdotes from time spent in the field. Through history, stories of hardship and freedom associated with fieldwork have been told (Nielsen et al. 2012) and students entering a geology department will most likely hear older students and teachers talk about their experiences in the field. The combination of a long tradition for fieldwork in the scientific exploration of Earth, the attached emotional values and the belief in the inherent necessity of fieldwork produces a loaded and complex space to explore.

This is the stage I am entering when choosing to research fieldwork in Higher Education Earth Science. A stage both familiar and unfamiliar to me. As a geologist, I love fieldwork. As an educational researcher, I am curious about this special learning space and want to be critical about the spaces I explore. I am thus both 'inside' and 'outside' of both Earth Science and Educational Science. Being positioned in many spaces can be an advantage and a challenge when conducting this kind of research. In the following, I describe some of the conditions for the research outlined as a way of creating transparency.

This research is situated at the University of Oslo, where I have observed teaching in classrooms and in the field and where I had access to both teachers and students in the Department of Geosciences. Other duties have been to teach first-year students in an introductory course to geology, to introduce new teaching assistants to teaching at university, to teach a teacher-training programme for High School teachers and to assist colleagues in Scholarship of Teaching and Learning (SoTL) projects. My involvement in developing the national Centre for Integrated Earth Science Education, which gained status as a Centre of Excellence in Education in 2019, provided me with opportunities to collaborate with geoscientists across Norway. Part of this has included conducting research projects with colleagues at The University Centre in Svalbard and The Arctic University of Norway in Tromsø as well as assisting SoTL projects at University of Bergen. The collaboration between the institutions also provided me with access to collect data across the four institutions and thereby insights on national Earth Science education in Norway. Being engaged in different types of projects and being present in several Earth Science

communities has informed my research, enabled access to collecting various data sets and helped me to see new perspectives.

Throughout the years, there has been a constant and strong push for developing digital solutions and technology for teaching in the field. The strong discourse around the use of technology aided by local and national funding schemes in Norway means that I have been on the periphery of projects working with technology throughout this research process. Thus, I have engaged in many discussions, reviewed manuscripts and been part of one publication with technology in the focus. However, discussions on the use of technology in geological fieldwork is not part of this thesis.

1.2 Defining the research aim

In order to explore roles of fieldwork in Higher Education Earth Science, this thesis addresses the overarching research question: How does students' engagement in fieldwork practices in Higher Education Earth Science shape their senses of belonging and negotiations of identity, as well as their possibilities for participation?

By addressing this question, the thesis aims to contribute in a two-fold way to the existing empirical literature. First, it provides a descriptive account of students' engagement in fieldwork practices that reaches beyond the established notions and understanding of what working in the field means for students' participation in Earth Science. Second, it offers empirical insights into how students' fieldwork experiences intersect with their sense of belonging and their identity work within Higher Education Earth Science. With this, the thesis aims to expound insights that nuance established assumptions about fieldwork, which will hopefully inspire our community to reflect on how to plan, conduct and discuss fieldwork in Higher Education Earth Science in the future.

1.3 Thesis outline

This thesis comprises three chapters that introduce the rationale behind the thesis and position the work in the research landscape.

The following chapters link the position of fieldwork in Earth Science with learning in the field, Communities of Practice, students' negotiations of belonging and students' identity work in Earth Science. The review discusses different discourses around fieldwork, which is used to illustrate how previous research has approached teaching and learning in the field and taken-for-granted ideas about fieldwork in order to underline the position of my thesis. The review is followed by a chapter outlining fieldwork's position in the scientific discipline, as well as its in the knowledge production in Earth Science. This chapter thus unfolds in what ways geologists

ascribe meaning to fieldwork and learning in the field. The final chapter presents two pillars of the theoretical framing of the thesis: Communities of Practice and Science Identity.

The analytical core of the thesis is comprised of three articles in which roles of fieldwork practices in Higher Education Earth Science are explored:

Article I: Madsen, L. M., and Malm, R. H. (under review). Doing geoscience: negotiations of science identity among University students when learning in the field. In L. Archer and H. T. Holmegaard (Eds.) *Science Identities - Theory, method and research*. Springer series.

Article II: Malm, R. H., Madsen, L. M., and Lundmark, A. M. (2020). Students' negotiations of belonging in geoscience: experiences of faculty–student interactions when entering university. *Journal of Geography in Higher Education*, 1-18. DOI: 10.1080/03098265.2020.1771683

Article III: Malm, R. H. (under review). Geological reasoning and Identity: exploring links between fieldwork and students' identity work. *Journal of Geoscience Education*.

One additional article is included. This article analyses data on students and staff's perceptions of the teaching-learning environment in Earth Science at four Higher Education institutions in Norway. The article argues for how to develop the current programmes and provides directions for the future of Earth Science education in Norway. The article is based on a semi-quantitative questionnaire including answers from 210 students and 115 members of staff. This enables a large-scale analysis of programme structures and provides insights into the pervasive ideas about teaching and learning geoscience in Norway. The article provides a context for the conducted research on fieldwork and geoscience identities and is used to discuss the findings and possible future directions for Higher Education Earth Science.

Article IV: Malm, R. H., Lundmark, A. M., and Hannisdal, B. (to be submitted). Geoscience for the future: Are we ready to change Geoscience education in Norway?

The concluding chapter summarises the work presented in my thesis and discusses the main findings and insights. Reflections on possible implications of the work and potential areas for future research are included.

2. Review

This thesis is situated within the research field of Science Education and in order to get an overview of Science Education research on fieldwork, I conducted a literature review in June 2019. A search with the key words *geology*, *fieldwork* and *higher education* in the database ERIC resulted in 241 articles. These articles were sorted into four categories: geology, geography, biology and other i.e. clinical fieldwork, cross cultural fieldwork and animal behaviour fieldwork. The full review methodology including key words, search concepts and sorting procedure is outlined in Appendix 2 - *The review strategy*. The sorting process resulted in 24 central articles. The review was then used in two ways; first to analyse the pervasive discourses on fieldwork in the literature and second to map out the methodological approaches used in the respective studies. I use the results of the review in this way in order to avoid the reproduction of normative discourses around fieldwork, the very same discourses that I aim to nuance. Instead of outlining the benefits of fieldwork, I outline how a selection of previous studies have approached research on fieldwork and what methods have been used to explore teaching in the field. I do not aim for a systematic or exhaustive review of the field and have placed the description of the categorisation process in the appendix. I use the review to argue for the methodological choices I have made and to show why I see a need to nuance our ideas about fieldwork. With this, I use the review to place the thesis in the educational landscape and the discourses of fieldwork in Higher Education Earth Science.

2.1 Exploring discourses of fieldwork in Higher Education Earth Science

In the introduction, I refer to Calabrese Barton and Yang's (2000) concept of 'the culture of power' in order to argue for explorations of the practice of fieldwork and the inclusive and exclusive power normative notions about fieldwork entail. I claim that Earth Science education research has been concerned with outlining the benefits of fieldwork, which on one hand is based on the taken for granted assumption that 'fieldwork is good' and on the other hand leads to the systematic exclusion of critical perspectives on teaching in the field. In this section, I critically analyse some of the discourses that are at play when we conduct research on fieldwork and teaching in the field. Being critical is not a goal in itself, the aim is rather to read the literature with a fresh pair of eyes in order to be able to illustrate how assumptions about the inherent qualities of fieldwork are outlined but not questioned (Jørgensen and Phillips 2002). Thereby, I can explore and understand how a romanticised idea about being in the field has been established and maintained to then develop a more nuanced perspective on the benefits and pitfalls of learning in the field.

I therefore take a closer look at three articles and analyse how these articles describe the value of fieldwork. The chosen articles display three different ways of researching fieldwork and how fieldwork affects students. They thereby illustrate examples of how fieldwork has been

approached. The first study, Boyle et al. (2007) is based on a quantitative research design, the second, Stokes et al. (2011), takes a phenomenographic approach and the last, Streule and Craig (2016), is a theoretical article with focus on social learning theories.

In an example from a quantitative study, Boyle et al. (2007) report on the effectiveness of residential field courses at UK geoscience institutions. Based on 300 students' survey answers collected immediately before and after a field class, this study analyses the changes in responses within the affective domain i.e. the feelings and attitudes attached to fieldwork. The article bases the research design on the assumption that:

(...) fieldwork is good if it triggers positive emotional responses, i.e. if it is particularly likely to trigger a chain of emotional and learning responses: high confidence in ability to do well— low levels of anxiety—high motivation—deep-learning approach—high performance

(Boyle et al. 2007, p. 302)

This study therefore analyses students' pre- and post-answers on these parameters and finds that most students 'demonstrated very positive affective responses' and that positive feelings 'have been strengthened during the field experience' (Boyle et al. 2007, p. 314). The group of students that experiences anxiety before the field encounter 'has tended to mitigate these feelings' (p. 314) and show higher levels of confidence after the fieldwork (Boyle et al. 2007). The article further suggests that the positive effect of the fieldwork therefore could be understood as having an equalising effect.

(...) in addition to raising positive affective responses across the board, the field experience particularly helps to boost the affective responses of those groups who are less positive prior to the field class. This finding is quite surprising, suggesting that fieldwork is, in this particular respect, equitable.

(Boyle et al. 2007, p. 315)

The study does not discuss students being anxious in the first place. Furthermore, they outline their results in the, to me, most positive way possible by highlighting that the fieldwork experience mitigates students' anxieties. However, the article also suggests how the group of anxious students could gain a better experience in the field:

Whilst the field experience appears successful at reducing such concerns, this mitigation should not be a cause for complacency. Ideally, some of these causes of anxiety can be mitigated through effective pre-field-class preparation. A useful strategy might be to use students who have previously attended the field class to discuss what is entailed with prospective field-class students.

(Boyle et al. 2007, p. 315)

This argument places the responsibility on the preparation of students, to create a better field experience, which could be understood as there is no intention of changing the fieldwork or the conditions around it. It is arguments like these that tend to result in an inherently positive and unreflective approach to conducting research on students' engagement in fieldwork. The article identifies a group of students 'who are less positive prior to the field class', which is almost a third of the sample, but does not attempt to explore what this apprehension implies or means to students. The article concludes with 'the fact that only 5 per cent of students did not enjoy the field class suggests the apprehension is not warranted' and the concluding recommendation for teachers, course developers and leaders is therefore to 'consider ways of mitigating apprehension' (Boyle et al. 2007, p. 316). Preparing students before going into the field is important and part of the general recommendations for designing fieldwork (e.g. Orion and Hofstein 1994; DeWitt and Storksdieck 2008; Remmen and Frøyland 2014). However, this solution is directed at the students and not reflexive about the practice of fieldwork and what it is in the practice that makes students anxious. The article applies a quantitative research design and it can therefore be difficult to explore the meaning behind the findings and students' perspectives, however, the lack of reflection on the results is noteworthy. When reading this article with the aim of searching for implied values or discourses on fieldwork, I argue, that this is illustrative for the *positive* discourse of fieldwork in Higher Education Earth Science. This is one example of researching fieldwork with the intention of highlighting the positive sides and not discussing and to some extent downplaying the troublesome insights.

In the second example, Stokes et al. (2011) explore the conceptions of the purpose of fieldwork held by undergraduate students and academic staff in geography and geology. By analysing the responses to the open-ended survey question, 'what do you think is the main purpose of fieldwork?' the aim is to explore how students experience and characterise learning in the field and how they understand the purpose of fieldwork (Stokes et al. 2011, p. 125). The study therefore identifies the conceptions of purpose held by students and staff to determine the variation in conceptions both in the academic disciplines and between the researched groups. In the introduction, they state that a 'dominance of 'traditional' methods of teaching and learning' means that students have limited opportunities to develop conceptions. They argue that this is because these traditional methods limit opportunities to meet novel learning environments (Stokes et al. 2011, p. 122). However, the geosciences are perceived to be different because of the extensive fieldwork conducted.

Students of geography and geology, however, encounter fieldwork consistently (if episodically) throughout their undergraduate programmes, and its usually dramatic contrast to other learning environments.

(Stokes et al. 2011, p. 122)

Here fieldwork is described as a 'dramatic contrast' to both the traditional teaching methods and learning environments. The study explores academic staff's conceptions about fieldwork

as it is thought to influence their ideas about effective teaching strategies and what types of knowledge is valued in this context (Stokes et al. 2011). This way of approaching teaching and learning in the field thus presumes that the field is a special space, a space where a specific type of learning can take place and where teachers' ideas about the same space influence their teaching. The study identifies six qualitatively distinct conceptions and provides valuable insights into how academic staff and students conceptualise and experience fieldwork in different ways. The authors highlight that their findings imply that teaching staff needs to be aware of and reflect on the fact that students' conceptions of fieldwork, 'may conflict with their own conceptions, and which may prove remarkably resistant to change' (Stokes et al. 2011, p. 137). This they link with the alignment of students' expectations and the authors suggest that an implication of this for teaching is that the purpose of the fieldwork must be made explicit to students. However, there is something more to how fieldwork is framed and how the findings are communicated to staff. There is an implicit tone of knowing that staff has strong beliefs (and feelings perhaps) about fieldwork and it is important to show that some students do not necessarily share these ideas. There is a carefulness in the way it is described. The authors further describe that 'this 'mismatch' in conceptions suggests that students and staff are likely to embark on field activity with conflicting beliefs about its purpose' (Stokes et al. 2011, p. 137). This is an important finding and I argue that the authors could take this discussion one step further and suggest that staff may pause their own fieldwork ambitions and ideas when they teach in the field. Teaching in the field is not about them as teachers, but rather about students having an opportunity to sense and learn. However, I understand the tone and the carefulness used in the article since teaching in the field is indeed seen as 'embarking', which is a term used for starting an adventure, right? Staff and students are starting a fieldwork adventure together and everybody is excited to go to this often 'dramatically' different space. When we want to do research on this special space, we nevertheless need to be reflexive. Also, in this article, the implicit assumption about fieldwork to be exclusively good shines through and again prompts my argument that more critical research is needed. The authors suggest ways in which fieldwork could be improved, hypothesising that staff's ideas about fieldwork might be a hindrance. The approach is to explore staff's ideas and use a relatively large sample in order to (carefully) make the argument for change.

The third example of how fieldwork is framed in the literature is Streule and Craig's (2016) theoretical article. This article uses the Communities of Practice framework (Lave and Wenger 1991; Wenger 1998) to argue that fieldwork is important for students' development of geoscience identities, which makes them powerful tools for effective learning. They also argue that fieldwork provides students with opportunities to function as 'real' geoscientists, which prepares them for entering the geoscience profession. Streule and Craig (2016) further argue that 'simply participating in field trips gives students a unique sense of identity as geoscience students' (p. 103) as they compare the field with the hospital for medical students. Being in the field they link to 'unique locations of learning that inherently promote and develop the

student's identity' (Streule and Craig 2016, p. 103). The wording is interesting; 'simply' participating in field trip with its 'unique' localities will 'inherently' develop student identities. This discourse is built on the taken-for-granted idea that students' engagement in fieldwork will naturally make them part of the community. This is argued for in the following way:

It is not simply that many exercises on field trips involve group work and actively promote developing the community of practice within the field trip, but it is more an inherent social property of human beings: Put 40 students on a cold, windy hillside, ask them to tackle a geological problem, or undertake some geological investigation, even individually, and social interaction will inevitably follow. Those students that participate in this social interaction, formulate the greatest meaning for their practical experiences, migrate on an inbound trajectory towards the center of a community of practice, and are comfortable with changing their identity from student to geoscientist.

(Streule and Craig 2016, p. 105)

First, it is interesting that 'a tough day in the field' is chosen to illustrate this argument. Even under difficult and cold circumstances, students are perceived to engage in the field and 'formulate the greatest meaning' of being there. This reflects a view of students' engagement in the field as productive and positive under any circumstances. Also, I question the example used and ask why the fieldwork has to be tough and what do this toughness stand for? Second, students are perceived to 'comfortably change their identity' through the social interactions in the field. I consider this to be an observation rather than an explanation. Furthermore, they do not provide arguments for a 'comfortable' transition, it is simply stated. It leaves the impression that students' transition and identity development is considered effortless. More detailed research on students' transitions into Higher Education show the complexity of how students negotiate their identity and position in the institution and in the discipline as a way to feel a sense of belonging (Holmegaard et al. 2014). With this thesis, I aim to nuance assumptions about fieldwork in Higher Education Earth Science and show in what ways fieldwork participates in the development of students' geoscience identities.

2.2 The methodological approaches

The review was also used to map out the methodological approaches used in the studies on fieldwork in Higher Education Earth Science. In the following section, I therefore outline the methods and elaborate on why I decided to draw on ethnography for this thesis.

Nine papers explicitly study fieldwork and learning geology in the field (appendix 2) using questionnaires, interviews or a combination of the two methods.

Boyle et al. (2007), one of the articles discussed above in relation to the methodological part of the review, represents a study using quantitative methods to analyse the changes in student

responses within the affective domain, which is understood to be linked to effective learning. Jolley et al. (2018) also explore the affective domain of field education using questionnaire data collected at the start of two geoscience field trips with students enrolled in a study abroad programme. In a study of students' sense of place, Jolley et al. (2019) compare the field experience and development of sense of place in three separate course elements in a six-day introductory geological mapping field trip, through student interviews and pre-post surveys. Marra et al. (2017) also use a combination of a student survey and a focus group interview when researching changes made to a first-year Earth Science field course where new GIS methods were introduced. Stokes et al. (2011), also mentioned above, is the only study that analyses responses to an open-ended survey question.

Two studies use technology to follow the students in the field; GPS tracking (Riggs et al. 2009) and eye tracking (Maltese et al. 2013) and two studies analyse field notes from students. In Balliet et al.'s (2015) study, the authors analyse field notes and interview data from 36 undergraduate students engaged in fieldwork. Their study shows how geology students initiate and develop geological models as part of the problem-solving process. Dohaney et al. (2015) use notebooks, observations of fieldwork and interviews in their study of an introductory geothermal field lesson.

The review shows that in most cases, studies apply quantitative methods that are supplemented with qualitative interviews. There has been a call for using methods from social and educational science the past years, which for example can be traced in the succession of The Geological Society of America special publications. In 2009, Stokes and Boyle use a combination of quantitative and qualitative methods to investigate students' learning processes during a field course. They offer a detailed description of learning processes; however, they recommend future research to employ even more sensitive data collection over time. In a special paper on 'Qualitative Inquiry in Geoscience Education Research' Feig and Stokes (2011) guide geoscientists to use methods and theories from social and educational science. They include an article by Williams and Semken (2011), which uses ethnography to explore students' sense of place. In 2012, Kastens and Manduca (2012) advocate for a stronger theoretical framework to explain the specific findings within the field-based educational research and point to several theories from social science research. In the same volume, Stokes and Feig (2012) outline how ethnographic methods have proven especially useful when exploring fieldwork in Earth Science.

These articles thus advocate for the application of research methods from the social and educational science in order to expand our knowledge on students' learning in the field and advance the research on fieldwork. This thesis heeds this call by contributing with a piece of research that uses ethnography as the main method, complemented by interviews with students. With this, I aim to show how this approach can yield new and valuable insights into Earth Science education research on fieldwork as well as on students identity work.

The critical reading of a selection of articles in the field of Higher Education Earth Science showed how a consistent discourse constructs fieldwork to provide students with valuable learning opportunities and to help them develop professional identities. In order to understand how these discourses are created and sustained, I start out with outlining the main principles of geological reasoning and inquiry. This next section therefore aims to show how the scientific discipline of geology has traditionally approached the scientific exploration and what role fieldwork has played. This is followed by a section on how implicit and tacit knowledge helps to sustain our ideas about the position of fieldwork in the educational practice. These chapters are used as a background to understand the findings from the studies included in this thesis.

3. Earth Science as a scientific discipline

A geologist climbs into an imaginary time machine, where every observation, every cryptic piece of evidence in the rocks is viewed not as part of the stonily silent cliff but as a landscape as vibrant as it was at the time the sediments were deposited. When a geologist finds a trace fossil, formed by a disruption of sediment when an organism burrowed into a river sand a hundred million years ago, he can imagine being that organism. He hears the waves crashing overhead, and imagines burrowing deeper. Strata left by an ancient stream migrating across a sandbar pulls the geologist back to a river 150 million years ago. He can envision gravel tumbling along the bar during flood stage, stinging his feet, his boots providing no protection against the deluge.

(Turner 2000, p. 54)

Christine Turner is an experienced field geologist. Her description of a geologist working in the field captures the narrative type of logic, the creativity and imagination geologists use when working in the field. The description includes cognitive and embodied skills a geologist applies during fieldwork. For many trained geologists, these skills are highly integrated parts of themselves and how they see the world.

3.1 A historical and hermeneutic science

Geology is a historical and hermeneutic (interpretive) science, where naturally occurring processes are interpreted to reconstruct and explain past events in Earth's history (Frodeman 1995; Dodick et al. 2009). Interpretation is essentially a retrodiction, a series of justified conclusions in a historical order, each based on a causal model that explains them (Ault 1998). In this process, time plays a significant role since it is the study of present environments that creates the basis for interpreting past ones. This stands in contrast to e.g. physics, which traditionally focuses on establishing time invariant laws (Dodick and Orion 2003). The elements of time and interpretation of observations distinguish the historical based sciences from the experimental sciences. Experimental sciences traditionally focus on a single hypothesis and repeatedly test hypotheses, ideally in controlled laboratory settings (Cleland 2001). Historical sciences in contrast focus on formulating multiple hypotheses based on observations of natural phenomena (Cleland 2001). The idea of multiple hypotheses can be traced back to the nineteenth century, where Chamberlin (1890) advised geoscientists to test several hypotheses to avoid developing affection for one idea. In the process of deciding between different hypotheses, historical scientists search for pieces of evidence that sets the hypotheses apart. Cleland (2001) argues that the historical sciences need this empirical grounding in observations to avoid 'a dreaded just-so story' (p. 990) i.e. an interpretation that builds on only one idea, and hence fail to explore and distinguish between possible viable alternatives. The lack of

consistent and complete data sets is a premise for most geological exploration. The ability to make inferences from incomplete data and work with ambiguity is integrated in the reasoning process (Ault 1998). This requires an evaluation of possible and plausible interpretations of data in accordance with existing knowledge or theory. In the field, geologists start this interpretation process, and learning to observe and reason in the field becomes important for teaching purposes, as it is an illustrative way of showing the reasoning processes embedded in the scientific exploration.

3.2 The narrative logic

Geologists use a narrative form of logic in the scientific production of knowledge (Watson 1969; Frodeman 1995). In narrative logic, details are made sense of in the overall structure of a story. Geologists will tell a story that put details, i.e. observations from an outcrop, into a larger context of the geological setting. The goal with constructing historical narratives is to integrate details into an organised whole and not to create generalisations (Kitts 1977; Frodeman 1995; Ault 1998). Therefore, an outcrop or dataset will not make sense before it is a component of an overall story (Gould 1989). Frodeman (1995) discusses the scientific rigour of narrative logic, drawing on Paul Ricoeur, the French philosopher who combined phenomenological description with hermeneutic interpretation. Frodeman argues that using narratives 'is our most basic way of making sense of experience' (p. 966). He emphasises that all scientific knowledge production uses narratives.

Scientific explanation is based on narrative in the sense that, through telling a story, we create a context that defines and gives meaning to our research and data.

(Frodeman 1995, p. 966)

Geological explanations are thus based on a discrete set of logical narrative procedures and the classical scientific methods, which makes geology an example 'of a synthetic science, combining a variety of logical techniques in the solution of its problems' (Frodeman 1995, p. 966). Learning to reason in this way and applying this type of logic is also part of learning in the field where a story about the area is constructed based on direct observations. The geologists' abilities to observe and reason are therefore intertwined in the field, creating a complex set of skills to be learned by students.

3.3 Embodiment

Geological reasoning can be described as an embodied type of thinking. The geologist is an embodied observer of the environment and the observations are dependent on the geologist's experiences in the world (Raab and Frodeman 2002).

Geologists will remember being at the stage of a novice, when huge amounts of time in the field were consumed in consciously pondering about what to do next and where to look. There is a great deal of stress connected with this reasoning.

(Raab and Frodeman 2002, p. 78)

The interpretative nature of the scientific discipline and the embodiment of fieldwork imply that the geologist's intuitive selections and judgements depend on prior experience (Raab and Frodeman 2002). One example that continuously appears in the literature is Marie Tharp's discovery of the rift valley of the Mid-Atlantic Ridge (Burek and Higgs 2007). In the 1940's she went through thousands of kilometres of echo sounder profiles and plotted her measurements by hand (Blakemore 2016). The process of going through all the data provided her with the experience she needed in order to recognise patterns that lead to her discovery. Her work also provided additional evidence for the theory of plate tectonics. Marie Tharp's work is an illustration of the embedded correlation skill, being able to recall similar features from disparate localities, and interpret and compare observations across settings. Another example of embodied knowledge is illustrated with the famous quote by Herbert Harold Read 'The best geologist is [the one] who has seen the most rocks' (Read 1957, as cited in Young 2003), which is often used to describe the value of the experience that geologists build over time. The quote originates from the heat of the raging debate over the origin of granite. Here some scholars entered discussions with interpretations of geological phenomena they had never observed and Read argues for a stronger connection to concrete observations (Young 2003).

The scientific exploration in Earth Science is linked to the hermeneutic features of the historical sciences, where interpretation, imagination, pattern recognition and correlation skills are used to develop multiple hypotheses to explain the origin of the geological phenomenon. These skills are entrenched in the professional geologist and applied when working in the field. Geologists' work in the field thus include a series of embodied, implied notions and practices linked to the act of scientific exploration. In the following, this to some extent invisible embodied and implicit knowledge is unfolded and described as the disciplinary tacit knowing of Earth Science.

3.4 Disciplinary tacit knowing in Earth Science

The disciplinary tacit knowing of Earth Science is linked to participants' conceptions about the scientific discipline and the values attached to performing scientific inquiry in Earth Science. In this thesis, I draw on the ideas of knowledge as described by Polanyi (1966), where knowledge is both practical and theoretical. These notions include a tacit dimension of 'knowing' (1966, p. 7). Tacit knowledge can be described as the norms and ideas legitimatised in the scientific discourse. As every scientific discipline, Earth Science includes a set of rules. In order to become a member of the community, participants must learn to navigate these rules (Gerholm 1990; Lave and Wenger 1991). In science, these rules are linked to how we understand science and

constituted in values within the community. The characteristic methods, the accumulated knowledge and the cultural values, which govern the activities in the discipline, are all part of the scientific discipline (Merton 1973). Science discourses can be described having a front stage; an explicit, official style presented in research proposals and research reports, along with a backstage; which represents the tacit and informal knowledge (Goffman 1959). Tacit knowing includes tradition, inherited practices, implied values and is 'the awareness of knowing how to do something without being able to provide an adequate analytical description of it' (Strati 2003, p. 56).

Both explicit and tacit knowledge is important for students' socialisation into an academic discipline. Gerholm (1990) argues that students will meet two main categories of tacit knowledge; one created by the discipline and one created by the students themselves. The disciplinary tacit knowledge has grown out of long experience; 'it is a practical, almost subconscious, knowledge or competence that the department elite fully masters' (Gerholm 1990, p. 271). This type of tacit knowledge is linked to the ability to read a situation correctly and apply the appropriate discourse, as the 'inability to do so is often interpreted as a sign of general incompetence' (Gerholm 1990, p. 266). Knowing the repertoire of scientific discourses and mastering it is important as students enter the scientific community becoming (or not) legitimate members of the scientific community. This is also a central element of Lave and Wenger's (1991) *Communities of Practice* where new members learn through interactions with more central members of the community. Among the students, a tacit knowledge will also develop as they try to make sense of their experiences (Gerholm 1990). In other words, when students enter Higher Education, they meet the scientific discipline both in terms of content and in terms of the cultural values explicitly and implicitly attached. The values and discourses are linked to the scientific discipline, shaped by the local departmental community and the student community. It is in the interactions between participants of the community that students gain access to the explicit and tacit knowledge; here the discourses about the discipline and how to act is formed.

In this thesis, I aim to address the discourses of the scientific discipline and the local departmental values, as well as how the students understand these discourses when they negotiate their belonging and identity in Earth Science. This is part of how the discourses about fieldwork are sustained in the educational practices of Earth Science. Here, Polanyi's conceptions of knowing and Lave and Wenger's *Communities of Practice* are useful as they bring into play the relationship and intersections between knowing and learning science in a practice.

4. Learning Earth Science: Communities of Practice

In contrast to cognitive theories of learning, situated learning concerns the whole person acting and participating in the world (Lave and Wenger 1991). In this framework, learning happens in interactions, through activities and participation in communities of practice, which in turn leads to more central participation. Social practice is the central element and Lave and Wenger (1991) draw on a long Marxist tradition in the social sciences. With references to Bourdieu's (1977) critique of structural and phenomenological theory and Giddens' (1979) human agency, they suggest a social practice theory for education.

A theory of social practice emphasizes the relational interdependency of agent and world, activity, meaning, cognition, learning, and knowing. It emphasizes the inherently socially negotiated character of meaning and the interested, concerned character of the thought and action of persons-in-activity.

(Lave and Wenger 1991, pp. 50-51)

The relational interdependency of the agent in the world is inspired by Giddens' (1979) ideas about decentering. They use decentering as an argument for a shift from the notion of an individual learner to learning in a social practice. A key concept in this shift is 'legitimate peripheral participation'. Newcomers in the community transition from participating in the 'periphery' towards becoming 'full' members of the community, as they learn through interactions with members of the community (Lave and Wenger 1991). The analogy is that of a master teaching an apprentice when learning a craft or ways of being in a specific context or profession. The decentered notion thus applies to the master-apprentice relations, 'mastery resides not in the master but in the organisation of the communities of practice of which the master is part' (Lave and Wenger 1991, p. 94). The central idea is that 'learning is never simply a matter of "transmission" of knowledge or the "acquisition" of skill' (Lave and Wenger 1991, p. 116) from the master to the novice. It is rather through participating in a social practice with a full member of a community that the novice learns what it means to be part of that practice. This also entails that learning happens continuously:

(...) learning through legitimate peripheral participation takes place no matter which educational form provides a context for learning, or whether there is any intentional educational form at all. Indeed, this viewpoint makes a fundamental distinction between learning and intentional instruction. Such decoupling does not deny that learning can take place where there is teaching, but does not take intentional instruction to be in itself the source or cause of learning.

(Lave and Wenger 1991, pp. 40-41)

A central idea and implication of this is that learning involves the whole person and does not relate to a specific activity, but rather happens in relation to a social community. Activities and understandings exist in a system of relations that gives them meaning and these relations are

created in a social community (Lave and Wenger 1991). The meanings the community create around a practice therefore become important for the participants both in the forming of the community and their own possibilities to participate in it.

Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations. To ignore this aspect of learning is to overlook the fact that learning involves the construction of identities.

(Lave and Wenger 1991, p. 53)

The system of relations consequently determines the possibilities for learning, at the same time are the members evolving in the social practice. Therefore, learning in a Community of Practice is dynamic, as all members influence the practice and develop identities simultaneously.

5. Science Identity

Geological fieldwork has been described as a meaningful setting for learning and has the potential to provide students with a sense of belonging and develop identity as geoscience students (Raab and Frodeman 2002; Mogk and Goodwin 2012). As outlined in the review, it is my contention that fieldwork has not been researched critically and qualitatively, involving perspectives on students' senses of belonging and identity work. This thesis aims to explore processes and negotiations of belonging and identity, and I therefore unfold how these processes are framed and understood in the following section.

The study of science identities has been used as elements of various theoretical frameworks often closely connected to the concept of communities of practice (Varelas 2012; Lee 2012; Avraamidou 2020). Here, identity is understood as non-static, fluid process that is as deeply integrated in the learning process where 'learning can be viewed as an outcome of identity transformation' (Shanahan 2009, p. 57). Consequently, learning is about more than obtaining knowledge: 'it is [a] matter of deciding what kind of person you are and want to be and engaging in those activities that make one part of the relevant communities' (Brickhouse 2001, p. 286). Lucy Avraamidou (2020) argues for seeing identity as part of a social practice and not as isolated to the individual in a communities of practice framework. In her work, she conceptualises science identity as a 'constant process of becoming a science person, instead of a product' (p. 326). I position this research along fluid understandings of (science) identity, the 'negotiation approach', in which identity is perceived to be dynamic (Poizzer and Jackson 2015). In physics education research, several studies explore the specific physics practices in relation to identity and gender performance (i.e. Hasse 2002; Carlone 2004; Danielsson 2012; Gonsalves 2014; Johansson et al. 2018). These studies, and others, explore how physics practices create spaces and obstacles for student participation.

This thesis draws on conceptualisations of the process of becoming and developing identity within science as part of social learning processes in a practice. In this particular case, I focus on how students are introduced to fieldwork, included in the practice and recognised, as well as how this influences their sense of belonging and their identity negotiations. The aim is furthermore to pay particularly attention to recognition as a driving factor in identity building but also as a means to reproduce established practices.

Research on science identity has been highly influenced by the model developed by Heidi Carlone and Angela Johnson (2007) in which three dimensions, namely competence, performance and recognition, are identified as central when developing and maintaining a science identity. Carlone and Johnson conceptualise science identity as formed in and through practice that over time can result in more stable habitual patterns.

Through their years of science education, students learn to participate in similar practice in similar ways and often get recognized (or not) in similar ways. We see science

identity as fragile (contingent, situationally emergent) and, if habitually accessed, performed, and recognized, as stable, carried across time and context.

(Carlone and Johnson 2007, p. 1192)

Their conceptualisation emphasises that science identities must be sustained by performance and recognition in the practice. Interaction between and among participants of the practice furthermore involves negotiations of identity, which in turn shape the community as a whole. This is especially demanding for new participants, as they negotiate their place in and into the existing community.

The different ways in which old-timers and newcomers establish and maintain identities conflict and generate competing viewpoints on the practice and its development. Newcomers are caught in a dilemma. On the one hand, they need to engage in the existing practice, which has developed over time: to understand it, to participate in it, and to become full members of the community in which it exists. On the other hand, they have a stake in its development as they begin to establish their own identity in its future.

(Lave and Wenger 1991, p. 115)

These identity negotiations are important as they determine whether a new member finds their place in the community and thereby is able to learn in the community. Gaining access to and maintaining a position of legitimate (peripheral) participation is crucial for learning to take place. Carlone and Johnson therefore argue that 'it is essential that we understand how neophytes affiliate with, become alienated from, and/or negotiate the cultural norms within these communities' (2007, p. 1189) when researching student science identities. Further research also shows that students evaluate their potential to fit in and negotiate their identity and belonging as they meet the institution when entering (Holmegaard et al. 2014; Ulriksen et al. 2017). These negotiations are important in the process of students finding their place in the study programme or not.

The social practice that students enter has the power to provide access and make visible what kind of learning is considered valuable in the community. The practice therefore needs to create transparency and 'organizing activities that makes their meaning visible' (Lave and Wenger 1991, p. 105). The argument is that newcomers can be in a position of legitimate peripheral participation and gradually learn the implicit and explicit rules of the community.

The communities of practice framework is considered useful when studying identities in a practice, however, it has been criticised for not paying attention to issues of power (Salminen-Karlsson 2006). Here, I would like to connect this to issues of recognition as a way of reproducing a culture.

5.1 Recognition of identities

Carlone and Johnson conclude that receiving recognition from other members of the community is important when building and maintaining a science identity and particularly ‘consistent and repeated recognition from established members of the scientific community, or “oldtimers,” in Lave and Wenger’s (1991) terms’ (2007, p. 1199) is central. However, this poses challenges when recognition is given based on the values and established notions within the practice. This reproduces both positive and negative ideas, values and notions within a practice (Carlone 2003). In the review section, I argue that there is an uncritical and prevailing positive notion about fieldwork being ‘good’. In this thesis I aim to explore more critically what role fieldwork plays for students’ participation in geoscience practices. Therefore, I here outline broader notions on recognition in relation to performing in a fieldwork setting and what it means for students possibilities to develop an identity within Earth Science.

In order to explore recognition, I draw on Sara Ahmed who states that recognition is a process of how ‘certain lives become valued over other lives’ (2000, p. 30). She argues that recognition is coupled with a visual dimension, as it ‘involves differentiating between others on the basis of how they ‘appear’’ (2000, p. 24). This is one example of framing recognition and Ahmed contextualises it in power relations and people’s possibility of being heard and recognised or not in the context of skin-color and gender. In her study ‘The Becoming of Good Soldiers’ Beate Sløk-Andersen (2018) uses Ahmed’s valuing as an operationalisation of recognition. With this, she shows what is perceived to be and recognised as, ‘good’ in a military context and how this recognition is based on more-or-less defined categories. Sløk-Andersen uses this as an entrance to discuss who it is that gets to define what is ‘good’ and how recognition play a role:

The visual recognition that Ahmed discusses makes gender and race crucial to matters of recognition, as these marks on the body ‘interfere’ with the external gaze; we cannot speak of recognition without speaking of these bodily, visual dimensions.

(Sløk-Andersen 2018, p. 231)

In the context of fieldwork in Earth Science, bodies play an important role in being able to perform physically, which illustrated with the photo of students on a glacier hike in the beginning of the thesis. The body also plays an important role in developing an embodied way of knowing, as outlined in the previous chapter. Recognition given by central members of a community will be based on signs that students fit in the existing practice, e.g. by being able to perform physically in the field in order to learn. These structures of recognition hold the power to include or exclude people in a community in various ways and thereby (re)produce the existing, hegemonic culture. Ulriksen et al. (2010) discusses recognition in relation to retention in science and how recognition reproduces the existing ‘hegemony of a culture of whites and males’ (p. 228) and challenges the participation of non-whites and non-males. Seymour and Hewitt (1997) also noted features in science departments to be aligned with masculine norms and values, which was visible in e.g. a competitive culture. Consequently, it is important to have

a critical focus on 'the masculinized culture of science and science education, and on how 'doing science' is a way of constituting certain kinds of social identity' (Harding 2005, p. 244). In this thesis, I therefore pay attention to what is recognised in the fieldwork practice and how students understand their possibilities for participating in this practice.

6. Methods

In this chapter, I elaborate on the methodological considerations behind the research design and the methods applied. The chapter includes reflections on methodological quality and the analytical framing used for approaching the empirical material in Article I, II and III.

6.1 Research design

The research question in this thesis required a research design that would allow for an analysis of the fieldwork practices and the students individual perspectives. Students' engagement in fieldwork practices were delved into through observations of teaching in the field and students' independent work in the field. How these experiences shaped the students' senses of belonging and negotiations of identity was explored through interviews with individual students. This research design deemed appropriate as it explores both the practices and how the students relate to them. The design offers the possibility to combine data from observations and interviews that can provide insights into the complexity of the fieldwork practices and how we can understand their role in Higher Education Earth Science.

6.1.1 An ethnographic approach

The exploration of students' engagement in geological fieldwork practices takes its departure in observations of students in the field. In order to study students' work and lived experiences in the field, this thesis employed participatory observations (Spradley 1980; Davies 2008; Wolcott 1999). The decision to conduct participatory fieldwork was motivated by an interest in exploring the meaning of actions and events during fieldwork. Spradley (1980) describes how meanings can be expressed directly in language, however, many meanings are also taken for granted and only indirectly communicated. In order to make sense of the world we live in, we make constant use of meaning systems to organise our language and behaviour: 'these systems of meaning constitute their culture; ethnography always implies a theory of culture' (Spradley 1980, p. 5). The use of participatory fieldwork to explore geological fieldwork is therefore an exploration of the culture around fieldwork and not exclusively students learning or an evaluation of teaching methods. The aim when employing these techniques is broader and includes multiple elements in the researched practice.

When ethnographers study other cultures, they must deal with three fundamental aspects of human experience: what people do, what people know, and the things people make and use. When each of these are learned and shared by members of some group, we speak of them as *cultural behaviour*, *cultural knowledge*, and *cultural artifacts*.

(Spradley 1980, p. 5)

When aiming to understand cultural behaviours and knowledge, is it imperative to be immersed in the natural environment with the study objects (Wolcott 1999; Angrosino 2005). In this case, the aim was to document students' direct engagement in the practice of fieldwork, how they understood the cultural rules and learned the cultural knowledge associated with working in the field. By studying the culture or practices around fieldwork, this thesis searches for meanings in fieldwork and how the 'tacit rules' for behaviour are learned (Spradley 1980, p. 53).

In this thesis, ethnography is used to gain insights into how the fieldwork practices shape students experiences in the field and their ideas about becoming Earth Scientists. The aim of centring the disciplinary practice of fieldwork has been to explore these practices and the discourses around fieldwork, as students experience them. The studies in this thesis all combine observations and interviews with students in order to explore their individual learning and becoming processes. The complementary interviews provide additional space for exploring students' conceptions of fieldwork and their personal experiences with and stories about fieldwork. The interview approach has either been semi-structured interviews (Kvale 2007) based on a thematic interview guide or timeline interviews (Adriansen 2012) using time as the organising structure of the interview. Interviews were chosen as we consider them appropriate for obtaining insights into students' ideas of the fieldwork i.e. their feeling of being competent in the field, how fieldwork influences their sense of belonging or how experiences in the field shape their identity work. The combination of observations and interviews provides a strong empirical foundation for this thesis.

6.1.2 Gaining access to the practice

As briefly outlined in the section *Setting the scene*, my presence in the various geoscience departments has been important in order to collect the empirical material. It can be challenging for educational researchers to gain access to the practice they wish to research. Particularly a practice that involves prolonged engagement, transportation, accommodation and safety measures, as fieldwork often do. I have been fortunate to be placed in a department that has supported me and I have been surrounded with teachers that could see some potential in this research. Both the financial support and the trust has been important as means to gain access to the many different fieldwork practices I have experienced during the last four year (see table 1). Each fieldwork encounter has been an opportunity for me to train my observation skills and to learn from participating students and teachers. My presence in the department has been especially important in relation to the cohort of students I followed. During the first year, there were a lot of small introductions and questions to 'the strange research I was doing'. In the third year, my presence was no longer questioned; I could easily join groups working in the field and gained access to learning processes and group work. Inviting students to participate in interviews was equally effortless. Being present and building trust over a long period of time has therefore been important for entering the practices I wanted to research.

6.2 Empirical settings

In order to generate a comprehensive empirical account of students' engagement in fieldwork practices, this thesis draws on various data sets. The empirical material was collected across a four-year period with students from The University of Oslo and with students associated with the University Centre in Svalbard (see table 1). A cohort of students was followed across their enrolment in the three-year bachelor's programme. The students were observed in multiple spaces during their first year and in their third year during three months in a course including an independent fieldwork exercise. The longitudinal empirical material is used as a background in the articles and functions as an empirical grounding in practice. The fieldwork settings and the followed cohort are described here in general terms in order to secure anonymity of the students and teachers.

6.2.1 University of Oslo

The Earth Science bachelor's programme in Oslo has been the main research object in this thesis. The observations of teaching focused on the fieldwork encounters and interviews explored the fieldwork as well as wider themes, i.e., the students learning processes, motivations for studying Earth Science and their aspirations for the future. My position in the department has entailed being a PhD student, a teacher, a supervisor and an educational researcher exploring the context I have been a part of.

Being present in the department also offered the opportunity to observe fieldwork in other courses as well as to observe and interview several master students working in the field (see table 1). These observations and interviews have provided insights into how students work on advanced level. These studies with master students also served as a way for me to improve my observation and interview skills. The more time I spend in the field the better I became at finding good ways to approach students and teachers, finding my role as an observer and refine my way of writing field notes.

Table 1: Empirical work. *workshops were primarily part of teaching development projects

| Empirical material | Place | Students | Content | Observations in the field in days and length of interviews in hours |
|--------------------|---------------------|------------|--|---|
| Observations | Finse, Norway | First-year | Introduction to Earth Science | Fifteen days |
| Observations | Oslo region, Norway | First-year | Introduction to the Oslo region | Nine days |
| Interviews | Oslo, Norway | First-year | First-year in the programme and learning in the field | Nine hours |
| Workshop* | Oslo, Norway | First-year | Mineralogy | Three hours |
| Observations | Oslo region, Norway | Third year | Mapping Cambro-Silurian sediments and structural geology | Fifteen days |
| Interviews | Oslo, Norway | Third year | Students reasoning processes and identity-work | Eleven hours |
| Observations | Svalbard, Norway | Master | Glacial morphology and geophysics | Thirty-five days |
| Interviews | Svalbard, Norway | Master | Learning in the field | One hour |
| Observations | Europe | Master | Sedimentology and structural geology | Twelve days |
| Observations | Europe | Master | Magmatic petrology and structural geology | Twelve days |
| Interviews | Oslo, Norway | Master | Students reasoning processes and identity-work | Five hours |
| Workshop* | Svalbard, Norway | Graduates | Fieldwork skills | Ten hours |

6.2.2 The iEarth collaboration

After just two weeks in Oslo, I was called into a meeting: 'it is something with education, if you want to join'. This turned out to be the first meeting introducing the idea about iEarth to the Department of Geosciences in Oslo. The initial idea about creating a national collaboration and applying to become a Centre for Excellence in Education was ambitious. Since then, the development of iEarth has been a central part of my work reality. The possibilities to collect data across four Higher Education institutions in Earth Science was an opportunity not to be missed. I therefore include an article (Article IV) based on empirical material from a semi-quantitative study that I conducted with partners in iEarth. The study comprises questionnaire data from 210 students and 115 members of staff from the University of Oslo, University of Bergen, The Arctic University of Norway in Tromsø and the University Centre in Svalbard.

Article IV uses a selection of data from the questionnaire survey to outline some general trends in the current Earth Science education landscape in Norway. The method, questions and analytical strategy is described in Article IV and the full questionnaire is available in Martens and Malm (2019), which also includes analyses of data from The Arctic University of Norway in Tromsø.

In this thesis, Article IV provides a context for the conducted research as it outlines some general trends in the current Earth Science education landscape in Norway. The article is used to bring the discussion of fieldwork practices and identities into the wider setting of Higher Education. I therefore exclude discussions on the methods used in Article IV and restrain to use the article's content to discuss Higher Education Earth Science and the possible future directions in the changing reality we face.

6.2.3 The University Centre in Svalbard

The iEarth collaboration also resulted in an invitation from Lena Håkansson to observe a newly developed course with a central fieldwork element at the University Centre in Svalbard (UNIS). This fieldwork was an opportunity to use ethnographic methods for five weeks while observing teaching on campus in Longyearbyen and during geological fieldwork. The fieldwork provided me with valuable experience in using the ethnographic methods and developing my research ideas. The following years, Lena developed the course and we used my observations and her reflections in the development process, in an article as well as several conference and seminar presentations.

6.3 Analytical framing

In this thesis, I have used parts of the empirical material to provide a background informing the analysis, and other parts of the empirical material for detailed analyses. For each study, the analytical steps are described in the respective article, while this section outlines my broader thinking when approaching the empirical material.

6.3.1 Observations

After each fieldwork, the observational data and fieldnotes were treated in different ways in order to preserve the impressions from the field. In a first step, all notebooks were read and unclear words would be written out. In a second step, additional notes were added to help describe and preserve the observations. Detailed observation vignettes and/or summaries of each day in the field were written and then used in the analyses. The vignettes helped me to organise the data throughout the analytical process, and when recalling specific episodes during the fieldwork periods. They also made further descriptions of the context possible and I often added pictures from the field. With this, I want to provide the best possible contextual credibility and secure transparency in my work (Hammersley and Atkinson 2007).

Based on the assumption that fieldwork practices involve processes, actions and meanings created collectively by students and teachers in the field, the analytical approach in this work has been to understand some of the dynamics of geoscience fieldwork from a social practice perspective (Lave and Wenger 1991). The analysis of the various practices combined in this thesis provides insights into different contexts and conditions for students' engagement in fieldwork practices. Inspired by social practice theory, the analytical work in this thesis focuses on the interactions in the field, the norms and values expressed. The observations have thus functioned as a way of analysing and contextualising social interactions in fieldwork and the interviews described in the following section explored how students make sense of the fieldwork practices. Since the students perspectives were the main focus of this work, I have knowingly excluded teachers perspectives, even though the teachers naturally participated in and influenced the fieldwork practice. However, they were not the analytical focus of the thesis.

6.3.2 Interviews

The individual interviews with students were all analysed openly and thematically in order to identify patterns across the interview data (Braun and Clarke 2006). The interviews were usually conducted soon after the fieldwork. In some cases, the interviews were conducted while the students were still working on a field report or assignment based on the fieldwork, while other interviews were conducted after assignments were handed in. In both cases, the students were able to remember what they did during their field work and often used their own maps or photographs to explain events.

Vignettes were also written after each interview with the aim to capture the main themes of the interview and to describe the general atmosphere and impressions during the interview. Additionally, thoughts about the respective conversation were noted, following general recommendations for ethnographic methodologies (Hammersley and Atkinson 2007; Emerson et al. 2011). These notes functioned as a reminder of details from the interviews even years later. These initial notes turned out to be important to keep track of all the different students and especially when analysing data across several years. Notes could look like this:

This becomes a somewhat unstructured interview. I lost track of time but there were many interesting things here but probably a bit difficult to sort out. [The student] worked together with [another student] and [they] explain more clearly how they did the fieldwork. [The student] has a few good examples of how to trace the becoming of and feeling more like a geologist in the past three years. (Based on interview notes)

The interviews have been used in various ways in the articles. Article I uses interviews conducted across one year and a retrospective timeline interview. This succession of interviews made a focus on development of science identity across time possible. In Article II, interviews with first year students form the basis for the analysis of faculty-student interactions and senses of belonging and Article III analyses interviews with science identity as an analytical lens.

6.4 Being in the field

In the section *Setting the scene*, I claim to be 'inside' and 'outside' of both Earth Science and Educational Science. Being thus positioned by others, and actively taking the different positions has been a constant condition for this work. This has created both advantages and challenges to reflect upon. And the question is: How does this influence my research?

As described in the section on gaining access, my background as a geologist on the one hand has been important for gaining access to the practice and I can act according to the practice and thereby I am recognised as someone who knows geology. On the other hand, being able to understand the scientific content of teaching and research practices has been important in order to come close to understanding both teachers and students and their practices. In this way, my role can be described as an insider role, as someone who is 'considered an insider by the other members of a community and/or who participates on a par with the other members of that community' (Adriansen and Madsen 2009, p. 147). In some cases, this can be seen as an advantage i.e. gaining access, but it is not necessarily imperative for research quality. Being 'too much' of an insider can also make you overlook important elements because they are implicit to you and you do not unfold them further e.g. in an interview situation.

In the context of cultural analysis, Brian Fay (1996) questions the notion that 'You have to be one to know one'. The presumption is that you need to be a member of a certain group to understand the group, hence, to know other insiders you have to be an insider (Fay 1996). He

argues that we understand others when we can translate their experiences ‘in terms which *render them intelligible*’ (Fay 1996, p. 25). This means that we need the ability to interpret the meaning behind the processes we observe, and this is more important than being a member of a group. Instead, Fay argues that we need to be sensitive to the others we wish to know more about.

I may *be* myself but this doesn’t mean that I therefore *know* myself. Knowing an experience doesn’t mean having it: it means being able to say what it is. (...) *Knowledge consists not in the experience itself but in grasping the sense of this experience.*

(Fay 1996, p. 27)

Through interactions with others, it is more likely that we become able to grasp the meaning of the experience and thus create this needed sensitivity.

Sensitivity heightened by shared experiences is often an important step in understanding the lives of others: this is the truth contained in the thesis that “You have to be one to know one”. But genuine understanding goes beyond sensitivity. To know others – indeed to know oneself – is to be able to make sense of their experiences.

(Fay 1996, p. 28)

This takes me to the core; my attempt is not to become a complete insider or to use the outsider position strategically. My attempt is to apply sensitivity, explore practices and try to make sense of the experiences students gain in the field to understand how these experiences matter. Returning to the question on how this influences this piece of research. I believe that my abilities to occupy different spaces and positions and having navigated the space between geology and science education create a sensitivity to see and analyse situations. This ability makes it possible for me to question the role of fieldwork in Earth Science education and thereby contribute to both communities with meaningful insights.

6.5 Reflections on methodological quality

The methodological quality is important in order to present compelling and plausible insights. In this section, I present some reflections on the issues of trustworthiness, generalisability, reflexivity and research ethics. This chapter furthermore includes an account to outline the limitations and some of the challenges I experienced during the collection of the empirical material and analysis.

6.5.1 Trustworthiness

Trustworthiness is a term for validity and reliability in qualitative research and entails that the researcher reflects on credibility, transferability, dependability, confirmability and reflexivity in the research process (Lincoln and Guba 1981, 1985). These elements are all important to

consider throughout the research process. Employing ethnographic methods requires a high degree of transparency and honesty, as the insights depend on the researcher's presence and engagements in the practice (Davies 2008). In ethnography, credibility can be understood as 'the extent to which an account accurately represents the social phenomena to which it refers' (Hammersley 1990, p. 57). In order to secure this type of credibility, 'prolonged engagement' with the site of investigation can be applied (Lincoln and Guba 1985). In this thesis, this principle has been applied by following the cohort of students across time in different types of fieldwork encounters.

My presence as a researcher has unavoidably influenced the practices I studied. In particular, the group of students I followed throughout several years. Some of these students would often refer to earlier fieldwork and talk about common experiences we have had in the field. This shows how my participation in the practices was noticed and how I *inhabited the shared space* with the students, which is characteristic of participatory observations (Emerson et al. 2011). Therefore, transparency and reflectivity are important when conducting observations. Transferability can be ensured if readers are given the possibility to judge the interpretations and to make their own generalisations based on their reading of the study (Lincoln and Guba 1985). For this reason, I have aimed to construct thick descriptions and use students' quotes and field notes in the various analysis to illustrate the link between observations and interviews, as well as the respective constructed interpretation.

Another general recommendation in qualitative research is to apply strategies that improve the rigour of the research by triangulation, frequent debriefing sessions and peer scrutiny or review (Guba and Lincoln 1981). Triangulation has to some extent been embedded in the research design by combining observations and interviews as a way to unpack the observations and make sure episodes were not misunderstood. Debriefing sessions and peer scrutiny have been secured by sharing (anonymous) data with both supervisors and developing analyses together.

Other elements of trustworthiness are dependability and confirmability, which are ensured by transparently describing the research steps from the start to the development and reporting of the findings (Lincoln and Guba 1985). In ethnographic studies, fieldnotes can be the audit trail in the research process (Korstjens and Moser 2018) and are the written accounts of the practices observed and represent the experiences in the field (Emerson et al. 2011). The fieldnotes are also the basis for constructing the important 'thick descriptions' of the practice (Geertz 1973). In this thesis, fieldnotes describing events, episodes and interactions have been the backbone of every analysis including my reflections on the observations and my own position in the field.

6.5.2 Generalizability

Ethnographic research is often criticized for not producing generalizable findings (Davies 2008). The research is situated in the practice it describes and it can be difficult to see how that can

be transferred to other practices. However, Davies (2008) argues that it depends on how we adopt the term generalizability. For example, the conclusions of ethnographic analysis can be viewed as ‘theoretical inference’:

That is, the conclusions of ethnographic analysis are seen to be generalizable in the context of a particular theoretical debate rather than being primarily concerned to extend them to a larger collectivity.

(Davies 2008, p. 103)

Davies uses the example of a researcher conducting ethnographic fieldwork in four different organisations and thus offering empirical generalizations that are ‘not restricted to the specific four organisations’ but possibly also applicable to other organisations (Davies 2008, p. 103). Collecting several cases can also show variations that will refine and strengthen the explanation and thus gradually create valid generalizations (Davies 2008). However, Davies notes that the critique of ethnography often occurs from a positivist view of research and ‘the unexamined assumption that it rests primarily on the ethnographer becoming a part of the group being studied’ (Davies 2008, p. 104). Instead, Davies argues that honesty and reflexivity secure the rigour of ethnographic research. In this thesis, however, I have also used multiple field sites in order to build up a rich empirical material to base the analysis on.

6.5.3 Reflexivity

In this type of research, it is acknowledged that the empirical material and analyses depend on researchers’ presence in the practice and the recommended measures are to create transparency. Davies (2008) argues that ethnographic methods may produce valid knowledge as ‘long as they honestly examine, and make visible in their analysis, the basis of their knowledge claims in reflexive experience’ (p. 104). The approach employed here refers to social constructivist and critical theorists’ emphasis on the researcher’s ability to be reflexive and provide thick descriptions when conducting credible research (Alvesson and Sköldbberg 2009; Creswell and Miller 2000). The articles in this thesis have aimed to fulfil these demands in different ways. In Article I, we describe our positionality and how it influences the production of our empirical material. In Article II, we outline the conditions for the observations in tables and openly provide analyses of the observations. In Article III, I describe the analytical strategy in detail and how the analysis is informed by the used framework.

As briefly introduced in the *Prelude*, reflections on methods and how to understand the empirical materials have been a major part of this research, as well as my own development as a researcher. This is difficult to visualise in a thesis format. Nevertheless, I have several places in which I tried to describe how it is possible to develop new ways of seeing. Here, I include what I can only describe as fieldnotes written for the very first draft of this thesis:

Over the years, as I continuously observed fieldwork, interviewed students and discussed with teachers, new patterns began to emerge in the material and new questions arose: who gains access to participation, what are legitimate ways of participating and how does participation play out as students and teachers engage in and interact during fieldwork. Therefore, the focus of this thesis has developed into a piece of research that aims to unfold some of these structures around fieldwork and what fieldwork means for students' sense of belonging and negotiations of identity in Earth Science.

The challenge, as I experience it, is finding a balance with reflexivity. With a thoughtful and ruminating nature, it is difficult not to be caught up in reflections and more so, writing passionately and adding personal accounts. I hope to be able to strike an even better balance in the future. With this thesis though, it has definitely been difficult to explore themes I am very entangled in and have many thoughts about while still producing scientific texts and create progress in the PhD programme. So, I end a section on reflexivity with a personal wish for the future; to find better ways to use reflexivity when producing and doing scientific research that better reflects the lived experiences it aims to describe.

6.5.4 Ethical considerations

Ethical considerations have been a constantly present part in this research process. Naturally, all participants were informed and gave their informed consent for their participation in research per ethical guidelines by the Norwegian Center for Research Data (Norsk Senter for Forskningsdata, NSD). On top of this, students were offered the possibility to read manuscripts and comment before publication. The ambition has further been to 'do no harm' and secure the anonymity of students. In the articles, I either used pseudonyms or described 'students' in general terms. When using fieldnotes and quotes from interviews, they have been used thoughtfully and without making students recognisable. Especially students I followed several times and over a longer time span, I have presented in ways that do not make it possible to recognise them. Some student stories have also been excluded or not described in detail; however, they all are part of the wider analysis or functions as background material for the analysis conducted.

6.5.5 Limitations

With this thesis, I have aimed to collect empirical material in various contexts with different teachers and students, in diverse environments and in several subdisciplines within Earth Science. The focus has been on achieving methodological quality and generating a rich empirical material across a four-year period. Methodological limitations are present in all settings, and here I outline some of the (conscious) limitations important to this thesis.

First, the findings in this thesis are constructed from specific fieldwork episodes, representing examples of fieldwork practices in Earth Science. The episodes are examples of what fieldwork practises can look like, though, it is obvious that fieldwork in Earth Science is more diverse. For some students it includes fieldwork in urban settings for others virtual fieldwork, both examples of fieldwork practices not studied in this thesis.

Second, the access I gained, as described above, was very dependent on teachers' willingness and curiosity in having me explore their students' practices. This, however, might also have excluded me from observing other equally interesting fieldwork practices, as my time was restricted and spent on the chosen cases resulting in turning down several opportunities to observe other practices. The selection process was conscious regarding the bachelor students I followed, though the additional fieldwork I conducted was more chosen based on a teachers' curiosity and invitation as well as my own interest in the respective practice. The same goes for the students I chose to observe, they also sometimes chose me, and we chose each other. Especially in prolonged engagements where I selected a specific group of students to follow. Here I would be conscious about choosing students that I saw discussing and working together, as it would be easier to access their practice. This obviously involves the risk of bias, which would imply that the participating students might have been systematically different from other students. However, it was here where there was an opportunity to gain access to the practice of interest. Each student is an individual, each group specific and every piece of observation is interesting in this line of research.

Third, the fact that the fieldwork was physically strenuous had an impact on the quality of the material in some cases. Some of the fieldwork was conducted during times of immense physical pain or over very long timespans and in some instances, I needed to take breaks from observing to recover. However, I believe that it is not possible to continuously stay in the intense role of an observer and the breaks were often used to polish fieldnotes and write additional reflections.

7. Summary of Findings

This chapter presents the findings from the three empirical articles constituting this thesis as well as the fourth article, which provides a wider context of where the studies took place and which was used to discuss future perspectives of Earth Science education. This section also includes a short background for each article with a description of how the article came about. These stories are included to create transparency. In this section, I furthermore aim to explain the connection between the articles and their relevance for the overall aim of the thesis.

Article I. Doing geoscience: negotiations of science identity among University students when learning in the field

Lene Møller Madsen and Rie Hjørnegaard Malm

Under review for L. Archer and H. T. Holmegaard (Eds.) *Science Identities - Theory, method and research*. Springer.

This article investigates how disciplinary culture and tacit knowledge intersects with students' sense of belonging and identity work. The article explores how these concepts are produced and negotiated in learning situations within Higher Education Earth Science. With this approach, the aim is to unfold what is at stake when becoming and negotiating an identity as a geologist.

This article is the culmination of several years of collecting empirical materials in geoscience with an identity focus and therefore combined three cases. We included a case from my previous research at the University of Copenhagen and a case from Lene's research at the same university as well as a case from my research at the University of Oslo. This article we have wanted to write for years with the aim of exploring how the discipline and ideas about the discipline shape students' identity work. In order to do so, we have collected stories and cases over several years while at the same time refining and nuancing our argument for exploring science identity with a disciplinary focus. With the material from my PhD research, we finally had an example of a Master student, which made it possible to compile the stories and build up a consistent analysis showing how disciplinary identity work can occur continuously from the students' first year to writing up their master's thesis at the end of the master's degree.

Article I presents three portraits illustrating different ways of how students negotiate the discipline of geology, describe the use of instruments and conduct fieldwork, as well as how this influences the students' understanding of themselves and their geoscience identity.

The analysis presents first-year student Ada's story and shows how science identity negotiations are a central part of making sense of the geoscience content in relation to the different forms of knowledge in geology. Ada struggles to understand the interpretative

reasoning styles in geology and being in the field turns out to be an important turning point in Ada's learning process. The analysis also shows how Ada struggles with creating a science identity that is recognisable and with making sense of the self as a geoscience person. This is highly influenced by the encounters with different teachers in different learning situations. Following Ada throughout the first year, it becomes visible that identity negotiations in different learning settings and types of recognition constantly influence and, in various ways, interact with learning processes. The second portrait illustrates the process of learning to 'see' and to be in the field practice and how this is linked to the students' process of becoming a geologist. The case shows the practice geology exemplified through learning to measure strike and dip with a clinometer compass, and through learning how to 'see' as a geologist and how this is embedded in tacit knowledge of the discipline. We describe how a teacher repeatedly shows how to use a compass instead of describing the procedure when teaching students in the field. The teacher's knowledge is tacit in a way that makes it difficult to explain the procedure. Strongly embedded in the practice, it also appears difficult to be made explicit and thereby taught. The tacit knowledge intersects with the students' sense of belonging and identity and becomes of immense importance for the students and their science identity, both in terms of recognition and competence. This is further unpacked in the third portrait, showing how a student's experiences in the field and reflections on the fieldwork have a major impact on the way the student does not identify as a competent geoscience person. In the field, the student struggles with 'seeing' what the supervisors see and follows their continuous development of different hypothesis in a complicated geological story. Although the student performs 'well' in the field, gets recognition from the supervisors and demonstrates competence in producing valuable research data, the student still struggles with recognising the competence of the self. The student connects being competent in the field with being a good geologist, and the feeling of having failed in the field has consequences for the student's self-image as a future geologist. The article's portraits show how students negotiate the interpretive nature of geology, the embodied practice of fieldwork and how to 'see' like a geologist in the field.

The article contributes to answering the research question of this thesis by showing in what ways field experiences are central in the practice of geology and how the students' learning experiences become a part of their identity negotiations of becoming a geologist. The article furthermore provides thick descriptions of how disciplinary knowledge occurs, is negotiated and contested in learning situations in the field and thus creates a strong argument for considering how fieldwork is introduced and conducted in Higher Education Earth Science. The article therefore poses questions on how to address future studies of science identity with a disciplinary approach by asking how disciplinary culture and tacit knowledge interact with inclusion-exclusion practices within geoscience, especially in relation to fieldwork practices.

Article II. Students' negotiations of belonging in geoscience: experiences of faculty-student interactions when entering university

Rie Hjørnegaard Malm, Lene Møller Madsen and Anders Mattias Lundmark

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The focus of Article II is on first year students' interactions with faculty and experiences in the field, and how these interactions and experiences influence students' negotiations of belonging in a geoscience study programme. This study uses the concepts of belonging and culture to analyse various activities and faculty-student interactions during geoscientific fieldwork and in an 'interview exercise'.

This article is based on one year of observations of a group of students in various teaching and field settings. A longitudinal approach was chosen to explore how students experienced different activities in the first year and how these experiences influenced their negotiations of the discipline. As the students progressed into the programme, it turned out that the experiences in the field were something the students continuously referred to. This study therefore explored these narratives further and became a strong example of how learning in the field creates both spaces and barriers for students learning. It took one year to collect the empirical material and the article was developed during the following two years. This long process became an opportunity for me to develop the analysis based on the (vast amount of) empirical material and to develop reflections on how fieldwork influences students' possibilities to create a sense of belonging to the discipline.

Our article shows how interactions with faculty can give students access to explicit and tacit knowledge about doing geoscience research, the department culture as well as possible careers in geoscience. The analysis shows that faculty-student-interactions offer important avenues for the students' negotiations of how they belong in the study programme (who they are) and in assessing their future possibilities (who they want to become). The students encounter a disciplinary culture in the department with a strong emphasis on being personally invested in the geosciences as the pathway to become a successful geoscientist. The students interpret this strong culture among faculty as a requirement for them to be equally interested or even equally devoted to geoscience to belong in the study programme. This notion becomes entangled with the students' experiences in the field, where they meet a culture with a strong emphasis on being able to perform physically. The strong position of fieldwork in the culture and fieldwork practices performed in rough terrain, especially during the first fieldwork encounter that requires a relatively high level of physical fitness, raises questions about diversity, inclusion and equity.

Article II therefore contributes to this thesis by providing an empirical account of how students' participation in different activities during the first year shapes their understanding of the

discipline and negotiations of how they can belong. The concepts of belonging and culture allow for a deeper understanding of how the activities legitimise particular ways of becoming a geoscientist. Further, the article contributes with insights into how encounters with the departmental culture play a strong role for the students' ability to see themselves in the study programme and the field of geoscience in the future. The article therefore argues that institutions must offer possibilities for creating a sense of belonging to first year students that are varied, authentic and inclusive.

Article III. Geological reasoning and Identity: exploring links between fieldwork and students' identity work

Rie Hjørnegaard Malm

Under review for Journal of Geoscience Education.

Based on three months of ethnographic fieldwork with students in their third year of an Earth Science bachelor's programme, this article focusses on students' learning and geological reasoning processes in the field and how learning and reasoning geologically influence their identity negotiations of becoming geologists.

By following the students in class, in different fieldwork settings and during their independent fieldwork, I was able to come close to their disciplinary practice. During this ethnographic fieldwork, I was able to capture the students' ways of working in the field and let them describe what they did, sometimes already in the field and always in the following interview. With this empirical material, it was possible to gain insights into learning processes and the students' identity work in a way that was more detailed than I could imagine. This article has therefore been important to write since it adds the most detailed account from students that I have collected. In the context of the thesis, this article plays a core role as it presents powerful stories about inclusion and exclusion in a disciplinary culture with a strong focus on fieldwork.

This study analyses students' performance, feeling of competence and ways of being recognised in the field as well as how these aspects shape their ideas about becoming geoscientists or not. The analysis shows how students develop geological narrative reasoning as well as intuitive skills and are competent and perform in accordance with the scientific norms of the fieldwork practice. They have learned which practices are recognised, what it means to be a 'good' geology student and how to adjust to the discourse. However, this strong discourse creates a one-dimensional structure of recognition, which reduces the space created for students' participation. Students in the programme perceive a need to relate to the strong discourse about liking to be in the field and this, coupled with teaching in the field that is not inclusive, leaves some students with the a feeling of not 'fitting into' geoscience. As one student notices, fieldwork 'is perhaps not adjusted for everybody' and not liking to be in the field, is not

recognised or considered as legitimate. This is an example of how the disciplinary practice of fieldwork produces space for some students to learn and become part of the community while creating barriers for others.

Article III contributes to this thesis' research questions by illustrating how closely the students' perceptions of being a good geology student are linked to liking to be in the field. The article furthermore shows how a disciplinary practice can create barriers for learning and belonging in Earth Science. With these insights, it becomes even more pressing to discuss the status of fieldwork in the programme. As it creates a specific non-inclusive notion about who a geologist is and what a geologist does. The image of the enthusiastic field geologist creates a narrow space for participation in geology, which could be broadened by identifying multiple ways of belonging in Earth Science.

Article IV. Geoscience for the future: are we ready to change geoscience education in Norway?

Rie Hjørnegaard Malm, Anders Mattias Lundmark and Bjarte Hannisdal
To be submitted

This article provides insights from a baseline survey designed to address the teaching culture and learning environment among students and staff across four geoscience departments in Norway.

Article IV is based on a semi-quantitative questionnaire data set including answers from 210 students and 115 members of staff. In the context of iEarth, I developed the questions, designed the questionnaire and had it sent to all members of staff and students in the four institutions as well as conducted the first analysis of the data. This work was part of mandatory teaching and teaching development duties during my PhD, and it is an example of the development work I have been involved in. It thus represents an effort to collect data from the community in order to conduct a research-based development of iEarth and the involved programmes.

The questionnaire data provides insights into the pervasive ideas about teaching and learning geoscience in Norway. The article provides suggestions for the development of the current programmes and directions for the future of Earth Science education in Norway.

We argue that the geoscience education is at a crossroads, as we are faced with large-scale environmental changes and a society that will increasingly depend on Earth system science for making informed policy decisions. At the same time, the calls for reform of Higher Education to improve quality and accountability are growing in Norway. Taken together, these trends underscore the need for renewed thinking about the future of geoscience education. The

article thus adds to the current research literature in two ways. First, it analyses data on students' and staff's perceptions of the teaching-learning environment and in what ways the researched geoscience programmes prepare students for the future. Second, the data offers insights into the existing teaching culture, which we used to discuss how change can be supported in the programmes. The article tentatively outlines some responses to the challenges highlighted by the questionnaire data and argues for a more coherent geoscience education. We propose adopting an Earth System approach, which emphasises the interconnectedness of the different subdisciplines that traditionally are taught as separate subjects, as well as the links to socioeconomic systems. The systems approach needs to be embedded in the type of problems students learn to solve. Authentic, "wicked" problems involving complex Earth systems require a type of training that prepares students not only for scientific research, but also for real-world problems in the workplace and society at large.

In the thesis, this article contributes with a national perspective on Earth Science education in Norway and provides a context for the conducted research on fieldwork and geoscience identities. However, it is primarily used to discuss the findings from this thesis and the possible future directions for Higher Education Earth Science.

8. Discussion

This chapter comprises a recapitulatory discussion of the findings presented in the articles included in this thesis and presents possibilities for further research. In order to explore roles of fieldwork in Higher Education Earth Science, this thesis project has aimed at answering the overarching research question: How does students' engagement in fieldwork practices in Higher Education Earth Science shape their sense of belonging and negotiations of identity, as well as possibilities for participation?

In the following, I therefore discuss how the articles provide insights into fieldwork practices, students' sense belonging and negotiations of geoscience identities. In the discussion, I include perspectives on in what ways the analyses illustrate how the reproduction of the disciplinary culture (of power) is constituted in fieldwork practices in Higher Education Earth Science and how we can widen what is considered (legitimate) participation. Finally, I discuss how the findings can be used to see possible new roles of fieldwork in Higher Education Earth Science.

8.1 Students belonging and geoscience identity

In this thesis, I have explored how interpretations of learning situations and fieldwork settings in Earth Science give access to insights into the intersections of belonging, science identity and disciplinary practices. By observing students during geological fieldwork and through interviews, I could identify some of the tacit knowledge and taken-for-granted conceptions about fieldwork currently present in Higher Education Earth Science. These tacit and embodied practices of geoscientific fieldwork play different roles for students' identity processes.

Through fieldwork, students can experience and negotiate the interpretive nature of geology, which can help them make sense of the discipline and move from a peripheral to a more central participation in the community. The fieldwork practices also provide access to embodied practices i.e. using instruments and learning to observe. Especially these embodied and implied structures around fieldwork make it important to provide students with opportunities to learn in the field and develop embodied skills and learn about implied structures.

The insights from the articles point to a disciplinary culture that recognises a specific way of working and being in the field, which creates a narrow idea about who belongs and what kind of geologist students must become. The thesis also shows how teaching in the field has, over time, repeatedly made it difficult for some students to learn in the field. In the first and third article, those struggles become a theme when openly inquiring into how students perceive teaching in the field. Here students notice that 'perhaps [fieldwork] is not adjusted for everyone' and the strong discourse of liking fieldwork makes it necessary for students to negotiate themselves in relation to this discourse.

The thesis thereby shows that performing a science identity within the discipline is linked to a specific idea about a field geologist performing in rough terrain, something not all students can recognise, identify with or are physically capable of doing and being. This is part of the image that students build up through engaging in fieldwork and teaching activities in Earth Science. Therefore, is it important to reconsider how we frame fieldwork and which spaces we create for participation.

Based on this, some directions for future research are to pay more attention to how aspects of disciplinary culture and tacit knowledge interact with inclusion-exclusion practices. This thesis demonstrates how tacit knowing and values within the geoscience discipline, especially in relation to fieldwork practice, are picked up by students and used in their identity negotiations. This raises questions about the construct of geoscience identity and how it can allow for wider participation in geology. Valuing the idea of and focus on the 'field geologist' identity creates a narrow space for students' participation. The question is therefore how we can develop the idea about the geoscience identity to include the different subdisciplines in geoscience. This will require a reconsideration of how the fieldwork practice is valued and will allow for imagining more types of geoscience identities. What it implies is that we recognise more various skills, abilities and interests, and thereby broaden the discourse about who a good geologist is.

8.2 Physical aspects of fieldwork

This theme about the physical aspects of fieldwork has emerged through the various analysis and over time became part of this work. The physicality of fieldwork is one of several underlying themes that were difficult to capture, however, it has played a substantial role in the analysis of student participation in different ways. In Article I, we describe how the student Ehm is perceived to perform in accordance with the norms of the fieldwork practice. They are seen as being both 'tough' and 'capable' in the eyes of the supervisors. This, we discuss, created the impression that the student was doing well, an image the student could not recognise. In Article II we conclude that the first-year students meet a culture with a strong emphasis on being able to perform in the field, which becomes visible in the students' negotiations of belonging. The combination of the strong position of fieldwork in the culture and fieldwork practices performed in rough terrain that require relatively high level of physical fitness, made us raise questions concerning inclusion and equity. Article III shows how the students, among other skills, demonstrate field competences related to visible hands-on skills, like drawing a map and using a hammer and less visible skills, illustrated with 'feeling the hammer' example. These embodied skills are central to the fieldwork practice, however, the article questions how these skills are part of our patterns of recognition and what we value in the fieldwork practice. Exactly here I see the intersection between recognition and the perception of fieldwork practices and how students are expected to participate. The idea about 'toughness' in the field can be

interpreted as a reproduction of a masculine-coded culture. The image of the enthusiastic, tough field geologist has the potential/risk of creating a narrow space for participation in geology, which could be broadened by identifying multiple ways of belonging and being able to participate in fieldwork practices. Employing a framework of intersectionality can help identify the multiple individual, structural and cultural dimensions that shape Earth Science as a way for broadening participation (Avraamidou 2020; Mattheis et al. 2019; Núñez et al. 2020). This could be a way to create a wider space and more diverse opportunities for engaging in and becoming an Earth Scientist.

8.3 Future roles of fieldwork in Higher Education Earth Science

Article IV outlines the large-scale changes in Earth's systems and the status of the educational landscape of Higher Education Earth Science in Norway. The need to create change and reduce our consumption of Earth's resources is acute and necessary, as the Earth's battery is running low. The need to change Earth Science education is also desired if we wish to educate geoscientists who are able to solve the problems they will be facing in the future. The article shows how a slight change in focus that twists the existing curriculum and creates a stronger link to an Earth Systems approach can create study programmes that better prepare students for the future and the complex problems ahead. We argue that the use of authentic problems both strengthens and reveals the applicability of the education when the students work with contextualised problems. The argument is also to teach students to work with uncertainties, complexity and wicked problems in collaboration, as this will help them to tackle the uncertainties of the future (Barnett 2007, 2012). This is a direction that will help fulfil the potential of the geosciences to address global challenges, which is inherent in the geosciences but not fully exploited or framed in the existing programmes. In addition to this, geological fieldwork can be used to create tasks that include working with ill-structured problems and uncertainties, as we show in an example from undergraduate geoscience teaching in Denmark (Madsen et al. 2020 in press). Here we argue that wicked problems can be a way to frame fieldwork and provide opportunities for authentic scientific engagement through inquiry. In the example, students are presented with the task to predict how a future Holocene-Anthropocene boundary would look like in e.g. 10,000 years from now. The students need to apply what they know about geological boundaries based on their fieldwork experiences, their theoretical knowledge about boundaries and environments and the search for the scientifically viable reasoning when developing predictions they argue for. Framing fieldwork in this way creates an alternative to the existing confirmatory fieldwork, where we go out and observe what we know. The unknown element of wicked problems thus creates a space for students to genuinely inquire phenomena without fixed 'answers' in the process (Madsen et al. 2020 in press).

This positivistic idea about science being fixed and providing correct and precise answers is exactly what Ada struggles with in the first year of an Earth Science programme, as we show in

article I. Meeting a science subject that is based on interpretations and embodied knowledge can be challenging, as it conflicts with how science is framed in school and in the public communication of scientific research and results. Geoscientific findings are often based on incomplete data and involve interpretations. The reasoning behind the interpretations can be difficult to understand as they often are tacit and thereby difficult to communicate. However, when students and teachers engage in fieldwork, there is a potential to unpack the way of reasoning, show students how data is collected and how interpretations are made. This is exactly the strength of fieldwork and in Ada's case, we also see that some of the initial problems with understanding geology as a scientific discipline is solved by engaging in fieldwork. In the analysis of students in their third year of the bachelor's programme (article III) I show how the students have learned to reason geologically. Through working in the field, they can see their own learning progress i.e. being able to collect data and sketch and work out plausible interpretations. This becomes particularly visible when they face a task that requires them to work independently and solve problems in a group. This challenge and overcoming it is something the students highlight as important for them to feel more confident and consequently a sense of belonging. For these reasons, it is important that we create fieldwork experiences during which students have the opportunity and possibility to engage in the field.

9. Concluding remarks

This thesis provides insights into fieldwork practices in Higher Education Earth Science and into the ways practices influence students' sense of belonging and their negotiations of geoscience identity. The work illustrates how the social practice of fieldwork reveals ideas about how we perceive a 'good' geology student and how taken-for-granted perceptions influence students' possibilities to become and feel part of the practice. Additionally, I show how these relations become relevant in students' negotiations of belonging in Earth Science, which reveal inclusion in or exclusion processes. The empirical material consisting of observations and interviews enables the investigation of fieldwork practices that goes beyond seeing fieldwork as an inherently 'good' teaching method but includes notions of disciplinary culture and tacit knowledge embedded in the practice. As such, this thesis contributes with a descriptive account of students' engagement in fieldwork practices and provides insights into how students' fieldwork experiences intersect with their sense of belonging and their identity work within Earth Science. With this, the thesis generates nuances of how fieldwork practices can be perceived by students in Higher Education Earth Science. This will hopefully inspire the geoscience community to reflect on how to plan, conduct and discuss fieldwork in Higher Education Earth Science in the future.

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11. Appendix

1: Additional contributions

Co-authored publications not included in this thesis

Madsen, L. M., Evans, R., and Malm, R. H. (2020 in press). Using a wicked problem for inquiry-based fieldwork in high-school geology: addressing climate change and mass extinction events. In Achiam et al. (eds.) *The role of out-of-school science education in addressing wicked problems*. Springer.

Senger, K., Betlem, P., Birchall, T., Buckley, S. J., Coakley, B., Eide, C. H., Flaig, P. P., Forien, M., Galland, O., Gonzaga, L., Jensen, M., Kurz, T., Lecomte, I., Mair, K., Malm, R. H., Mulrooney, M., Naumann, N., Nordmo, I., Nolde, N., Ogata, K., Rabbel, O., Schaaf, N. W., and Smyrak-Sikora, A. (2020). Using digital outcrops to make the high Arctic more accessible through the Svalbox database. *Journal of Geoscience Education*. DOI: 10.1080/10899995.2020.1813865

Martens, I., and Malm, R. H. (2019). Baseline undersøkelse av studiekvalitet og undervisningskultur på Institutt for geovitenskap ved UiT Norges arktiske universitet. Tromsø. <https://hdl.handle.net/10037/16728>

Malm, R. H., and Håkansson, L. (accepted). Developing an Arctic geology course: exploring the role of fieldwork and use of metacommunication.

Conference proceedings

Malm, R. H., and Lundmark, A. M. (2020). What are the future challenges of higher education geoscience in Norway?. 34th Nordic Geological Winter Meeting. Oslo, Norway.

Malm, R. H. (2019). Doing fieldwork in geology: processes of negotiations and identity. Invited talk in Special Interest Group Symposium. 2019 ESERA International Conference. Bologna, Italy.

Håkansson, L., and Malm, R. H. (2019). Aligning a course in Arctic Geology through analysing student participation and challenges. MNT Konferansen. Tromsø, Norway.

Malm, R. H., and Martens, I. (2019). Exploring the teaching environment in a higher education geoscience programme. MNT Konferansen. Tromsø, Norway.

Malm, R. H. (2019). Fieldwork in Higher Education Geoscience. Invited talk. Special Interest Group Seminar. University of Copenhagen, Denmark.

Malm, R. H. (2018). Fieldwork in Higher Education Geoscience: why should we improve teaching in the field?. Invited talk at teaching seminar. Lund University, Sweden.

Malm, R. H. (2018). What do we actually teach students in the field?. 33rd Nordic Geological Winter Meeting. Lyngby, Denmark.

Indrevær, K., Malm, R. H., and Lundmark, A. M. (2017). Nye karttjenester for mobil gjør det enklere å undervise geologi i skolens nærmiljø. Geological Winter Meeting. Oslo, Norway.

Malm, R. H. (2017). Hvilke potentialer for læring skaber feltarbejde?. Feltarbejde i gymnasiet. Invited talk. Natural History Museum. University of Copenhagen, Denmark.

Malm, R. H. (2017). Integrating first year geoscience bachelor students in academia. The Geological Society of London Higher Education Network 2017: Teaching excellence in the geosciences. London, United Kingdom.

Malm, R. H., Lilleøren, K. S., and Lundmark, A. M. (2017). Linking students and lecturers – a first year student-staff interview project. European Geosciences Union General Assembly. Vienna, Austria.

Malm, R. H., Lundmark, A. M., and Lilleøren, K. S. (2017). Interviewing researchers-introducing first year bachelor students to their scientific discipline. MNT-konferansen. Oslo, Norway.

Malm, R. H., and Madsen, L. M. (2017). Using inquiry to facilitate high school teachers' use of fieldwork in their future teaching. Invited talk at GEO GO seminar on field-based education. NTNU, Trondheim, Norway.

Science communication

Madsen, L. M., and Malm, R. H. (2017). Geovidenskab skaber omverdensbevidste studenter. *Geografisk Orientering*, 42(2), 42-48.

Malm, R. H., and Elmoose Vad, K. (2017). Naturvidenskab er vigtigere end fjollede forsøg. *Dagbladet Politiken*.

2: The review strategy

Here I present the review strategy described above and the categorisation of articles shown.

The key words relevant for the research are geology, fieldwork, belonging, identity and higher education. The related search concepts are shown in table 1. The search source is the ERIC database: <https://eric.ed.gov/>.

Table 2. Search concepts for keywords.

| Search concept | | | | |
|----------------|-----------|-----------|----------|------------------|
| 1 | 2 | 3 | 4 | 5 |
| geology | fieldwork | belonging | identity | higher education |

| | | | | |
|---------------|-------------|--|--|------------|
| geoscience | field based | | | university |
| earth science | | | | college |

The search concepts turned out to create too many results e.g. “geology OR geoscience OR earth science AND “higher education” OR university OR college” created 29,758 journal articles where “geology AND “higher education” created 588. I therefore returned to using the original single keywords. I tried to find a useful combination of keywords shown in table 2. From this, I evaluated that search no. 2 provided the best results in terms of relevance.

Table 3. The literature searches in ERIC with various keywords, the search setting and number of peer reviewed papers.

| | Key words | Specific setting | Total |
|---|---|---|--------------|
| 1 | geology, fieldwork, identity, higher education | Publication type: Journal Articles Educational level: Higher Education | 2801 |
| 2 | geology, fieldwork, higher education | Publication type: Journal Articles Educational level: Higher Education | 241 |
| 3 | identity AND higher education | Publication type: Journal Articles Educational level: Higher Education | 2552 |
| 4 | geology AND fieldwork AND “higher education” | Publication type: Journal Articles | 2 |
| 5 | geology AND fieldwork AND identity AND higher education | Publication type: Journal Articles | 0 |
| 6 | geology AND “higher education” | Publication type: Journal Articles Educational level: Higher Education | 588 |
| 7 | geology AND belonging | Publication type: Journal Articles | 0 |
| 8 | geology AND fieldwork | Publication type: Journal Articles | 13 |

The 241 articles were sorted in four categories: geology, geography, biology and other i.e. clinical fieldwork, cross cultural fieldwork and animal behaviour fieldwork, see table 3. 24 articles are placed within the category ‘geology’ and these articles were categorised in five themes:

- Diversity and gender – 2 articles
- Laboratory and technology – 3 articles
- University pedagogy – 4 articles
- Learning subject matter – 6 articles
- Fieldwork – 9 articles

Sixteen of these papers are published in the Journal of Geoscience Education and four are published in the Journal of Geography in Higher Education.

Table 4. Results of search no. 2 divided in four categories.

| Fieldwork in geology Total: 24 | | Fieldwork in geography Total: 37 |
|--|---|---|
| Examples of themes | GIS gender geologic models student attitudes earth systems eye tracking spatial visualisation nature of science understanding problem solving case based teaching exam motivation hydrology sandbox inquiry sense of place spatial reasoning economic geology conceptual model development field notes | assessment of the quality review of papers emotional Geographies relationship between teaching and research student Attitudes playful and Multi-Sensory Fieldwork enabling Remote Access to Fieldwork remote locations the Bologna Declaration citizenship education Bring Your Own Device (BYOD) in a fieldwork context geographic affiliation and sense of place normative whiteness Geographers and the Scholarship of Teaching and Learning Promoting and Assessing "Deep Learning" |
| Fieldwork in biology Total: 7 | | Other types of fieldwork Total: 173 |
| Examples of themes | students' Perception of Biology Fieldwork the Future of Bioscience Fieldwork in UK biodiversity students' peer assessment | cultural studies technology disabilities environmental science transferable skills policy teacher education music education anthropology laboratory gender simulations assessment clinical fieldwork cross cultural fieldwork animal behaviour fieldwork |

Article I

Doing geoscience: negotiations of science identity among University students when learning in the field

Lene Møller Madsen and Rie Hjørnegaard Malm

Book chapter under review for L. Archer and H. T. Holmegaard (Eds.) Science Identities - Theory, method and research. Springer.

Article II

Students' negotiations of belonging in geoscience: experiences of faculty-student interactions when entering university

Rie Hjørnegaard Malm, Lene Møller Madsen and Anders Mattias Lundmark



Published in Journal of Geography in Higher Education (2020)

Article III

Geological reasoning and Identity: exploring links between fieldwork and students' identity work

Rie Hjørnegaard Malm



Under review for Journal of Geoscience Education

Article IV

Geoscience for the future: are we ready to change Geoscience education in Norway?

Rie Hjørnegaard Malm, Anders Mattias Lundmark and Bjarte Hannisdal

To be submitted