Developing an Arctic Geology course: exploring the role of fieldwork in a challenging learning space

Rie Hjørnegaard Malm  
Department of Geosciences, University of Oslo  
r.h.malm@geo.uio.no

Lena Häkansson  
Department of Arctic Geology, The University Centre in Svalbard  
lena.hakansson@unis.no

Abstract
This article explores how students are positioned to participate in an Arctic Geology course, what challenges students meet and how developing the course might mitigate these. By analysing the decisions made in the course design, we show how the course creates specific spaces for student learning and specifically how the course challenges the students’ understanding of fieldwork practice. Fieldwork is an important arena for learning key concepts in geology, for the initiation into the community of practice and the disciplinary identity. The study therefore analyses the pre-, syn- and post-fieldwork components and uses the framework of Threshold Concepts to discuss the students’ experiences. The independent data collection in the field stands out as challenging for students because they are encouraged to postpone interpretations to the post-fieldwork projects. This analysis informs the discussion on the course development process and we present strategies for developing the course further. The complex interplay between the intention of the course, the function of each component and the students’ space for participating are all considered. The article thereby contributes with a detailed case study of the teaching development process within higher education.

Keywords  
higher education, threshold concepts, course design, earth science education

Introduction
In this article, we analyse an Arctic Geology course with the aim of exploring how the course design influences the students’ participation in the course and how this can inform the development of the course. The case study uses five weeks of observations of the course, feedback from students, and teacher’s reflection notes as empirical material to analyse the course. The focus is placed on understanding the spaces and barriers created for students’ possibilities for participating in the course created by the course design. Together the detailed account of the intentions behind the course design and the students’ experiences provides a valuable knowledge base for developing the course.

The researched course takes place at The University Centre in Svalbard (UNIS), which offers specialised courses in natural science and engineering with focus on the Arctic region (Misund et al., 2017; UNIS, 2014). The course includes a field research experience with...
emphasis on active student participation and demands independent decision-making in the field. The course comprises three main components: 1) pre-field introduction to theory and preparation for data collection, 2) the fieldwork with data collection, and 3) the post-field data processing leading up to a presentation of a small research project based on the field data.

In geology, fieldwork has traditionally been integrated in the scientific research process and geologists use a narrative form of logic to explain their observations in the field and thereby reconstruct past environments (Frodeman, 1995; Dodick et al., 2009). In higher education, fieldwork is integrated in geological courses in order to provide students with the opportunity to engage in the natural environment, learn to make observations, collect data, apply critical reasoning and construct interpretations (King, 2008; Mogk & Goodwin, 2012; Malm et al., 2020). The fieldwork practice is furthermore important when learning to act in accordance with the scientific rules of the discipline and is part of defining the geological identity (Raab & Frodeman, 2002; Malm, 2020). In the field, geologists gather scientific data and construct preliminary interpretations and hypotheses simultaneous to the data collection process. However, a problem may arise if the data collection is too heavily influenced by hypotheses formed in the field (Cleland, 2001), i.e. the data is collected to prove or disprove a particular hypothesis may be too narrow in scope to address other hypotheses formed after the fieldwork. Therefore, teachers are often attentive to teaching students the importance of separating observation from interpretation. The researched course aims to address this challenge by teaching the students to collect data in an ‘open’ way, which allows multiple hypotheses and research questions to be addressed. We have identified this learning experience as a learning threshold according to the Threshold Concept Framework (Meyer & Land, 2003, 2005); in all disciplines there are certain concepts and learning experiences which could be likened to passing through a portal where the learner encounters new conceptual territory on the other side. Things not previously perceived are brought into view on the other side of this conceptual gateway but it is often a struggle to get through. Before the new way of seeing has come fully into view, the learner finds herself in a transitional space which has been referred to as a state of liminality (Meyer & Land, 2003, 2005). This is a state of transformation but here the learner also risks feeling suspended and stuck.

In this study, we explore the course design and inform the analysis of students’ experiences by using the framework of Threshold Concepts. The course exposes students to new learning situations by creating a new role for fieldwork in the course. The students will in addition meet an extreme environment in the Arctic, which entails uncertainty in planning due to unpredictable weather and possibilities of polar bears encounters. In this study, we explore the students’ challenges when learning and engaging in the field and discuss possible pathways for developing the course to mitigate the students’ challenges. With this, we present a detailed case study of teaching development within higher education in Norway.

Method

Case study of an Arctic Geology course

The researched course is the master and PhD course, Arctic Glaciers and Landscapes (10 ECTS). The course was designed and taught by the second author and ran for the first time during five weeks in the summer of 2017. In total three teachers taught the course and in the field, one additional field supervisor and one safety responsible joined the team. The course had a diverse student intake and enrolled students in geology, geography, geophysics and
mathematics. In both 2017 and 2018, the student number was 17, with 15 master and 2 PhD students from Norwegian and international master and PhD programmes.

Empirical material

The empirical material includes five weeks of ethnographic observations of the course and one group interview with four students, conducted by the first author. Reflexive notes written across two years by the course coordinator and second author are included in order to track the development process. Additionally, are insights from two types of course evaluations used (Table 1). The observations of the course include observations of lectures, student presentations, students’ group work, the teachers planning of the fieldwork, the fieldwork and the following data processing. The observations in the field focused on one group of students: how they solved problems, communicated, used previous knowledge and collected data. Thus, the observations aimed at documenting the lived experiences of the students during fieldwork (Feig, 2010; Walford, 2009; Emerson et al., 2011; Malm, 2020). The group interview was held after the fieldwork, lasted about one hour and was transcribed verbatim. The students were informed that participation was voluntary, personal information would not be shared and participating would not influence their grades or course assessment. The course was evaluated in a structured group discussion after the exam, recorded by the course coordinator, and in a standard evaluation questionnaire designed and carried out by the study administration UNIS.

Table 1. Overview of empirical material and use in the analysis

| Empirical material          | Description                                                                 | Analysis                                                                                     |
|----------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Ethnographic observations  | The observations were carried out across five weeks. This included the teaching before the students entered the field, with lectures, group exercises on campus and preparations for the fieldwork off campus. The observer joined the students and teachers for a six-day field cruise, where the ship provided accommodation, meals and transport between sites. In the field, the observer followed one group of students, when they were ashore and working. After returning from the field, the observations focused on the students’ data processing and group work on campus. | The observer recorded field notes throughout the five weeks. The field notes are the basis for understanding the connection between the course components and the students’ challenges in the course. The field notes were also used to choose themes for the group interview. In the presentation of the findings are quotes from the field notes used. |
| Group interview            | The observed group participated in a group interview, which took place after the fieldwork while the students were working on their projects. Here the observer asked questions about the general experiences in the field and the course. In particular, the interview unfolded specific episodes from the fieldwork in order to come closer to the student’s thoughts behind their actions in the field. | The interview was part of the thematic analysis with the aim of understanding the connections between course components. The interview was afterwards analysed with focus on the students’ participation in the field and their challenges. Selected transcripts from the interview are presented in the findings. |
| Structured oral evaluation | After the exam, the group of students and teachers discussed the course. The students were prompted to provide the teachers with feedback on the outline of the course, their learning process, challenges and ideas for developing the course. The course responsible wrote summary notes. | In the analytical process the notes have been used to validated and understand the results of the standardised evaluation questionnaire. |
Empirical material Description Analysis

Evaluation questionnaire Students answered the standard evaluation questionnaire designed by UNIS after the end of the course. The survey includes both closed likert scale questions and open-ended questions. Results from the questionnaire were included in the thematic analysis of the course components. In the presentation of the findings are citations from the questionnaire used.

Analytical strategy

The empirical material was analysed in three steps 1) through thematic analysis, 2) based on reflexive notes and 3) focusing on students’ challenges initially. The first author mapped the course components through a thematic analysis of field notes from the observations, the interview transcript and results from the evaluations (Braun & Clarke, 2006). This first step included a focus on how the students experienced and evaluated the course. This analysis revealed how the different components in the course design were interconnected and indicated a link to some of the challenges the students experienced. In the next step, the analysis was validated, supplemented and developed in cooperation with the second author’s notes. The reflexive notes document the ideas and intentions behind the design and were used to understand the function of each component. Understanding the intentions of the course design created a framework to understand the students’ experiences in the course. In the last step, the students’ challenges were analysed with inspiration from the framework of Threshold Concepts in order to explore the students’ experiences. The next analytical step connected the analysis of the students’ participation in the course with the analyses of the course design. These analytical steps ensured that both the course design and the students’ challenges were explored and could function as analytical input to developing the course. In order to show how the different empirical material informs the analysis this study use quotes from the group interview, field notes from observations and citations from the student evaluation questionnaire in the presentation of the findings.

Findings

Course component: Pre-field learning activities

The pre-field teaching focuses on using the strengths of the student diversity and on developing a shared scientific language. The students’ research interests and background knowledge are mapped with a questionnaire before arriving at UNIS. Based on this, each student is assigned two research papers and prepares a 12-minute oral presentation about the research, including two questions to the class. After the presentations, each student receives individual feedback on their performance. The observations of the students’ presentations show that this course element provides a series of opportunities for making connections between the students’ backgrounds and important learning goals.

Between the presentations, the teachers comment on general things, e.g. the importance of working across the disciplines. This is especially prominent after a presentation done by a student with a background in physics. The student questioned the model that researchers developed in the research article and pointed out the weaknesses from a physics perspective. (Field notes, observation of teaching)
The discussions offer a space to make connections across the scientific field and activating the students’ backgrounds prompts interdisciplinary discussions. Analyses of the questionnaire shows that this approach created a reflective learning environment:

Even though it [the course] may not have been directly related to my own research interests, I think the course helped to shape me as a natural scientist. Both by opening my eyes for this field of study and by including so much practice in working in groups. (Student, questionnaire)

Working together with people from different countries with different academic backgrounds is highly advantageous and spices up debates. (Student, questionnaire)

The pre-field teaching and the teachers’ communication establishes a reflexive learning environment by approaching the students with curiosity, framing discussions and providing feedback. The focus on creating a safe learning environment is reflected in the students’ evaluation of the course:

We were encouraged to ask (more) questions pretty much every step along the way. Feedback was always personal, adequate and to the point. (Student, questionnaire)

Everyone was good at communicating and teaching, and made it comfortable to ask questions. (Student, questionnaire)

The first week includes lectures on the theoretical framework, classification and terminology with the aim to create a shared scientific knowledge base and language. The teaching includes active sessions with classifying landscapes, describing sediments and exercises on collecting data. The last preparation exercise is carried out outside near campus. Through this two-step training the students build confidence in using the instruments, first through practicing in a warm and safe indoor environment and then in a controlled outdoor environment.

In the second week of the course, the students work in groups on case studies from Svalbard. The students work with a dataset from a specific glacial area and present their findings. As part of the exercise, the students classify the different stages of the glacier as it evolves through time and in the future.

The question of predicting the future of the glacier works well in the way it makes the students reflect. The students use the classifications lectures actively. Very good follow-up questions from the lectures: do we know anything about the subglacial landforms? What would happen if there were a rise in air temperature? (Field notes, observation of teaching)

The pre-field teaching addresses important elements in preparing the students for the fieldwork and the independent research project, including creating a safe and inclusive learning environment through clear communication and repeatedly explaining the intentions of the course and the upcoming fieldwork.

Course component: The fieldwork
The fieldwork is carried out during a six-day cruise. The ship provides accommodation, all meals and transport between sites at night. Students work in fixed groups of four to five students. Each day follows the same schedule: landing at a field site with workstations focusing on data collection techniques and in the evening students work on board the ship. Four sites with different types of glaciers are visited. Each student group spends half a day on each
workstation where they collect field data with assigned techniques. A field supervisor is responsible for and present at each workstation. The students dispose of their own time, decide what data to collect and are encouraged to collect data without interpretations. In the afternoon, everybody meets at the beach for transportation back to the ship, where dinner is ready. After dinner, the students organise samples, work on field notes and discuss the events of the day; what went well, any problems encountered and possible changes for the following day.

In the following, we present a situation where students are researching the deglaciation history of an area. The group has decided to explore the processes that formed a ridge in the field area and decide to dig into the sediments to interpret the internal structures.

Field notes, observation of Andrea, Kim and Noah: Kim starts to dig out a profile halfway up the ridge. Andrea arrives and asks, “So what is the plan here? Should I go up, down, to the side?” Kim asks back, “What do you think?” They decide to work on two different areas. The more they dig the more structures they see. After a while, the two students discuss how they should continue: they have the choice to continue on the first profile or make the second one better. They realise that it takes too much time to dig out both. They cannot decide and Kim continues to work. Andrea (rolls eyes at me) whispers, “It’s all the same!” in an irritated voice. It seems they are both frustrated. Kim keeps digging. Andrea sits down on the slope. Noah arrives and asks what the plan is. Andrea: “I am very confused. I cannot assess what to do”. Noah suggests digging deeper on the first profile, making the angle steeper. Kim replies, standing in the second profile, “Don’t dig too much Noah”, thus implying not to waste too much time. Andrea and Kim start to discuss their strategy. Kim says that the profile is too small and perhaps they should have focused on one area. Kim is not sure how much they can interpret from the profiles they have dug out thus far. Noah keeps working on the first profile and does not take part in the discussion. After a while, Noah says, “Now it looks really cool”. There is now a 3D profile in the ridge, reaching down to what looks like a sediment layer with coral sands. Kim and Andrea look at the profile and the tense atmosphere disappears. The students are excited about the new discovery. Kim says, “It was good that you just kept digging (laughing)”. Andrea replies, “Yes, that you kept up the motivation” (smiling at me). Kim laughs and agrees. Andrea moves down the slope and returns with snacks. They celebrate the discovery with chocolate. (Based on field notes, observation of fieldwork)

The episode illustrates some of the challenges the students encounter when they plan their own data collection. The strategy to dig out two different profiles is sound, since they want to observe structures across the ridge. However, during the work they become uncertain about their plan as it turns out to be more difficult and time consuming than they thought. This situation is addressed in the following interview and the discussion starts with an open question on how the group made decisions during the specific fieldwork at the ridge. After a while, the interviewer turns to the ‘digging strategy’, with a specific question to Noah: why did you keep digging?

Noah: The thing was. We had the first profile, the one we cleaned, it was angular. It was not straight down and then when we looked at the slope, well, if there are slope processes in this area, it could be quite tricky. So, I didn’t actually dig deeper but just made it more, like straight down, and then that makes quite a big effect, if you just change that.

Andrea: I think, also, at least for me, I was not convinced that we were not in slope processes and that we would see a change further in. I was giving up hope that we would see anything more remarkable than what we saw. I think you just had a bit more patience with the digging.

Kim: Yes, I was also convinced that it was slope processes, but what to do? Like, you are not going to dig for hours just to prove that it is not slope processes. It already felt like we were halfway through our time.
Noah: Yes, that is true, it was quite late.

Interviewer: This angle of the profile, I remember that you discussed that in the beginning.

Noah: Yes, in the beginning I said we should dig this way (showing the angle with his hands) because it would save us a lot of work (all laughs) but then I realise later on that, yes (laughs)/

(...) And Andrea: I know that I said to you, Kim, oh maybe we need some more theory about how slope processes look to assess this. I felt very, like, left alone. Like, I can’t assess this, can’t make any sense of this, and you were like, “yeah well, it is hard for people, like, I don’t know if [the teachers] know either, and you don’t know how the slope looks when you dig into it”. And I was like, “Yeah okay that is probably true” but I think I was really frustrated then.

Noah: I didn’t realise that you guys were so frustrated (smiles at them).

Andrea: Well . . . (pause).

Kim: We spent a lot of time digging before we found that beach stuff.

Andrea: But in the end, we got a good section.

(Students, group interview)

The students individually made ongoing evaluations of their observations and they were all insecure about what they saw and what it meant: did they really see the original internal structures or was it just a disturbed surface (what the students refer to as slope processes)? When they found the coral sand, they grew more confident in seeing internal structures, which would allow them to interpret the processes that formed the ridge. In the field, the students discuss strategy, theory, time, techniques and aim of the data collection. They also discuss with the teachers during the fieldwork and here they can bounce ideas but never get straight answers or conclusions. The conversation in the interview highlights that the students are aware that the teachers are new to the area. In fact, it is the teachers’ first time at the locality, which becomes a factor in the experienced ‘authenticity’ of the fieldwork. The students can get help to describe what they see but not to do interpretations. The group constantly evaluates strategies and develops a more refined approach to the data collection as they gain more experience during the week of fieldwork. However, this independence is also challenging, as Andrea says: ‘I felt very, like, left alone,’ suggesting that the students are in a state of liminality, where they are experiencing uncertainty and a feeling of being stuck (Meyer & Land, 2003; Land et al., 2014). The organisation and data collection turns out to be a common challenge among the other groups too; this becomes evident in the evening discussions on the ship. The openness of the data collection and the fact that students need to make decisions in the field emerge as a theme in the empirical material. Thus, we identified this learning experience as a learning threshold (Meyer & Land, 2003, 2005).

Course component: Post-field data processing
After the fieldwork, the students spend two weeks on processing and compiling the results. All students worked on all data collection techniques and now need to organise and share the data. In a semi-structured session, the students form new groups based on interest,
they select data and formulate research questions for their independent research project. The groups attend daily supervision meetings and the teachers provide half-day workshops to support the data processing. In this process, one group discovers a mistake in a dataset:

The group wants to use a selection of geophysical data but have problems with the data processing. They find out that the group collecting the data has not recorded the GPS points for the data correctly. The group needs to find a new dataset for their project. (Based on field notes, observations of teaching)

The group ends up defining a completely different research project using other data. The example illustrates how all the students are dependent on each other and in particular collecting data that others can use.

The exam is organised as a full-day seminar with poster presentations of the research projects and individual follow-up questions by an external examiner. The examiner evaluates the posters and the individual performance and grades the students.

Synthesis

The overall analysis of the course shows that there is a good alignment between the course components (Biggs & Tang, 2011). The students gained insights into the complex process of collecting data and valued this interdisciplinary learning experience. However, the analysis also identified challenges related to the openness of the data collection in this course, which we identify as a learning threshold. This also becomes visible in the observations of the students interactions with the teachers, exemplified here where the teacher encourages student autonomy.

During the first few days in the field the students collect the data without asking too many questions, but as they progress into the fieldwork, they ask more questions and insist on getting explanations from the teachers. I sense that the students become frustrated when the teachers reply, “What do you think?” to their questions and they require a greater justification of why there is no space to make interpretations in the field. (Based on field notes, observation of fieldwork)

From the evaluations, we see that there has been an internal discussion among the students about the length of the fieldwork and the number of sites visited. The ‘discussion’ also reveals students’ perceptions of how to collect data and conduct research in the field.

Some students think there should be fewer sites visited during fieldwork. I agree with them from a research perspective. If we had read more site-specific literature, and if we had more time to do research at (for example) three sites, we would have had a more thorough understanding (and data set) of these sites. (Student, questionnaire)

(….) the course bears the potential of assigning certain sites to students before the field trip so they could propose hypotheses in advance and carry out the data sampling to support or falsify these preliminary hypotheses. (Student, questionnaire)

The students refer to doing ‘research’ to get a more ‘thorough understanding of data sets’ and ‘falsify these preliminary hypotheses’. These terms make sense in a context where you design a research project, plan the data collection and use the data in your research project. The role of interpretations in the field is downplayed in this course design and that challenges the students’ understanding of fieldwork and their learning process.
Discussion

The empirical material, as well as student evaluations, indicate that the students gained a valuable learning experience as the course provided a space for both experiencing and reflecting on fieldwork and data collection in geology. The ethnographic material enabled further insights into the students’ challenges related to the openness of the data collection and show how this can be understood as a learning threshold. This finding prompts discussion on how the course design challenges our ideas about fieldwork practice in educational settings. The recommendations for integrating fieldwork in the curriculum emphasises the alignment between the preparation, the field and the follow-up phases (DeWitt & Storksdieck, 2008; Remmen & Frøyland, 2014, 2015; Midtaune et al., 2018). In this course, there is a strong alignment between these components, and every component in the course has an intention linked to the overall design of the course. The preparation for the fieldwork is thorough; however, some students find the fieldwork challenging, as illustrated by one student expressing that they felt ‘left alone’ at times. Our analysis points out that the students encounter a difficult learning threshold and here they experience being suspended in a liminal space during fieldwork (Land et al., 2014). This occurs even with the thorough preparations, follow-up discussions and supervision during the fieldwork. On this basis, we raise the question of whether the course should be developed in its current format or redesigned: do the challenges that students meet lead to learning, or are they too overwhelming and hinder learning? We suggest that the students’ challenges are linked either to the course design or to encountering a difficult learning threshold. In the course, the students not only control the data collection independently, they also depend on this data for the post-fieldwork projects. This course design does create a new and challenging learning situation, in addition to taking place in an unpredictable Arctic environment. We know that when taking learners into new situations, they are likely to experience cognitive dissonance (McFalls & Cobb-Roberts, 2001), which can be part of the experienced ‘suspended and stuck’ feeling in the liminal space. The cognitive dissonance theory proposes that humans strive for internal psychological consistency in order to function in the world (Festinger, 1957). A person who experiences internal inconsistency tends to become uncomfortable. This becomes a motivation to reduce cognitive dissonance, either by adding new parts to the cognition causing the dissonance, or by actively avoiding the contradictory information. In line with this, it could be argued that the course needs to be redesigned to reduce uncertainty and create a more predictable learning space. One strategy could be to redesign the fieldwork by to make it more predictable through giving students more instructions on data collection.

An alternative pathway for developing the course entails an appreciation for the existing course design and acknowledging that the course addresses important learning objectives i.e. how to collect data in the field. The proposed adjustment would then instead be to reduce the experienced challenges (or dissonance) by applying further scaffolding (Wass et al., 2011). The course already integrates several elements in the three course components aimed at supporting the students’ learning processes, e.g. the two-step fieldwork preparation, the debriefing sessions on board the boat, and daily supervision meetings in the post-fieldwork projects. We argue that the course design offers a unique learning experience, but the intentions need to be communicated more clearly to the students as they engage in a challenging learning environment. An additional layer of metacommunication about the intentions of the course components could supplement these scaffolding structures. Metacommunication might not be enough to mitigate cognitive dissonance, however creating awareness of conditions for the learning process might help students to better deal with the challenges related to the openness of the data collection. McFalls and Cobb-Roberts (2001) suggest adding
knowledge about and discussions on cognitive dissonance in courses as a way of using the concepts to make students aware of the possible resistance or dissonance created in the learning processes. Likewise, various scaffolding efforts can support students learning processes (Wass et al., 2011). In the case of the studied course, the course advisor chose to keep the course design and add this additional layer of metacommunication as a scaffolding element, along with a reflexive element that includes discussions about learning, thresholds and dissonance among students and teachers. The decision is based on the analysis that the students meet a learning threshold but are able to get through the gateway and experience a transformative learning process (Land et al., 2014). The analysis of the student evaluations points to the same conclusion, illustrated by this student explaining that the course was “challenging at times, but it all worked out and it made us think critically about the data we did collect” (Student, questionnaire).

The analysis of the course shows how a specific learning threshold in connection to fieldwork in geology can prompt questions related to both student learning and the course design. The discussion of the development process shows that reflections on student learning, students’ possibilities for participating, evaluations and an in-depth analysis of the course design are important when informing the development process. We argue that there is a need for systematic analytical approaches and theoretical considerations as well as disciplinary knowledge when conducting course development in higher education.

Concluding remarks
In this article, we have presented and discussed the case of an Arctic Geology course. We have explored how students are positioned to participate in the course, what challenges they meet and how we might understand these challenges. Through analysis of a rich empirical material, the study shows the spaces and barriers created for students’ possibilities for participating in the course and especially in the field. On this basis it was possible to explicitly address some of the most complex components and decisions in the course design when developing the course. The analysis shows that the course applies a variety of scaffolding elements that effectively support student learning. However, the course design challenges the role of fieldwork and thereby the students’ participation. Therefore the course is further developed in order to support the students’ learning process by adding metacommunication and discussions about learning, thresholds and cognitive dissonance. The article contributes with a detailed case study of a course development process within higher education.

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