KØBENHAVNS UNIVERSITET
INSTITUT FOR NATURFAGENES DIDAKTIK

The ice algae Ancylonema as icebreakers

A case study on how the international Deep Purple Research Project can create meaningful outreach in Greenland

Caroline Woergaard Gram & Dan Johan Kristensen

Speciale – Biologi

Vejleder: Marianne Achiam
Co-vejleder: Alexandre Anesio

14. September 2023

IND's studenterserie nr. 114, 2023

INSTITUT FOR NATURFAGENES DIDAKTIK, www.ind.ku.dk
Alle publikationer fra IND er tilgængelige via hjemmesiden.

IND's studenterserie

87. Jesper Jul Jensen: Formativ evaluering og faglige samspil i almen studieforberedelse (2020)
88. Karen A. Voigt: Assessing Student Conceptions with Network Theory - Investigating Student Conceptions in the Force Concept Inventory Using MAMCR (2020)
89. Julie Hougaard Overgaard: Using virtual experiments as a preparation for large scale facility experiments (2020)
90. Maria Anagnostou: Trigonometry in upper secondary school context: identities and functions (2020)
91. Henry James Evans: How Do Different Framings Of Climate Change Affect Pro-environmental Behaviour? (2020)
92. Mette Jensen: Study and Research Paths in Discrete Mathematics (2020)
93. Jesper Hansen: Effekten og brugen af narrative læringsspil og simuleringer i gymnasiet (2020)
94. Mie Haumann Petersen: Bilingual student performance in the context of probability and statistics teaching in Danish High schools (2020)
95. Caroline Woergaard Gram: "Super Yeast" - The motivational potential of an inquiry-based experimental exercise (2021)
96. Lone Brun Jakobsen: Kan man hjælpe elevers forståelse af naturvidenskab ved at lade dem formulere sig om et naturvidenskabeligt emne i et andet fag? (2021)
97. Maibritt Oksen og Morten Kjøller Hegelund: Styrkelse af motivation gennem Webinar og Green Screen (2021)
98. Søren Bystrup Jacobsen: Peer feedback: Fra modstand til mestring? (2021)
99. Bente Guldbrandsen: Er der nogen, som har spurgt en fysiklærer? (2021)
100. Iben Vernegren Christensen: Bingoplader i kemiundervisningen – en metode til styrkelse af den faglige samtale? (2021)
101. Claus Axel Frimann Kristinson Bang: Probability, Combinatorics, and Lesson Study in Danish High School (2021)
102. Derya Diana Cosan: A Diagnostic Test for Danish Middle School Arithmetics (2021)
103. Kasper Rytter Falster Dethlefsen: Formativt potentiale og udbytte i Structured Assessment Dialogue (2021)
104. Nicole Jonasen: A diagnostic study on functions (2021)
105. Trine Nørgaard Christensen: Organisatorisk læring på teknisk eux (2021)
106. Simon Funch: Åben Skole som indgang til tværfagligt samarbejde (2022)
107. Hans-Christian Borggreen Keller: Stem som interdisciplinær undervisningsform (2022)
108. Marie-Louise Krarup, Jakob Holm Jakobsen, Michelle Kyk & Malene Hermann Jensen: Implementering af STEM i grundskolen (2022)
109. Anja Rousing Lauridsen & Jonas Traczyk Jensen: Grundskoleelevers oplevelse af SSI-undervisning i en STEM-kontekst. (2022)
110. Aurora Olden Aglen: Danish upper secondary students' apprehensions of the equal sign (2023)
111. Metine Rahbek Tarp & Nicolaj Pape Frantzen: Machine Learning i gymnasiet (2023)
112. Jonas Uglebjerg: Independence in Secondary Probability and Statistics: Content Analysis and Task Design (2023)
113. Hans Lindebjerg Legard: Stopmotion som redskab for konceptuel læring. (2023)
114. **Caroline Woergaard Gram & Dan Johan Kristensen: The ice algae Ancylonema as icebreakers: A case study on how the international Deep Purple Research Project can create meaningful outreach in Greenland. (2023)**

IND's studenterserie *omfatter kandidatspecialer, bachelorprojekter og masterafhandlinger skrevet ved eller i tilknytning til Institut for Naturfagenes Didaktik. Disse drejer sig ofte om uddannelsesfaglige problemstillinger, der har interesse også uden for universitetets mure. De publiceres derfor i elektronisk form, naturligvis under forudsætning af samtykke fra forfatterne. Det er tale om studenterarbejder, og ikke endelige forskningspublikationer.*
Se hele serien på: www.ind.ku.dk/publikationer/studenterserien/

UNIVERSITY OF COPENHAGEN

DEPARTMENT OF SCIENCE EDUCATION

The ice algae *Ancylonema* as icebreakers

A case study on how the international Deep Purple Research Project can create meaningful outreach in Greenland

Master's thesis by

Caroline Woergaard Gram & Dan Johan Kristensen

Supervisor: Marianne Achiam

Co-supervisor: Alexandre Anesio

Department of Science Education

Submitted on 14th of September 2023

Abstract

Greenland is a 'hot-spot' for international research. However, the knowledge produced from the research activities taking place in Greenland does not reach Greenlandic citizens. There is a need for change in the external researchers' communication approach, making their research and knowledge more accessible to Greenlandic citizens and society. In this study, we explored the potential of dialogue-based science communication as a way for international researchers to communicate their research to Greenlandic citizens. The study was conducted as a case study focusing on the international research team of the Deep Purple Research Project, which annually conducts fieldwork in Greenland, investigating the biologically induced darkening of the Greenlandic Ice Sheet by the ice-algae *Ancylonema* sp. Didactic transposition theory was applied as a tool to establish the scholarly knowledge, and we investigated how the scholarly knowledge could be embedded in an interactive installation. The installation had two objectives: communicating the research-based knowledge of the Deep Purple Research Project and engaging Greenlandic citizens in dialogue. Between January and April 2023, we were based in the community of Sisimiut, Greenland, and arranged three science communication events, both at the local upper secondary school (GUX) and as part of the Ilisamasat Science Festival. 25 participants took part in the installation. Data was collected using participant observations and observations were analysed using thematic analysis. Our findings indicate that the format of an interactive dialogue-based installation allowed for varied forms of engagement and that both the participants' and the scientific perspective were represented in the communication taking place within the installation. We found that images supported dialogue by communicating the scholarly knowledge and by bringing forward participants' perspectives. Furthermore, we found that non-verbal communication and the social aspects of communication were important aspects to consider. This thesis argues that meaningful communication is designed for the local context and contributes to existing communication networks, infrastructure, and initiatives made by local actors and institutions in Greenland.

Acknowledgements

This study would have not been possible without the help and support from a lot of people to whom we would like to express our deepest appreciation. A very special thanks to the citizens of Sisimiut and the Kalaallit Illuutaat who generously shared their perspectives with us and taught us a great deal about Ice algae, Ice, Greenland, Kalaallisut, science communication, the environment, Denmark, soul travels, family and much more which we would never have been able to understand from reading academic articles. Thank you for your contributions. We would also like to thank the citizens of Sisimiut for welcoming us into their home and their community.

Marianne Achiam for the great supervision, support and guidance when we entered and explored unknown disciplinary territory. Thank you for believing in us and our ideas and helping us realise them. Also, this project would not have been possible without the great researchers of the Deep Purple Research Project. We greatly appreciate your contributions both during the workshop and over coffee, your contributions are an essential part of this study. We would like to express a deep appreciation for our co-supervisor Alexandre Anesio for being open, excited and supportive towards our ideas and the project, for including us and inviting us to both the scientific conference and `julefrokost´ and other events with the team!

Additionally, this endeavour would not have been possible without DTU Arctic and all the great people working and studying there. We are deeply grateful for being given the opportunity to live and work in Sisimiut for two months. A very special thanks to Casper Gundelund Jørgensen (Cgun) for making this possible, for taking care of us and for including us. Thanks to Steffen Ringsø Nielsen for accommodation, office space and the possibility to participate in the Ilisimasat Sisimiut Science Festival. Also, Tina Chapman for always being helpful when we needed something and for the strong coffee!

We would like to express a special thanks to Arnajaraq Støvlbæk, Greenland Institute of Natural Resources, Kangiate Illorsua and Arctic Hub for their valuable insights and advice. Also, we are great admirers of your work. Throughout the process of this study, we have been told how difficult it was to bring scientists in contact with Greenlandic citizens. However, it has been overwhelming how much support, help, advice, and interest we have received. We would like to express thanks to the people we have not mentioned here.

We would also like to mention our family and friends for always supporting us, we hope you will join us in travelling back to Greenland one day. Lastly, we would like to express gratitude to each other. For the things we have learned from each other. For the many discussions and the experiences shared. We would not have been able to do this without one another and we are grateful for our friendship.

Positionality

Caroline

Since I will be collecting and analysing the data of this qualitative research study, I recognize that I should be transparent on my research position and how it relates to my research study. In the following section, I will present my positionality. This study is the thesis of my master's degree in marine biology at the University of Copenhagen and is therefore situated within the institutional context of academia, with its specific formalities and practices which influence this study. Additionally, to being a master's student, I am a white cis-gendered, Danish woman. I grew up in Denmark and all my family is Danish. When I grew up, I did not know anything about Greenland, Inuit, or the history between Denmark and Greenland. The only connection I had to Greenland was a seal skin purse and figure given to me by my grandmother who is the only person in my family who has ever visited Greenland. In my experience, Greenlandic society and the relationship between Greenland and Denmark has never been a topic in my formal education, amongst my family or friends nor in the broader societal discourse in Denmark.

The first time I was taught about the colonial history of Denmark and Greenland was when I had a university course which introduced me to colonialism and coloniality, specifically within the context of Natural History Museum and natural science practice and community. During the course I was taught about decolonization, and I analysed a museum specimen using a decolonial framework. This course started many new reflections on my own positionality, scientific discipline, and practice. Following the course, I spent a semester in Greenland, and it was during my studies in Greenland, when I was part of local academic institutions and research stations, that I became aware of how separated the research community, primarily consisting of Danes and other Western researchers, was from Greenlandic society. When I started this project, I did not know whether I was the right person to conduct this study, considering being a Dane and a master's student, since I have limited insights and experience in being a researcher and I do not know how it is to be a Greenlandic citizen. I was also questioning whether I was going to repeat the same approaches I was trying to question. How would I avoid conducting fly in/fly out research? Throughout this study we have been seeking advice on how to approach our research in a respectful and meaningful way from different actors in Greenland.

Whilst conducting this study I was part of several different contexts in which different aspects of my positionality was influential in different ways. As part of the Deep Purple Research Team at Århus University, my disciplinary background was an important aspect of my positionality, which led to me becoming a part of the research project. However, in Greenland, my nationality as a Dane became a more important aspect of my positionality, which influenced how I approach people and how people related to me. According to Graugaard (2021), a researcher positionality in Greenland is always located in a field of multiple colonial

entanglements and when researching in the Arctic one cannot entirely avoid its coloniality, no matter which position(s) in the complex web of relations between colonizer and colonized one might find oneself (Graugaard, 2021). When I am in Greenland, I represent something more than myself, which I cannot describe in words, but I experienced that my presence, as a Dane, sometimes affected social situations and sometimes brought up frustration related to the relationship between Greenland and Denmark and painful memories e.g., being forcefully displaced by the Danish Government. It is very difficult to articulate and describe this invisible "dimension" to the social situations when being in Greenland. In my experience this "dimension" originates from colonialism and the existing coloniality within the relationship between Denmark and Greenland. When being in Greenland I hold several privileges as a Dane in Greenland. People speak Danish and translate for me since I do not speak Kalaallisut. All the supermarkets are identical to Danish supermarkets, the currency is the same, the television channels are Danish showing Danish news, weather, and programs. It is very clear how extensive the implementation of Danish culture has been and continues to be in Greenland and how little knowledge and interest there is in the Greenlandic perspective and people in Danish society. Furthermore, there is, in my experience, a divide between Danish and Greenlandic communities in Greenland. This divide is sometimes intangible and sometimes very visible e.g., in Nuuk there is a bar in which Danes primarily go and another bar in which Greenlandic people primarily frequent. This asymmetry between the influence of Danish culture and language in Greenland in contrast to the prevalence of Greenlandic culture and language in Denmark also became clear during science communication events since participants spoke Danish with us, but we were not able to speak Kalaallisut. It was very difficult to navigate in this whilst conducting field work and being in Greenland. Throughout this study, I have tried to reflect on my positionality continuously and articulate and discuss its influence on my experience of conducting research in Greenland and navigating the complexity of the colonial structures embedded in the relationship between Denmark and Greenland and in Arctic research. I hope this thesis can contribute to the ongoing change of research practice in Greenland and to reflections and discussions amongst researchers conducting field work in Greenland.

Dan

This study has results, which are likely impacted by my background, motivation, and beliefs. Therefore, I want to address my own researcher bias in the following positionality statement. I think an important part of this positionality statement is to describe my origins, my relationship with Greenland, and to explain why I became interested in doing this project.

I was born in Denmark as a white man, and it has been my home my whole life. My family have lived here for many generations, and I see myself privileged in many ways, such as being able to attend a university and having a supporting family for that decision. It is my understanding that this is not an opportunity everyone has around the world. It is also my understanding that our colonial history with Greenland have created tensions which can be difficult to understand or talk about, which is something that has also impacted this

project and myself. How this tension is manifested is a bit difficult to describe, but there is an odd feeling from knowing the colonial history, the oppression, and the improper actions of my home country. Perhaps because I feel like I represent that history in some way? Even more frightening, is that I could do the same mistakes, and that I have potential to reinforce bad old habits. Therefore, any criticism and advice are wholeheartedly welcomed, as I am probably unwillingly ignorant of some colonial aspects, despite a conscious effort to understand this.

Prior to this project, the only relationship I have had with Greenland is from the few courses I have been luckily able to attend trough the university program. At that time, I also didn't know much about Greenland nor about the livelihood of its citizens, nor was it a place of particular interest to me. Instead, it was my ambition to become a researcher in marine biology, to study the microbial life in the sea, and the cold adapted organisms was particularly fascinating. That is the odd way, which led me to spend time in Greenland. However, during my visit, the tensions between science and society became more visible, and exponentially more interesting. For me, the idea that there were issues with how scientific research has been conducted, was especially thought-provoking. How could simply doing science be a problem? (Turns out, there is a lot). I have had many interesting conversations about this with my co-author and people I met in Greenland. This also became my motivation for the project, and suddenly I found myself deeply interested in the interface of science and society, in dialogues, and the academic field of science communication.

Table of contents

Introduction

The Arctic is undergoing large social and environmental changes driven by climate change (Hansen & Ren, 2021b). Climate change makes the Arctic increasingly accessible, changing the economic development and the geopolitical situation of the region, resulting in an increasing interest globally (Hansen & Ren, 2021b). The global focus is also reflected in research taking place in Greenland (Hansen & Ren, 2021b) with an increased number of scientists conducting research in Greenland (Mercer et al., 2022). Greenland is the world's largest island with an Ice Sheet that covers appx. 80% of the entire country (Raikar, 2023).The Greenlandic Ice Sheet attracts many natural science researchers who wants to study and understand various aspects of it, such as retrieving ice core samples that contains information about the atmosphere from the past (Rasmussen et al., 2014) or the implications of the ice sheet's melting on global sea level rise (Cuffey & Marshall, 2000). However, the research outcome and results do not often reach the Greenlandic population (Kristensen, 2023) since external researchers publish the data, they have collected in Greenland, in international journals and communicate and debate their results outside of Greenland, thus reflecting a fly in/fly out research practice (Halkier, 2021). The local term 'fly in/fly out' or 'hit and run' research practice refers to international researchers, especially within the natural sciences, who only transit through local communities as they access remote locations (e.g., the Ice Sheet) (Mercer et al., 2022). There is a lack of communication within the 'fly in/fly out practices' in which international researchers spend a short time in local communities (Halkier, 2021; Mercer et al., 2022).

How the fly in / fly out research practice is connected to colonial history

The 'hit-and-run research' echoes a history of colonial exploitation in and of Indigenous communities and peoples in the Arctic (Graugaard, 2021). 'Hit and run' research describes a nonreciprocal process of knowledge production which benefits the incoming scientist who travels to Greenland for conducting field work but leaves again without Greenland benefitting from the research (Hauptmann, 2016) The 'fly in / fly out research practice have sometimes led to a mistrust of visiting international scientists (Mercer et al., 2022).

In the 19th century, there was a large international research interest in Greenland and research activities were often explicitly part of colonisation to legitimize colonisation e.g., extraction of natural resources (Kaalund, 2021). Furthermore, the communication of the research taking place in Greenland had the objective of positioning Denmark as a central actor in Arctic research within the international research network (Kaalund, 2021). The research communication was an important tool to influence national and international discussion on the Danish colonisation of Greenland, since science and exploration were used to legitimize the Danish colonisation of Greenland (Kaalund, 2021), thus systematically excluding Inuit by omitting, and diminishing their expertise and contributions (Kaalund, 2021). This systematically exclusion is referred to as 'epistemological violence' and created a 'epistemological hierarchy' in who decides how knowledge

should be produced and represented and used as a tool for upholding power over Greenland (Kaalund, 2021). Today, Greenland is an autonomous country with self-government within the Kingdom of Denmark (Statsministeriet, No date). Currently, historical changes are happening within the research institutions, practice, and infrastructure in Greenland.

Changes in the way research is practiced and communicated in Greenland

Naalakkersuisut, the Greenlandic Government, has recently published the first national research strategy in Greenland. The new research policy states that there will be investments to strengthen the Greenlandic research institutions and infrastructure, thereby strengthening the position of Greenland in Arctic research. According to Kaalund (2021), research policy is a central part of broader political movements and ambitions both on an international and national level. This means that the changes happening in the research institutions and infrastructures in Greenland are related to changes in the relationship between Denmark and Greenland and in the Arctic region (Hansen & Ren, 2021b; Kaalund, 2021). The new research policy be Naalakkersuisut (2022) marks a historic change since it highlights that international research, being conducted in Greenland, should include local and Indigenous knowledge, contribute to the development of Greenlandic society, and that international researchers' understanding of challenges and opportunities which serves the people of Greenland (Naalakkersuisut, 2022). With the new research strategy Naalakkersuisut (2022) defines for overarching goals for the new national research strategy:

1. *Research must be anchored in Greenland.*
2. *Research must support sustainable societal development.*
3. *Research results must be easily accessible to all.*
4. *Research efforts must be at an international level.*

There are several initiatives, institutions and organisations that are working towards realising the national research strategy goals (Mercer et al., 2022; Naalakkersuisut, 2022). These include the website Isaaffik.org which serves as a platform over the research activities taking place and for establishing collaborations (Isaaffik, 2023). The Arctic Hub aims to establish connections between international research and Greenlandic society through dissemination of research. The Greenland Research Council's funding criteria encourage researchers to include Greenlandic society and to inform, engage, and inspire citizens via a diverse range of science communication practices (Greenland Research Council, 2023). The first natural science degree in Greenland, SILA, is currently being developed, specifically designed to a Greenlandic context (Hauptmann et al., No date). In Kangerlussuaq a 'Science Service' is established to support researchers to conduct and disseminate their research to citizens (Destination Arctic Circle, 2023). Another initiative is the event 'Greenland Science Week' , a platform in which international researchers can share their research, arrange stakeholder meetings, and connect with the broader community through outreach events (Greenland Science Week, 2023). The new Ice Fjord Centre, Kangiata Illorsua, combines research, art, local and Indigenous knowledge to communicate about the Ice Fjord in a variety of formats incl. public lectures and conversation about natural science research (The Icefjord Centre, 2023). Several of these organisations and

initiatives are workings towards the goals of national research strategy by creating connections between researchers and Greenlandic society including establishing a dialogue between researchers and citizens of Greenland.

Dialogue-based science communication as a way of connecting researchers and local communities

In addition to the changes happening in Greenland, there is an overall change happening within the field of science communication, since the traditional power balance between institutions and individuals since individuals has limited opportunity for participation and influence in conversations about science issues, thus creating a need for improved practices of knowledge exchange where different types of expertise are acknowledged and valued (Berditchevskaia et al., 2017). There has been a paradigm shift within the field of science communication from the deficit model towards dialogue-based communication approaches to achieve this goal (Nisbet & Scheufele, 2009; Reincke et al., 2020). Dialogue-based science communication is highlighted as a useful communicative approach since it promotes a shared understanding scientists and non-scientists (Nisbet, 2018), improves public understanding and awareness of science (Van der Sanden & Meijman, 2008), establishes trust, builds relationships, and supports collective action (Nisbet, 2018). Despite the benefits of dialogue-based science communication, researchers do not often use a dialogic approach to communicate their research (Simis et al., 2016; Suldovsky, 2016). Scientists are usually not trained to effectively communicate their research-based knowledge outside an academic context (Jucan & Jucan, 2014). Furthermore, standard communication strategies applied amongst researchers are depersonalized and disconnected, therefore not meeting the requirements of a dialogue-based communication format (Houtman et al., 2021). Dialogue is still an emerging communication tool (Van der Sanden & Meijman, 2008), and there is a need for more experimentation with dialogue in inclusive communication formats (Canfield et al., 2020). Thus, there is a need for concrete cases of dialogue-based science communication, which applies experimental and innovative approaches, exploring new ways researchers and citizens can engage in dialogue (cf. Skjervedal, 2018 and Horst, 2011).

Scope of study

This study will explore how dialogue-based communication can be a tool to create connections between international researchers and Greenlandic citizens, investigating how external natural science research projects can contribute to Greenlandic society in accordance with the Greenland Research Strategy by Naalakkersuisut (2022). We will apply a practical approach by conducting a case study on how the international interdisciplinary research project, The Deep Purple Research Project, can communicate their research in a way which will be easily accessible for Greenlandic citizens, reflecting the third goal of the national research strategy: "*Research results must be easily accessible to all"* (Naalakkersuisut, 2022). The Deep Purple team has been conducting field work annually on the Greenlandic Ice Sheet since 2019 (Deep Purple Research Project, No date-c). The project communicates their research in outputs common to academic practice incl. peer reviews papers, lectures and in international conferences. They also communicate their research to the broader public e.g., in television and news, however many of these communication outputs are targeting the public of the countries in which the research project is situated within (Denmark and Germany) and thus does not reach Greenlandic citizens. In this way, the Deep Purple Research Project resembles the characterisation of fly in/fly out research practice. To experiment with how the Deep Purple Research Project can communicate their research in a way that will reach and engage Greenlandic citizens, this study will apply didactic transposition theory to investigate the research-based knowledge and practice of the Deep Purple Research Project. On the basis of our investigation, we will transform the biological knowledge of the Deep Purple Project into a dialogue-based science communication design which will be engaging for Greenlandic citizens.

We will then explore and describe what happens in the dialogue-based communication of the Deep Purple knowledge with Greenlandic citizens and propose a set of recommendations based on our experience. The designed science communication product will be applied in Greenland and the results will be used to formulate a set of recommendations, that serve to advise international researchers within the natural science who wants to make meaningful science communication in a Greenlandic context.

Research Questions

We will investigate how the research results of the Deep Purple Research Project can be made accessible to Greenlandic citizens by investigating the research question:

RQ1: *How can the Deep Purple research project create meaningful outreach for Greenlandic citizens?*

To answer this research question, our study will be guided by investigating the following sub-research questions:

RQ2: *What aspects of the scholarly knowledge of the Deep Purple Research Project are relevant for citizens of Greenland?*

RQ3: *How can the relevant aspects of the scholarly knowledge of the Deep Purple Research be embodied in an engaging science communication design?*

Research objectives

This study aims to:

- Gain an in-depth understanding of the scholarly knowledge of the Deep Purple Research Project and explore how physical objects can be applied to communicate this knowledge.
- To design an engaging science communication product which has the objective of communicating the scholarly knowledge of the Deep Purple Research Project and enabling dialogue with Greenlandic citizens.
- To exhibit the designed science communication product in Greenland to explore if it enables dialogue with Greenlandic citizens.
- To provide a set of recommendations for international researchers who wish to communicate their research using dialogue-based science communication.

Focus of research

The science communication events of this study took place in the local community of Sisimiut, Greenland which has a heterogenous group of inhabitants. The Greenlandic population consists of appx. 90% Greenlandic and 8% Danish and 2% of other ethnic groups (The World Factbook, 2023). Within the Greenlandic population there are many perspectives on who is Greenlandic, some may be Inuit or Inuit descent, others may have European and Danish ancestry, and some may consider themselves Greenlandic if they have lived in Greenland for an extensive amount of time without being of Inuit descent (Rink & Reimer, 2021) Some considering the ability to speak Kalaallisat, Greenlandic, an essential aspect of being Greenlandic (Skjervedal, 2018). In this study, we have decided to refer to the participants of the science communication events as 'Greenlandic citizens', since we are not able to distinguish or categorize participants as Indigenous or not. This does not mean that we do not acknowledge Inuit and Indigenous knowledge. The objective of this holds similarities with the aim of inclusive science communication which address the shortcoming in how researchers communicate and engage with the public (Canfield et al., 2020). We wanted to create a science communication product using an approach which has similarities to inclusive science communication which acknowledges that people's individual characteristics overlap with each other including their age, ethnicity, gender, race, physical ability etc., which affects their status in the world (Canfield et al., 2020). The purpose of our science communication design was to include any perspective incl. indigenous and local knowledge in the dialogue within our science communication design, however, it was not the focus of this thesis to determine whether a perspective was Indigenous or not. Also, since participation in our science communication design was spontaneous, we did not know prior to events who would

participate, therefore it was not possible to determine any of the participants' nationality, ethnicity, or identity, and it was not within the scope of this study.

As Graugaard (2021) states, the hit-and-run research practice taking place does not occur in a vacuum: 'it echoes the colonial exploration and exploitation in and of Inuit communities and peoples of the Arctic' (Graugaard, 2021, p. 36). Thus, there is a need for a change in science conduct in Greenland (Holm et al., 2011). We acknowledge that our study is also part of existing colonial structures which evidently have influenced this research, especially considering our positionality as Danish. As defined as inclusive science communication practice by Canfield et al., (2020), throughout the research process we have been aware and reflexive of our own explicit and implicit biases which we have described in our positionality statements. We acknowledge that meaningful outreach in a Greenlandic context recognizes the colonial history and existing colonial structures within Arctic science. Still, we have not situated this study within a decolonial framework since it goes beyond the scope of this thesis. This does not mean that we diminish the importance and urgency of decolonial work on research practice and underlying colonial structures of scientific practice in Greenland. In this study, we do not investigate how the current research practice in Greenland is linked to colonial practices. Instead, we have taken on a practical approach and explored how international researchers can make their research accessible to Greenlandic citizens by communicating their research with dialogue-based methods, thus including the Greenlandic citizens' perspectives in the discourse.

Thesis structure

This thesis includes a total of 7 chapters. In **Chapter 1** we outline the research paradigm this study is situated within, the theoretical framework of this thesis, the Theory of Didactic Transposition, and models within the field of science communication.

In **Chapter 2** we investigate the second research question *What aspects of the scholarly knowledge of the Deep Purple Research Project are relevant for citizens of Greenland* (RQ2). This investigation is the *a priori* analysis in which we examine the scholarly knowledge and practice of the Deep Purple Research Project and identify the knowledge to be embodied in a science communication design which can be applied in a Greenlandic context.

In **Chapter 3** we explore the third research question *How can the relevant aspects of the scholarly knowledge of the Deep Purple Research Project be embodied in an engaging science communication design?* (RQ3). The chapter describes our design process, our pilot study conducted in the Greenlandic House, Kalaallit Illuutaat, in Copenhagen, and the final design of an installation communicating the scholarly knowledge of the Deep Purple Research Project.

Chapter 4 describes the methodological approach, data collection method and analysis of this study.

Chapter 5 presents our results both from science communication events and from the analysis.

In **Chapter 6** we discuss our results in relation to all three research questions of the study. We also discuss the limitations of the methodology used. Following this, we present a set of recommendations for international researchers who wants to communicate their research in Greenland using a dialogue-based approach. Lastly, we suggest how the findings of this study have potential implications for future research and practice in Greenland.

Finally, in **Chapter 7** we present our conclusion.

Chapter 1 Theoretical Framework

1.1 Research Paradigms

All research is directed by the researchers' own beliefs and feelings about the world and how to make sense of it (Denzin & Lincoln, 2005). The set of beliefs or framework which guides research is sometimes termed a *paradigm* (Denzin & Lincoln, 2005) and describes how the researcher perceives the nature of reality (ontology), and how the reality can be known to the researcher (epistemology) (Alharahsheh & Pius, 2020). While ontology and epistemology are philosophical concepts, they guide the researcher throughout the research process in the various steps from formulating the research question, selecting appropriate methods for data collecting and analysis, to reporting their findings, ensuring a coherent and valid overall research methodology (Alharahsheh & Pius, 2020; Treagust et al., 2014).

In short, research paradigms are the philosophical reasoning that guides the practical design of a study, and due to its hidden nature, it is important to understand and explain what paradigm is used in this study. To achieve this, we outline the three general research paradigms within science education research as described in Treagust et al. (2014): the positivist research paradigm, the interpretivist paradigm and critical theory research with special emphasis on the interpretive research paradigm. This study is grounded in science communication research but draws on various ideas, methods, and theories from science education research. Both of those scientific fields are about understanding how scientific information is transferred between individuals, but they differ in one main aspect, that is the social contract used in the dissemination. Research within the field of science education investigates various aspects of teaching science and how students learn in formal and informal educational contexts (Fischhoff, 2013), whereas research within the field of science

communication research explores how science is effectively communicated to different audiences such as decision-makers, journalists, and the public (Burns et al., 2003).

The positivist, interpretivist, and critical theory research paradigms

Within the positivist research paradigm knowledge is meaningful when it is based on logical reasoning and empirical data (Treagust et al., 2014). Researchers in this paradigm will try to approach an objective *truth*, which can be observed through systematic empirical experimentation and derived through logical reasoning and causality (Treagust et al., 2014). Results from studies within the positivist paradigm would be used to make generalisations, laws, and rules about a specific phenomenon (Treagust et al., 2014). Post-positivist paradigm acknowledges that our culture, value systems and surroundings influence our perception of the world. However, there is still a truth based on logical explanations and reason even though our own prejudice limits our understanding of a phenomenon (Treagust et al., 2014).

Interpretivist research paradigm focuses on "*localized meanings of human experience"* (Treagust et. al., 2014, p.7). Therefore, it does not make sense to search for the *truth* because it is the experiences, culture and context that determine how a person constructs their understanding of reality, reflecting the constructivist epistemology and relativist ontology connected to the interpretivist paradigm (Treagust et al., 2014). A relativist ontology assumes that there are multiple realities (Denzin & Lincoln, 2005), contrary to the perception of one objective truth within the ontology of the positivist paradigm (Treagust et al., 2014). Unlike positivist studies, interpretivist research does not measure or generalise human behaviours and understanding instead it focuses on the 'situated meanings' people construct from social interactions which are contextual and temporal (Treagust et al., 2014), this position distinguishes interpretivist research from other academic research which often strives to make generalisations, whereas interpretivists aim to describe in detail people's lived experiences. Instead of providing results which can be generalised, interpretivist research is regarded as worthwhile if it provides plausible, informative, or thought-provoking descriptions and interpretations of participants' lived experiences and meaning making in a given situation (Treagust et al., 2014).

Encapsulating people's subjective interpretation of social phenomena is not simple. In interpretivist studies the researcher does not take an objective or unbiased position towards their participants but is actively engaging and building relations with the participants of the study, often for an extensive amount of time, thus making the researcher an integral component of the study as the interpreter of the participants' experience and perspectives. This reflects the central belief in the interpretivist research paradigm as meaning being co-created through dialogue between the researcher and participants (Treagust et al., 2014). The close engagement with the participants raises ethical considerations that the researchers must consider. Furthermore, the researcher's interpretation of what the participants share with them could differ considerably, depending on the researcher's own personal and cultural background. Therefore, an interpretivist

researcher needs to examine their own values and perspectives as well as review their interpretations of a situation (Treagust et al., 2014). Even though interpretivist researchers address and investigate their own role and impact on their study, they do not claim that their results are complete or right but are a judicious interpretation of a social situation (Treagust et al., 2014). Results from studies within the interpretivist paradigm are not supposed to be generalizable but aim for the reader to find the author's interpretation plausible, informative, or thought-provoking, often by presenting extensive descriptions of the participants and the social context they study (Treagust *et al.* 2014).
Research designs within the interpretivist paradigm are often based on qualitative methods in which the researcher engages with participants in naturalistic settings such as case study and ethnography with interviews, and observations being the often-applied data collection methods (Treagust et al., 2014).

Interpretivist research is a 'sense-making' process of the researcher conducting the study, with the methodology of the research evolving during the research process. As the researcher situates themselves in a situation their understanding of their research question and study change and may result in a redirection of the research design. The quality of an interpretivist study depends on the researcher's integrity, sensitivity, and skills of the researcher as well as the researcher's ability to reflect and be transparent on personal values and biases rather than methodological rigidity (Treagust et al., 2014).

Critical theory paradigm is in many aspects similar to the interpretivist paradigm in their understanding of how there is not a single truth, but rather people have localized meanings of knowledge. The critical theory paradigm has an increased focus on the inequalities and power dynamics of human interactions, which is the main aspect that distinguishes the critical theory paradigm from the interpretivist paradigm. Critical theory paradigm therefore seeks to understand and uncover where and how there are inequalities, and researchers in this paradigm will state that the power dynamic is the most fundamental factor for social interactions. Critical theory paradigm desires to centralise marginalized people and change society to be more just, equal, and sustainable, making the political agendas more transparent than the other paradigms (Treagust et al., 2014). Research from this paradigm attains its quality by discussing the bias of the researchers and society, and not necessarily by having rigorous methodical measures which also allows them to have more experimental ways of designing and writing their studies (Treagust et al., 2014).

The research paradigm of this study

This study is situated within the interpretivist paradigm and is designed according to central aspects of interpretivist research including. These include immersing ourselves in the context we study, actively engaging with participants and being the interpreters of the interactions. Our study assumes the ontology and epistemology of the interpretivist paradigm since our study explores how to combine multiple ways of knowing and how the social context influences scholarly knowledge, thereby reflecting a relative ontology, which dismisses the positivistic perception of "one single truth" that can be understood objectively

(Treagust et al., 2014). Our understanding of our world is constructed based on our experiences, culture, and context, and therefore is subjective, reflecting a constructive epistemology (Treagust et al., 2014). As other interpretivist researchers, we do not aim for objectivity. Therefore, we need to investigate and be transparent about our own personality, which we have described in our personality statements since our positionality influences our interactions with the participants as well as our interpretations of these interactions and settings in which they took place. During our study, we have taken an explorative approach and during the thesis, we describe how our understanding, approaches and interpretations changed as we engaged with participants and spent time within the contexts of the Deep Purple Research Project and the local community of Sisimiut, which reflects as an intrinsic aspect of the process of interpretivist research (Treagust et al., 2014).

1. 2 Paradigms and models of science communication

This study is based in the field of science communication, and to better understand what science communication is and how it is used in this study we shortly describe the two paradigms of science communication which have a total of four models that are used to further categorize science communication. We use the ideas of two paradigms in science communication (Kappel & Holmen, 2019). The first paradigm advocates for one-way communication from the researcher (the expert) to the audience and is therefore called the *dissemination paradigm* and is recognized by information flowing in one direction (one-way communication). The second paradigm, the *public participation paradigm* advocates for dialogical interactions, so that information flows in two directions (two-way communication), from the researcher to the participant but just as much from the participant to the researcher (Kappel & Holmen, 2019). Furthermore, the science communication paradigms are further divided into a total of four models (Tayeebwa et al., 2022). In the following sections, we provide brief outlines and key critiques of the four models of science communication and finally describe what model and paradigm we are using in this study and what that implies for our study design.

The deficit model

The first model is known as the "The knowledge deficit model", which is also known as the "the dissemination model" is within the *dissemination paradigm,* and it describes the traditional one-way communication from the researcher to the public. This model has been and is still often used by scientists (Houtman et al., 2021), but it carries a notable assumption. The deficit model assumes that the reason why people are sceptical about science is because they lack knowledge of it. Following this assumption, it is logical for the scientist to teach/educate "the correct" way to understand a subject in a one-way presentation manner (Tayeebwa et al., 2022). However, this has been shown to not always be an effective way of engaging with the public, and it may even lead to the opposite of the intended, so this model may cause the public to have mistrust and less engagement towards science (Houtman et al., 2021; Reincke et al., 2020)

The contextual model

The second model, known as the "contextual model" or the "public engagement model", picks up where the previous model left off, but is still within the *dissemination paradigm*. This model assumes that science communication is more effective at engaging the audience once the researcher understands the needs, current understanding, and perspective of the audience. This idea, combined with the understanding that people are very different, has led to *the contextual model* adapting to the various *target audiences*. It has therefore become important to receive feedback from the audience to better understand how researchers doing science communication can improve their effectiveness for dissemination (Tayeebwa et al., 2022).

The lay expertise model

The third model, known as "the lay expertise model", is based on the *public participation paradigm*. This model is about acknowledging different ways to understand a topic and having the researcher as an equal to the other person. Often the researcher is the one to initiate and facilitate the conversation, but the knowledge of the other is treated as equally contributing to the conversation. The researcher is no longer a teacher, but a conversation partner together with whomever the researcher is discussing with. This model assumes that all knowledge is equally important. This position has been critiqued for devaluing science, as the other source of knowledge can potentially be based on hunches and guesses, whereas science values empirical inquiry for verification (Tayeebwa et al., 2022).

Public engagement and participation

The fourth model, called the "public engagement and participation model" is used in decision-making processes or in debating issues with science and technology. Here, the policymaker, the scientist and the public discuss a given topic, where the three parts are considered equals in the discussion. Similar to "the lay expertise model", this model makes the scholarly knowledge equal to the other types of knowledge. The key difference between this model and the previous one, is that it doesn't attempt to create a new understanding, but rather focuses on debating the best decision to make on socio-scientific issues (Tayeebwa et al., 2022).

Our study is grounded in the *lay expertise model* of science communication, hereafter we refer to this as dialogue-based science communication due to the way it is related to the dialogue paradigm. It is what decades of research from science communication have been advocating for rather than the deficit model (Nisbet & Scheufele, 2009; Reincke et al., 2020), and a meta-study on the attitudes towards science shows there is no linear relationship between attitudes and knowledge about science, as the deficit model suggests (Allum et al., 2008). In our study, we desire two-way communication with the people we interact with and want to understand what happens when we invite them to have an informal conversation about a scientific topic. However, there is a "challenge" concerning the equal representation of both parties in the dialogue, and it addresses how science uses a language that makes it difficult to understand for those who are not in

the exact field of expertise. It is therefore necessary to disseminate scientific knowledge, to transform it from its original form to something the layperson (the participant) may understand, and thus giving them a chance to enter the dialogue. We address this "challenge", in this study, by using the theory of *didactic transposition* as a tool for analysing and designing our science communication, which is described in the following chapter, *didactic transposition*.

1. 3 Didactic Transposition

Knowledge as an inherent part of social situations

Didactic transposition theory shines a light on the tangible, illusive nature of knowledge. Yves Chevallard introduced didactic transposition within the field of didactics of mathematics in the 1980s (Chevallard & Bosch, 2014). Chevallard argues that knowledge is an integral part of social situations, resulting in a ternary relationship, with knowledge defining a *social contract* between two people according to how much each person knows. Thus, knowledge determines the relationship in social contexts and how people interact e.g., doctor and patient, mechanic and car-owner, pilot and passenger. In these examples, knowledge is valued based on its *relevance* in doing something, a solution to a "how" e.g., the doctor knows *how* to cure a disease, or the pilot knows *how* to fly a plane, which positions the doctor and the pilot in relation to the patient and passenger, determining how the two "groups" interact with each other (Chevallard, 1989).
Didactic Transposition theory focuses on the transformation of scholarly knowledge through different societal institutions to taught knowledge acquired by students (Achiam, 2014b).

'Knowledge' in didactic transposition

In didactic transposition, 'knowledge' refers to *schorlarly* knowledge, which is produced within research institutions, often universities, by researchers (Achiam, 2014a; Chevallard & Bosch, 2014). Scholarly knowledge includes values, practices, and scientific knowledge of a science discipline e.g., biology (Achiam, 2014a). The process of how scholarly knowledge is transformed through different institutional and societal contexts, e.g., ministries and museums, into an object of taught knowledge acquired by learners, is called *didactic transposition* (Achiam, 2014b).
In didactic transposition knowledge is the subject which both influences the relationships in a social situation but is also determined by the social context in which it is situated within. This interrelationship between knowledge and its context is the focus point of didactic transposition theory. The theory of didactic transposition provides an analytical tool to bring light to the "illusion of transparency" of the nature of knowledge in educational contexts (Chevallard & Bosch, 2014).

Knowledge transforms between contexts

Didactic transposition describes and analyse the process of how scientific knowledge undergoes a *transformation* and *translocation* between contexts to become taught knowledge (Achiam, 2014a, 2014b). During

translocation, scholarly knowledge is significantly transformed to 'adapt' to the different 'ecologies' of the social contexts and institutions it moves within, since each context has its own laws, social demands, and didactic conditions and constraints (Achiam, 2014b; Chevallard, 1989; Chevallard & Bosch, 2014). Thus, there is an inevitable difference and institutional distance between the scholarly knowledge and the knowledge to be taught in another context e.g., a school (Tiberghein & Sensevy, 2015). Therefore, knowledge cannot be separated from its institutional, societal, or social context. Furthermore, this study does not address *institutional transposition*, when knowledge is transposed from one institution from another (Chevallard & Bosch, 2014) e.g., research institution to museum but take the theoretical position of didactic transposition of understanding knowledge as a "*result of human endeavour*" (Achiam, 2014a, p. 1) and that knowledge is inseparable from its social and cultural context, this it is a necessity of the transformation of scientific knowledge when it is translocated from a research context to another context e.g., a museum. Based on their analysis of 520 science and science-related sources, Gimenez et al., (2020) argues that scientific knowledge undergoes a transformational process when it travels across space and time. This process goes beyond simply rephrasing or simplifying the scientific content to make it accessible to different audiences and involves issues of social power, authority, and access. Therefore, an analysis of such transformations increases our understanding of the process of knowledge dissemination and informs the practice of communicating scientific knowledge to different audiences (Gimenez et al., 2020). Didactic transposition can be applied as a framework for analysing (Mortensen, 2010) and designing dissemination activities of scientific knowledge in various education institutions (Achiam, 2014a).

Scholarly knowledge needs to undergo transformation

This study reflects the position of didactic transposition which states that the transformation of scholarly knowledge is necessary since it is not produced for dissemination to non-scientists (Achiam, 2014b). Scholarly knowledge is to be used in a research context both to produce new knowledge and to organise it into a theoretical assemblage (Chevallard, 1989). Scientists work on specific science problems and their dissemination of their results, in e.g., research journals, is usually targeted their peers to participate in scientific debate, advancement their research fields and to support their academic career (Achiam, 2014b). Thus, didactic transposition of scientific knowledge is a necessity because scholarly knowledge cannot just be transmitted to non-scientist. The scholarly knowledge must be transformed to be teachable since the context in which the knowledge is produced is different from the context of the learners (Achiam, 2014a). This transformation is not effortless since there is the risk of introducing oversimplifications or even mistakes (Achiam, 2014a). However, the transformation of scholarly knowledge can improve the original transposed body of knowledge making it even more structured, accurate and understandable (Chevallard & Bosch, 2014).

Transposition of scholarly knowledge between contexts

To transpose a scientific body of knowledge from the research context in which it is produced, it is necessary to put in work to create an appropriate 'environment' and social context, consisting of activities with the purpose of making the scientific body of knowledge teachable, meaningful, and useful (Chevallard, 1989; Chevallard & Bosch, 2014). This process can be described as a negotiation between the 'authenticity' of the representation of scholarly knowledge and the conditions and constraints of the context (Chevallard & Bosch, 2014). This 'negotiation' has been described in a museum context (Mortensen, 2010) and in primary school context (Clément, 2007). Therefore, it is important to understand the choices made during the construction of the taught knowledge, be aware of what elements and aspects of the scientific content are excluded and why, and finally the reasoning behind the final organisation of the taught knowledge (Chevallard & Bosch, 2014).

Didactic transposition of the scholarly knowledge of the Deep Purple Research Project

We apply didactic transposition as a tool to design a communication event in Greenland with the aim of disseminating scientific knowledge produced by researchers within the context of a research institutions. Therefore, we must transform the scholarly knowledge before it is teachable and understandable for non-scientists in a Greenlandic context. The theory of didactic transposition guided our transformation of the scholarly knowledge of the Deep Purple Research Project which we aim to disseminate. Our transposition of the scientific knowledge of the Deep Purple Research Project can be organised, similarly to Nicolaisen et al. (2021), into of two phases: a *What* and a *How phase*. '*The What phase'* is the first step of the didactic transposition consisting of defining and establishing the scholarly knowledge within the interdisciplinary research domain of the Deep Purple Research Project, into an integrated whole (Chevallard, 1989). Following the establishment of the body of knowledge of the Deep Purple Project, we deconstructed the scholarly body of knowledge and extract specific elements of scholarly knowledge, values, and practices (Nicolaisen et al., 2021) with the purpose of making them applicable in a communication event in Greenland. The *How phase* consisted of rearranging and organising the selected content and thereby reconstructing the scholarly knowledge of the Deep Purple Project into a physical installation. The objective of the developed communication product was to create a dialogue-based science communication event in a Greenlandic context, which aims to include citizens' perspectives and knowledge as well as connecting the researchers of the Deep Purple Project with Greenlandic citizens. Throughout this thesis we will describe our transposition of the scholarly knowledge of the Deep Purple Project from a research to a dissemination context and how the scholarly knowledge changes as it is gradually transformed into a communication event in Greenland.

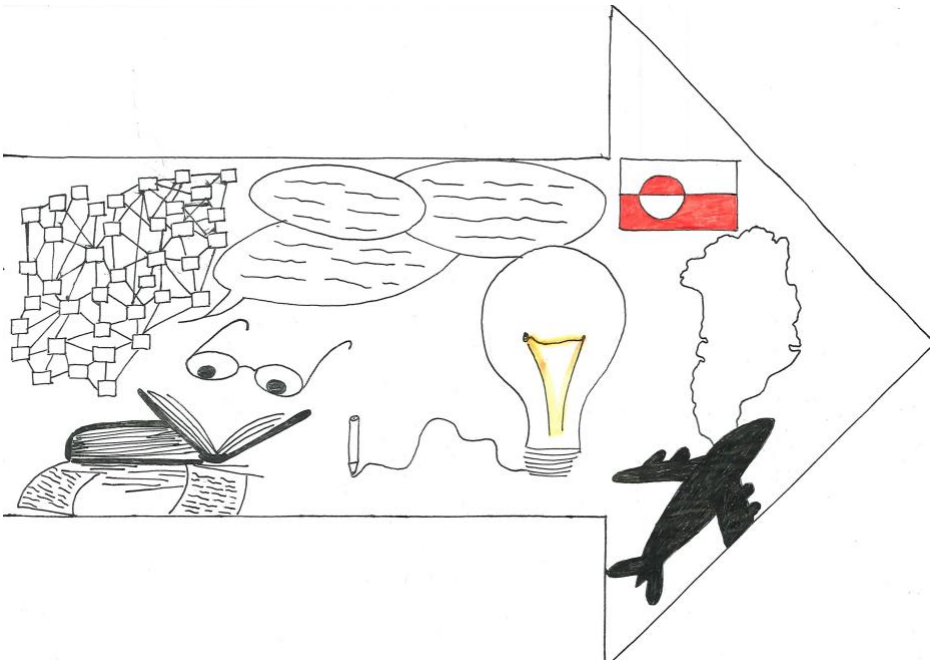

Figure 1. *Illustration showing the didactic transposition of this study. First, we established the scholarly knowledge of the Deep Purple Research Project and identified the central aspects of the scholarly knowledge. We explored how the central aspects of the scholarly knowledge of the Deep Purple Research Project could be transposed into a dialogue-based science communication design. We investigated this by conducting a pilot study in the Greenlandic House, Kalaallit Illuutaat, in Copenhagen. A central objective of the science communication design was that it could engage Greenlandic citizens in dialogue about the scholarly knowledge of the Deep Purple Research Project. We applied the designed science communication product in the local community of Sisimiut in Greenland to explore how the scholarly knowledge of the Deep Purple Research Project could be communicated using a dialogue-based format. Figure by Caroline Gram.*

Chapter 2 *A priori* analysis

2.1 Introduction

In the *a priori* analysis we investigate the second research question of this study: *What aspects of the scholarly knowledge of the Deep Purple Research Project are relevant for citizens of Greenland?* (RQ2). The analysis has the following objectives: **1) Identify the central concepts of the Deep Purple research project** and **2) investigate how these concepts are connected.**

Applying didactic transposition

In the introduction of didactic transposition theory in Chapter 1 we describe how scholarly knowledge needs to be transformed through series of deconstruction and reconstruction when transferred to other contexts (Achiam, 2014a; Chevallard, 1989). The first step of didactic transposition is to understand the research context of the *scholarly knowledge*, and then the second step is to identify and rearrange the scholarly knowledge into *knowledge to be taught* (Achiam, 2014a). Throughout this study, we investigated the research context, by immersing ourselves in the Deep Purple Research Project to gain insights into the social aspects, values, and practices of the project, which constitutes the context in which the scholarly knowledge is produced. This

approach is well situated within the interpretivist research paradigm as described in Treagust et al., (2014). The initial step of transposing the scholarly knowledge of the Deep Purple Research Project, from the research context to a Greenlandic context, is the selection and rearrangement of the scholarly knowledge into the knowledge to be taught.

The broader context - scholarly knowledge

There is an abundance of literature on what science is, and it is not within the scope of this study to give a complete outline of the existing literature, however in the following we provide a brief introduction of what scholarly knowledge is.

In modern *knowledge societies*, scientific knowledge and technology are particularly influential and authoritative and hold social, political and economic significance (Garvin, 2001; Stehr, 2018). This chapter focuses on *scholarly knowledge,* as produced by *science and scientists,* and is understood as a "*[…] A body of knowledge and generalized truths surrounding phenomena […] Scientists, therefore are those working within the arena of science as knowledge producers and validators"* (Garvin, 2001, p. 444). Science and scientific research have features and characteristics which distinguish scientific knowledge from other types of knowing, with science being defined as a range of "knowledge producing" activities (Emmeche, 2004). These activities and the knowledge produced from these activities are carried out and socially evaluated in a specific institutional, historically, and culturally context under a set of collectively accepted values, norms and principles (Turner & Mccreery, 2015). An example of these collectively accepted values is the CUDOS norms, which were identified as "norms of science" by Merton. The acronym stands for communality, universalism, disinterestedness, originality and scepticism with replication sometimes added to the acronym, and describes the ideal scientist as a neutral and curious person, though this description of scientists has met critique (Turner & Mccreery, 2015). Because scientific knowledge is produced in specific institutions, scientific knowledge is influenced by the societal and institutional context in which it is produced (Rutjens et al., 2018).

The scientific knowledge of the Deep Purple team

This study is a case study of the Deep Purple Research Project's outreach in Greenland and throughout the study we have immersed ourselves with the Deep Purple research team, as we needed to understand the context of their knowledge and knowledge acquisition. The Deep Purple Research Project is an interdisciplinary research project at The Department of Environmental Science, Århus University, and The German Research Centre for Geosciences (GFZ), Germany (Deep Purple Research Project, No date-a). The Deep Purple Research Project investigates the ice biome that inhabits the Greenlandic Ice Sheet. Their research aims to gain an understanding of the biological darkening and the factors controlling ice algal blooms (Deep Purple Research Project, No date-a) through systematic empirical experimentation. Results from their study are used for making generalisations and is meant to be applied in models predicting the melting rates of the Greenlandic Ice Sheet (Deep Purple Research Project, No date-a). This research approach reflects the characterisation of research within the post-positivism paradigm of research, as described by Treagust et al. (2014).

Visualizing knowledge

Knowledge visualization has recently become its own field of research (Meyer, 2010), but we found inspiration from the scientific disciplines of *museology* and *science education,* which both investigates how scholarly knowledge can be transposed from a research context to knowledge to be taught in another context (Mortensen, 2010; Achiam, 2016). Concept maps are recognized as a tool for visualizing knowledge, and with many practical uses (Hay et al., 2008). Though there are other ways to visualize knowledge (Davies, 2011; Meyer, 2010), we applied concept maps to visualise the scholarly knowledge of the Deep Purple Research Project because concept maps have been highlighted as a useful tool in gaining access to student's conceptual understanding of a phenomena (Hay et al., 2008). In our analysis, we wanted to gain insights to Deep Purple Researchers conceptual understanding of the biological induced darkening of the Greenlandic Ice Sheet. Additionally, concept maps are useful in a learning process (Novak & Cañas, 2008), which will benefit study, as we needed to acquire an overview and understanding of the knowledge of the Deep Purple Research Project. In a study of an exhibition of cave beetles, Mortensen (2010) applied concept maps in combination with didactic transposition theory to investigate how scholarly knowledge changed when transposed into a context of an installation in a museum exhibit. In this *a priori* analysis we applied a similar approach using concept maps to establish a scholarly body of knowledge into knowledge to be taught, the process of didactic transposition.

Concept maps

A concept maps is a visual tool for structuring and organizing knowledge within a given problem or knowledge domain, usually constructed to answer a pre-defined focus question within the given knowledge domain (Novak & Cañas, 2008).) Concepts are "*...a perceived regularity in events or objects, or records of events or objects, designated by a label"* (Novak & Cañas, 2008, p.1) The relationship between concepts is illustrated as a connecting line and should include a *linking word* or phrase which specify the relationship between the concepts (Novak & Cañas, 2008). A proposition is made when a concept is connected to another concept using a linking word (Novak & Cañas, 2008).

2.2 Methods

Our method to understand and visualize the central concepts of the Deep Purple project stems from three sources of information. The first source was an online workshop we facilitated, in which we created a concept map together with the researchers from Deep Purple Research Project. The second source of information was our experiences from immersing ourselves within the Deep Purple project and participating in various activities both within the research project and the broader scientific community of polar and alpine microbiologists. Whilst conducting the *a priori* analysis we received supervision from one of the principal investigators of the Deep Purple Research Project, Alexandre Anesio. Other activities included the everyday office setting, internal meetings of the Deep Purple Research Project, the 9th International Conference on Polar and Alpine Microbiology (PAM22), two PhD defences and informal conversations over coffee. The third source of information consisted of literature and media incl. peer-reviewed articles published by the Deep Purple Research Project

as well as other communication outputs from the project incl. podcasts, online articles, television, blog posts and social media (Deep Purple Research Project, No date-e). Based on these sources, we constructed a concept map that visualised the main concepts from the Deep Purple project (Fig. 2).

Workshop

The overall objective of the workshop was to explore and identify key concepts and connections by the researchers of the Deep Purple Project by creating a concept map. We designed and facilitated an online workshop the 29th of September 2022. The online format of the workshop ensured that both researchers based at in Germany and in Denmark could participate. Everyone within the Deep Purple research project were invited by email and encouraged to participate regardless of scientific discipline and academic ranks, referred to as 'researchers' in the following. 16 (out of 27) researchers from various disciplines participated in the 1-hour workshop. Zoom software was used to facilitate the workshop. The website padlet.com, which functions as a digital bulletin board, was used to create the concept map. Menti.com was used to get feedback on the participants' initial thoughts in the beginning of the workshop and their experiences at the end of the workshop. We collected data in the form of video recordings, notes, and participants' responses. Immediately after the workshop, we noted our reflections the workshop and how we experienced facilitating the workshop.

Facilitation of the workshop

The workshop started with a presentation of us as facilitators and a very brief introduction to the website Padlet.com and the activities of the workshop. The researchers were made familiar with the objective of the workshop: the co-creation of a concept map visualising the key concepts of the Deep Purple Project. In the first activity of the workshop, we asked the researchers to individually share their input to the question '*What words pop up when you think of the Greenlandic Ice Sheet?'* in an online Word Cloud on menti.com.

After the exercise, the researchers were given a brief introduction on how to create key concepts in the online Padlet. The researchers were randomly assigned into break out rooms of three people. The groups were asked to write key concepts to the following focus question: *"By using single key words and concepts describe what happens when the ice of the Greenlandic Ice Sheet changes colour?"* on the shared Padlet. The researchers were asked *not* to connect the key concepts at first.

After closing the breakout rooms the researchers were given 5 likes they could place on the concepts they found the most relevant to the focus question. We demonstrated how to connect and make linking words between concepts, how to change colours on the boxes with the concepts, and how to rearrange the concepts. Researchers were given the possibility to write questions and comment on each other's concepts. Furthermore, the researchers were invited to engage in a group discussion whilst rearranging and connecting the concepts. The researchers created connections, and they decided it was important to categorize the `certainty´ of each concept by giving them a colour code. Hence, this exercise established the connections between the concepts, in addition to relevance and `certainty´ of each concept.

The workshop and the final concept map provided insights into what concepts the researchers of the Deep Purple Research Project identified as the key concepts of their research domain and how they organise and connects these concepts. However, the resulting concept map did not have an organisation, so we reconstructed the concept map, as described in the following section.

Reconstructing the concept map from the workshop

The output of the workshop was a concept map with no specific organization or hierarchy, making it difficult to make sense of the concept map. In their feedback, the researchers expressed that the map appeared unfinished and chaotic. Therefore, we chose to make a hierarchal organization of the concept map with the spatial scale of a concept determining their horizontal positioning on the map. Organising biological concepts and processes according to spatial scale is an organisation approach used in ecology (Allen & Starr, 2019; Smith et al., 1998). The reorganization of the concept map consisted of 5 steps and was performed in the software "CmapTools" by Florida Institute for Human & Machine Cognition.

Step 1. Removal of repetitive concepts

Removal of repetitive concepts from the concept map to reduce the complexity. In total 7 concepts were removed.

Step 2. Removal of connections

Removal of all connections between concepts for the application of a new organisation. We changed the thickness of the outline of boxes relative to the number of connections the concept had in the original version of the concept map.

Step 3. Organizing concepts in a spatial hierarchy

We placed each concept in relation to each other with concepts representing small scale phenomena were placed above concepts that represented large scale phenomena.

Step 4. Re-connecting concepts and creating linking words

based on literature and feedback from researchers from the Deep Purple Research Project We created connecting lines between concept. Simultaneously, we created linking words for connections without. Many of the removed connections from step 2 were in this phase re-established, either directly or indirectly through the new organization..

Step 5. Validation and final adjustments

We validated the concept map with two researchers from the Deep Purple Research Project, rearranging some connections to align the concept map with their knowledge. The final concept map includes almost all the concepts formulated during the workshop.

2.3 Results

We established the scholarly knowledge of the Deep Purple Research Project by constructing a concept map (Fig. 2) based on all three sources of information outlined in section 2.2. We reconstructed the scholarly knowledge into three insights *Interactions, Scale* and *Systems* which we identified as central aspects of the scholarly knowledge of the Deep Purple Research project. In the following section the three insights are described as well as how they are reflected in the concept map. Finally, we summarize the current communication outputs of the research project.

The concept map

The concept map (Fig. 2) contains information in the form of 34 concepts relating to the biological induced darkening of the Greenlandic Ice Sheet. The concepts are connected by 26 connecting lines with associated linking words. 9 concepts are uncategorised and placed on the top right corner of the map (Fig. 2). The triangle on the left shows how the spatial scale of concepts increases downwards (Fig. 2) Concepts are shown in colour coded boxes with the colour purple denoting concepts which the researchers were certain of, the yellow concepts researchers were uncertain of, red concepts are concepts the researchers believed to be wrong and white concepts are uncategorized. Arrows indicates connections and direction for the linking word, which explains the relationship between concepts. The number on the right side of the concepts are the number of likes each concept received from the researchers during the workshop. The thickness of the outline of the boxes is relative to the number of connections the concept had in the original version of the concept map. The dotted horizontal line indicates the transition between concepts describing biological process and concepts describing physical processes of the ice (Fig. 2).

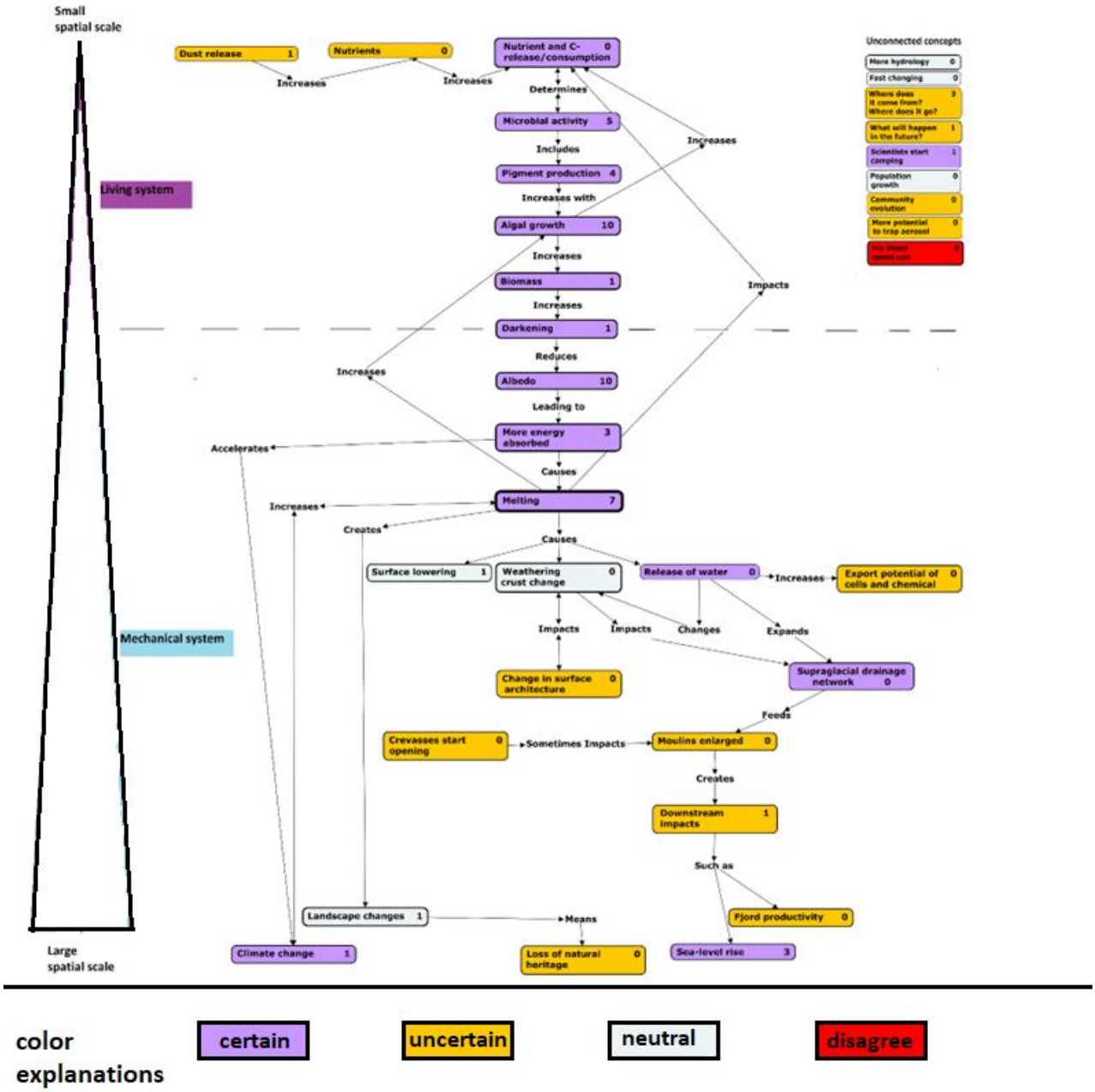

Figure 2 *Reorganized concept map including 34 concepts relating to the biological induced darkening of the Greenlandic Ice Sheet, including the uncategorised concepts in the top right corner. The triangle on the left illustrates that the spatial scale of concepts placed on the top of the map are smaller than concepts placed at the bottom of the map. Concepts are placed in colour coded boxes which reflects the levels of certainty researchers expressed towards a concept. Arrows indicates connections and direction for the linking word, which explains the relationship between the concepts. The number on the right side of the concepts are the number of likes that concept got from the workshop participants. The thickness of the outline of boxes is relative to the number of connections the concept had in the original version of the concept map. The dotted line indicates the transition between concepts describing biological process and concepts describing physical processes of the ice.*

The insight *Interactions* – how the Ice and ice algae interact

Algae is complex group of organisms due to their many different shapes, habitats and evolutionary origin which makes them a polyphyletic group. However, they share a common ecological function as primary producers since they are capable of photosynthesis in aquatic habitats (Guiry, 2012), similar to terrestrial plants (Graham, 1996). Algae are ecosystem engineers which is a term assigned to species that alter the abiotic

environment for other species (Schubert et al., 2020). Algae are fundamental organisms for many ecosystems found on Earth, and one of the most extreme ecosystems they inhabit is on land ice, such as the Greenlandic Ice Sheet (Hotaling et al., 2021). Deep Purple are researching the biological induced darkening of the Greenlandic Ice Sheet, which is mainly caused by the pigmentation of the two algae-species: *Ancylonema alaskanum* and *Ancylonema nordenskioeldii* (Bradley et al., 2023), however there are other algae species inhabiting the ice incl. *Cylindrocystis brebissonii* (Yallop et al., 2012). In the following, we refer to all species of ice algae as 'ice algae'. The ice algae do not only live but thrive in the seemingly unhabitable surface of the ice as long as their basic requirements are met (Chevrollier et al., 2023). Ice algae growth requires liquid water, available sunlight, and accessible nutrients (Chevrollier et al., 2023). Algae are exposed to sunlight during the summer season when the snow layer has melted away, the melting of the snow simultaneously creates access to water by the melting of ice and snow. The ice algae require nutrients, and while they get carbon from photosynthesis, the nitrogen and phosphor and other minerals are believed to be wind deposited from the weathering of rocks that have accumulated during the winter (Winkel et al., 2022). Interestingly, the sunlight is not only a requirement for the ice algae, but also a threat to them, as harmful UV-rays can cause cell death. Therefore, the ice algae have adapted to the threat of harmful UV-rays by having very strong pigmentation of their chloroplasts which gives them a unique dark purple coloration (Chevrollier et al., 2023). This pigmentation also functions to melt the surrounding ice by decreasing the albedo, which results in more available water for the ice algae (Chevrollier et al., 2023).

The ice algae live in the part of the ice known as the weathering crust, which is the surface layer of the ice. The weathering crust is known to have a unique mesh like structure suitable for microbial life (Stevens et al., 2022). The ice algae's pigmentation causes the albedo of the ice to be lowered which accelerates the melting rate of the Greenlandic Ice Sheet by 13% (Cook et al., 2020). Our concept map visualises darkening as the central interaction between ice algae and ice with the horizontal line going through the concept darkening (Fig. 2). The concepts above the horizontal line are concepts relating to the biological processes of the ice algae, whereas the concepts below the line describes the processes of the ice (Fig. 2). The connection between the ice algae, albedo, and meltwater as a positive feedback loop (Fig. 2). The chain-structure in the top of the map shows, through the connections of the concepts, how dust release (deposited on the icesheet) increases nutrients which impacts nutrient and carbon release and consumption (Fig. 2). This determines microbial activities including pigment production which increases with algal growth. Algal growth increases the biomass, which will increase the amount of darkening which results in a reduction in albedo (Fig. 2). Energy absorbed (from the sun) causes melting of the ice sheet. Melting then increases algal growth, reflecting a positive feedback loop (Fig. 2). Both algal growth and melting impact the nutrient and carbon release and consumption, resulting in another positive feedback loop. The positive feedback loops are both reflected in the concept map through the connecting but also the also the assigned linking words such as 'Increases', 'Creates' and 'Causes' (Fig. 2). Central questions about the ice algae and their interactions with the ice are still unanswered e.g., How do ice

algae survive through the winter? (Winkel et al., 2022). Or as one reflected in one of the concepts in the map: "*where do they come from, where do they go?"* (Fig. 2).

Scale - small microorganisms with global impact

Within biological research it is established that microorganisms have large global impacts e.g., the theory on `the great oxidation event´ which states that the origin and rise of oxygen in the atmosphere are byproducts of algae's photosynthesis (Berkner & Marshall, 1965; Kump, 2008) . The Deep Purple researchers are studying a phenomenon with a comparable spatial scale as the great oxidation event, as they study the microscopic ice algae and their link to global sea-level rise (Deep Purple Research Project, No date-d), thus understanding interactions across spatial scales is one of the central aspects of the research of the Deep Purple Research Project. This aspect was apparent e.g., in the Deep Purple researchers' presentations which often included illustrations of ice algae at different spatial scales and sometimes as an image of a magnifying glass 'zooming' in on the ice algae. Papers also included illustrations showing the large difference in the spatial scale of the ice algae and the Greenlandic Ice Sheet (Yallop et al., 2012). The structure of an alga is something that can only be observed through a microscope due to its small spatial scale, illustrated in (Fig. 3.A). However, the bloom (rapid population growth) of the very same algae can be so overwhelmingly large that it is best observed using satellite imagery (Fig. 3.B). The project applies a range of advance technologies to study the interactions between ice algae and the ice happening across a range of scales incl. satellite (Feng et al., 2023) to scanning electron microscopes (McCutcheon et al., 2021). We used spatial scale to organise our concept map to visualise the complexity of ice and ice algae interactions happening across different spatial scales (Fig. 2). Through the process of the reconstruction of the concept map, *Scale* was identified as a central aspect of the scholarly knowledge of Deep Purple project.

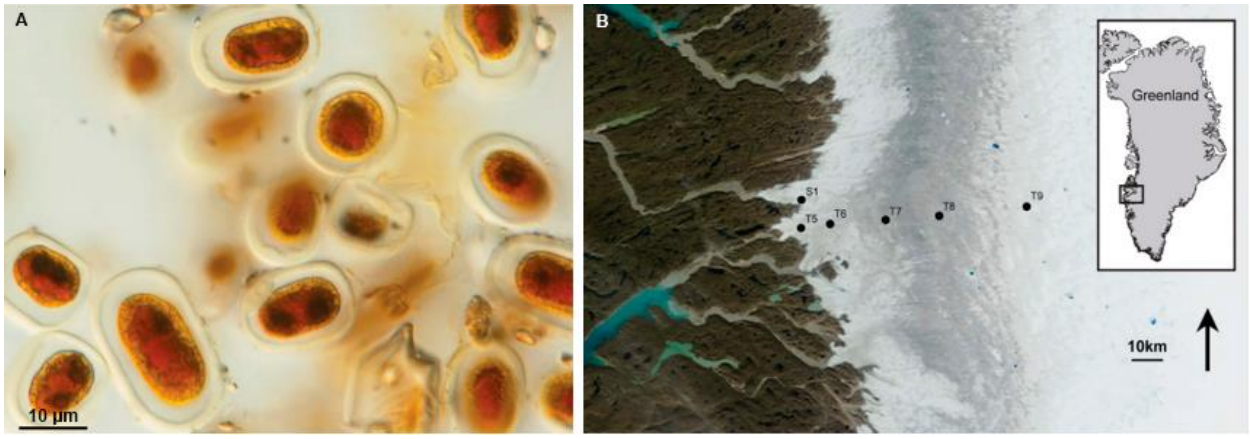

Figure 3. *Modified from Yallop (2012) Examples on different scales of ice algae. A) Microscope image of the ice algae Cylindrocystis brebissonii, 10 µm line for reference. B) Satellite image of the Greenlandic Ice Sheet where the grey area in the ice is from ice algae bloom, 10 km line for reference.*

System – a systems approach to explain complex interactions

The aim of the Deep Purple project is to: "[..] *Investigate the physical and microbial processes that darken the Greenland Ice Sheet and accelerate sea level rise"* (Deep Purple Research Project, No date-a). These

processes are studied as "*Continually evolving ice-water-particulate-microbe systems*" (Deep Purple Research Project, No date-a) or 'supraglacial ice-algal systems' (Halbach et al., 2023). According to Halbach et al. (2023) the reduction of the surface albedo of the Greenlandic Ice Sheet caused by ice algae is widely recognised but not well quantified. Research priorities to gain a better understanding of ice-algae systems incl. identifying controls on ice algal growth and mortality, quantification of spatio-temporal variability in ice algal biomass and processes, and determining albedo feedbacks between algal biomass and the weathering crust (Halbach et al., 2023). The changes in ice structure and variability of ice algae in the Ice Sheet are not well represented in climate models, resulting in an underestimation of predicted melt rates (Halbach et al., 2023). Climate induced changes of precipitation, hydrological processes, chemical and physical properties of the Greenlandic Ice Sheet have unknown consequences for algal bloom development and biological induced darkening (Halbach et al., 2023). To gain a better understanding of the ice-algal systems and the darkening of the Greenlandic Ice Sheet, The Deep Purple Research Project uses a wide range of techniques and technologies to collect empirical quantitative data and organise these into mathematical models to better understanding the complex interactions and feedbacks between environmental variables within the ice-algal system (Bradley et al., 2023; Halbach et al., 2023). The Deep Purple Research Project analyses different aspects of the ice-algal systems incl. the taxonomic diversity and activity of the microbial communities (Bradley et al., 2023), pigmentation signatures of the ice algae (Halbach et al., 2022) and light absorption and albedo reduction by the ice algae (Chevrollier et al., 2023) amongst others.

The Deep Purple team consists of scientific experts across various natural science disciplines such as microbiology, glaciology, and chemistry (Deep Purple Research Project, No date-a). These different natural science fields have some differences in how they investigate natural phenomena. We learned from informal conversation that within the discipline of glaciology the Ice Sheet is perceived as a mechanical system governed by physical laws. Thus, the focus is to understand the mechanical and physical properties of the ice. Simultaneously, they have microbiologist who are interested in understanding the many microbial interactions and the ecology in their abiotic surroundings. This distinction between the abiotic (mechanical) and the biological (living) is illustrated in the concept map as the horizontal line through the concept "darkening", which links the two fields together (Fig. 2).

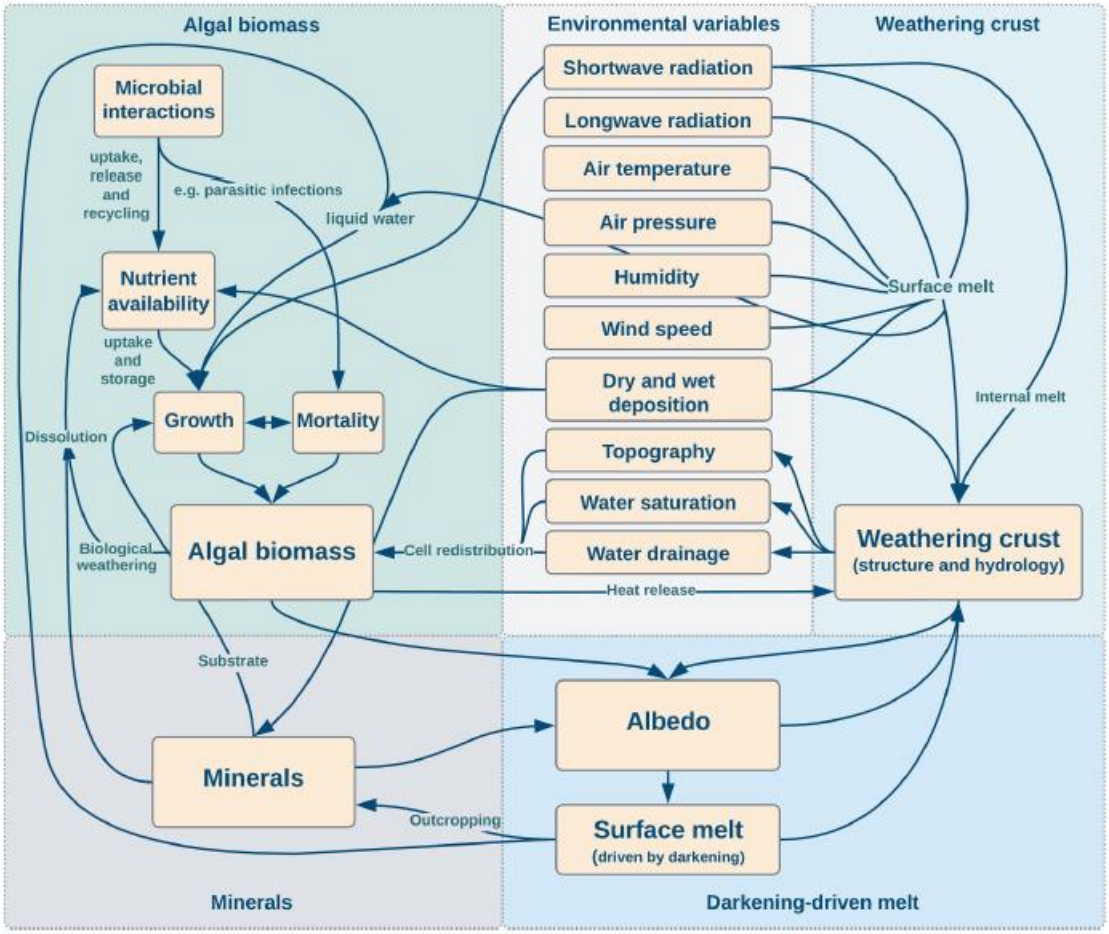

Figure 4. *Schematic overview of the ice algal system and key feedbacks with different environmental factors and the albedo of the ice surface. From Halbach et al., (2023).*

The Deep Purple Research Project summarizes the recent advances of research on the biological induced darkening by ice algae in the study of the Halbach et al., (2023). They present a schematic overview (resembling a concept map) over different abiotic and biotic factors and how they are interacting with each other (Fig. 4). Their schematic overview is comparable to our concept map, though it is not organised according to spatial scale, instead environmental variables are organized into different aspects of the ice-algal system which interact with each other in multiple ways incl. feedback loops (Halbach et al., 2023). Both representations separate the living systems from the non-living systems (Fig. 2, Halbach et al., 2023). The insight *systems* describe how the Deep Purple Research Project perceives the ice algae and the Ice Sheet as a system and how they understand the ice-algal system by collecting empirical data, quantifying processes across a wide range of scales, and construct mathematical models, using a wide range of disciplines, methods, and technologies.

The communication outputs of the Deep Purple Research Project

From our *a priomethods,,*ysis we found that Deep Purple Research Project communicate uses different formats to communicate their research. Some formats are used for communicating their research to peers incl. peer-reviewed articles, lectures and conference presentations (Deep Purple Research Project, No date-e). Other outputs are used for disseminating their research incl. podcasts, online articles, television, and blog posts (Deep

Purple Research Project, No date-e). Additionally, the Deep Purple Research Project does outreach on different social media platforms such as Twitter and Instagram, where the followers gain an insight into `behind the scenes´ of the research process. Regardless of communication media and format, visual representations are included such as graphs, plots, images from microscope, satellites, and drones as well as photographs and videos from field work. However, there are currently not any outreach targeted specifically to Greenlandic citizens or dialogue-based formats. From informal conversations we learned that the Deep Purple Research Project have been interested in engaging with Greenlandic communities, however they have not known what approach to use.

2.4 Reflections on methods and results

With the concept map we achieved the objective of this *a priori* analysis: "*Identify the central concepts of the Deep Purple research project, and investigate how these concepts are connected*", as the concept map visually represents the concepts and feedback mechanisms central to the Deep Purple project. Our concept map (Fig. 2) and the three identified insights describe the central aspects of the Deep Purple knowledge and have been validated by the researchers of the Deep Purple Research Project and compared to the schematic overview (Fig. 4) by Halbach et al. (2023). The concept map and three insights are the result of our first steps of transposition of the scholarly knowledge of the Deep Purple Research Project since they are the result of a deconstruction and reconstruction of the scholarly knowledge which is transformed to the *knowledge to be taught* in a science communication product in Greenland.

Overall approach

We have immersed ourselves in the Deep Purple Research Project, and as described in the method section, we partook in a range of activities within the research project to gain an in depth understanding of the scientific activities and practices of the research project. Furthermore, we facilitated a workshop in which the Deep Purple researchers identified the central concepts of the project. Didactic transposition theory recognizes that knowledge is context dependent (Chevallard, 1989), and therefore it was essential to analyse the research context in which the scholarly knowledge is produced. If we had based our *a priori* analyses on a literature review alone, we would not have gained the same insights and understandings of the scholarly knowledge.

The learning process with the concept map

We constructed the three insights and the concept map simultaneously. The insights and the concept map are both describing our understanding of the scholarly knowledge in the Deep Purple Research Project. By reconstructing the concept map we gained an in-depth understanding of the concepts and connections made by the Deep Purple researchers during the workshop. The new hierarchical organization guided our investigation of the scholarly knowledge and research of the Deep Purple Research Project. Whilst working with the concept map, we asked questions, such as "How is this concept linked to that concept?" or "What is a weathering crust?". The concept map was a useful tool since it provided a visual overview of the central concepts and

feedbacks, identified during the workshop, which could be validated by the researchers of the Deep Purple Research Project. In this way, our concept map was continuously validated by the researchers and ourselves, and the concept map therefore became a tool, where the *process* of developing the concept map, was much more rewarding than if we simply possessed a "final" version of the concept map. This is complimenting the idea that concept maps are great for learning and organizing knowledge (Novak & Cañas, 2008).

Feedback from the workshop

During the workshop, researchers gave feedback on the outcome and process of the workshop. Some gave suggestions on how to improve the constructed concept map: *"[..] the links between terms/concepts could be better organized and also maybe give some weight to them depending on the goals of the Deep Purple project."* The example emphasises how a reconstruction of the concept map was necessary after the workshop. Some of the researchers participating stated that the workshop and constructing the concept map gave them an overview of the research project: "*Seeing that we have all a good common goal to solve the issue related to the algal bloom induced darkening of the Greenlandic ice sheet – regardless from what angle of science we approach it from.*", reflecting that the concept map provided an overview for the participating researchers.

The workshop as a social phenomenon

Workshops can be facilitated as experimental, creative, and collaborative playgrounds where questions and ideas are presented, enacted, and discussed (Ørngreen & Levinsen, 2017). The workshop format gave us an opportunity to interact with the researchers and collaboratively explore the scholarly knowledge of the Deep Purple Research project. This approach fits well with the interpretivist research paradigm since researchers within interpretivist studies do not take an objective or unbiased position towards their participants but are actively engaging and building relations with the participants of the study (Treagust et al., 2014) thus making the researcher an integral component since meaning is co-created through dialogue between researcher and participants (Treagust et al., 2014).

2.5 Conclusion

As we described in the introduction of the *a priori* analysis, the aim of the analysis was to investigate the second research questions of this study: "*What aspects of the scholarly knowledge of the Deep Purple Research Project are relevant for citizens of Greenland?".* The objective was to establish the scholarly knowledge of the Deep Purple Research Project and gain an in depth understanding of the cultural, social, and institutional context in which the scholarly knowledge is produced within. As described, we did this by immersing ourselves in the Deep Purple Research Project. To identify the relevant aspects of the scholarly knowledge, we deconstructed and reconstructed the established scholarly knowledge into a concept map (Fig. 2), identifying central concepts relating to the biological induced darkening of the Greenlandic Ice Sheet. Based on our investigation of the second research question, we identified the relevant aspects of scholarly knowledge of the Deep Purple

Research Project, the three insights: *Interactions, Scale, and Systems*, which are in the following chapters referred to as `insights´. The insights constitute the content of our science communication design.

Chapter 3 Design of communication product

This chapter will explore the research question *How can the relevant aspects of the scholarly knowledge of the Deep Purple Research be embodied in an engaging science communication design?* (RQ3). Similar to approach of Nicolaisen et al. (2021) we established an overview of the scholarly knowledge of the Deep Purple Project which we subsequently deconstructed and extracted specific concepts, values, and practices with the purpose of making them applicable in a communication event in Greenland. This chapter will describe the *How phase* in our didactic transposition in which we transpose the scholarly knowledge of the Deep Purple Research Project into a physical installation which can be applied in a Greenlandic context.

Design objectives of communication product

Recall that one of the aims of this study, was to develop a communication product which would be relevant in a Greenlandic context and engage Greenlandic citizens in a dialogue about the scholarly knowledge of the Deep Purple Research Project. The communication product had the objectives: embodying the three insights of the Deep Purple Research Project, including physical objects, and facilitating a dialogue in which both the scientific and the perspectives of Greenlandic citizens were represented. It was important that the included objects were interactive, making it possible for the Greenlandic citizens to interact with the scholarly knowledge. of the Deep Purple Research Project, embodied in the objects. Furthermore, we designed the objects so the citizens' interactions with the objects would leave a visible mark, resulting in citizens contributing to the installation. The design of the dialogue-based installation 'Connecting Communities' reflected central aspects of the lay-expertise model of science communication (p. 23) since the design gave Greenlandic citizens a more equal standing point in the dialogue and provided a shared experience of engaging with the objects within the installation.

Design process

Throughout the design processes a central question was how we could design a science communication product which 1) communicated the scholarly knowledge of the Deep Purple Research Project and 2) facilitate a dialogue between the three actors (scientist, citizen, and object) all interacting simultaneously with each other. The process of designing a science communication product which would achieve the objectives, holds similarities to the process described by Horst (2011). They used a similar approach, as in this study, by applying visual brainstorming tools to identify the aspects of the research-based knowledge which could be spatially communicated. Through the process of designing the installation, Horst (2011) describes how the researcher becomes a designer-hybrid since they had to come up with ideas for material expression whilst investigating the relationship of the developed product and the original scholarly knowledge. According to Horst (2011) the task is to negotiate between practical possibilities to explore what will work, how, and in which circumstances. This process holds similarities to the process of didactic transposition in which scholarly knowledge is transformed from a research context into an object of taught knowledge

acquired by learners in a context outside the research context (Achiam, 2014b). To transpose a scientific body of knowledge, from the research context in which it is produced, it is necessary to create an appropriate social context which consists of activities that makes the scientific body of knowledge teachable, meaningful, and useful (Chevallard, 1989; Chevallard & Bosch, 2014). This process can be described as a negotiation between the 'authenticity' of the representation of scholarly knowledge and the conditions and constraints of the context (Chevallard & Bosch, 2014). Horst (2011) states that this process of transforming research-based knowledge from a research context into a science communication design cannot be split into research and design but is an integrated process in which both are learned at the same time. The question to whether research-based knowledge can be transformed into spatial installations has to be answered empirically through the experiment of physically creating an installation (Horst, 2011).

To explore how we could design a communication product that would be relevant for Greenlandic citizens and context, we contacted organisations and institutions communicating research in Greenland incl. Kangiata lllorsua, Arctic Hub and Greenland Institute of Natural Resources. This resulted in valuable considerations, insights, and advice which we would not have been able to find in literature. Based on these insights, we explored different ideas, particularly focusing on the communication and interactions we wanted our communication product to initiate and facilitate. During our design process we had many different questions to the design of our science communication product incl. what are the constraints and opportunities when communicating using a dialogue-based format? What should we say and in which language? How to design intuitive objects which will initiate dialogue? How to approach people? Where should position ourselves in relation to the person? To investigate these questions, we conducted a pilot study at Kalaallit Illuutaat, The Greenlandic House in Copenhagen.

3.2 Pilot study at Kalaallit Illuutaat

Setting and study period

Our pilot study took place in the period of 6th of December 2022 to 13th of December 2022 in Kalaallit Illuutaat, The Greenlandic House, in Copenhagen. For 40 years the house has been a meeting place for Greenlandic citizens and others with interest in Greenland (Kalaallit Illuutaat, 2023). The institution aims to facilitate the cultural meeting between Greenlanders and Danes through social and cultural events such as communal dinning, art exhibitions, lectures, and educational activities amongst others (Kalaallit Illuutaat, 2023). Kalaallit Illuutaat also houses social associations and offers legal, social, and educational counselling for Greenlandic citizens. Furthermore, the institution disseminates and provide educational resources on Greenlandic culture and society (Kalaallit Illuutaat, 2023). Following the meeting with one of the employees of the Kalaallit Illuutaat, we participated in the communal dining at the Ajamut Café four different days and had conversations with 13 people in groups ranging from 1 – 4 persons. All conversations were in Danish.

Prototype

Our aim was to design a prototype which communicated the insights from the Deep Purple Project described in the *a priori* analysis in Chapter 2. We developed a prototype based on a PowerPoint presentation from a lecture made by the principal investigators from the Deep Purple Research Project, Alexandre Anesio. The prototype consisted of 10 images primarily from the PowerPoint presentation and other communication outputs of the Deep Purple Research Project (Anesio, 2022). The 10 selected images were printed in A4 size and laminated. Pictures were placed randomly on a table at the Ajamut Café.

Conversations

As preparation for having conversations with the people at Kalaallit Illuutaat we formulated open-ended questions bringing forward the perspective of the other person. We wanted to explore how we could initiate conversations and let them unfold in many unexpected ways, however our main objective was to include the other person's perspective and let conversations develop from their starting point. Afterwards, the conversation could unfold in any possible way. At some point during the conversation, we asked the participants to organise the pictures explain their organisation.

Participant observations and field notes

Observations were collected during conversations with one of us conversing and the other taking notes. Immediately, after conversations we noted down our reflections. Collecting observations and writing reflections had a dual purpose; to apply what we learned from the conversations with the people at Kalaallit Illuutaat in our development of our communication product and events, and to get experience in conducting an observational study and applying the method of participant observation. We wanted to explore our role as an active participant, thus we wanted to get experience in having conversations and interactions which were authentic and comfortable for the other person to participate in, despite one noting observations during the whole conversation. The experiences with data collection were applied during data collection at the communication events in Greenland.

Experiences from Kalaallit Illuutaat

Our pilot study gave us experience and some valuable insight into applying objects to initiate and facilitate conversations centred around the three insights of the Deep Purple Project. The following describes the main insights and experiences from our pilot study:

Prototype:

- The prototype supported communicating the three insights of the Deep Purple Project.
- The prototype helped bringing forward the other person's perspective throughout the conversations we had.

Our role:

- To bring forward the other person's perspective and background, we had to bring ourselves forward.
- It was challenging connecting the other person's perspectives with the insights of the Deep Purple Project.

Conversations:

- The conversations led to new understandings reached through collaboration.
- The conversations brought us closer to the people we talked to.

Participant observation:

- It was challenging to note observations of verbal and non-verbal expressions and interactions taking place simultaneously as well as the interactions *not* taking place between us, images, and the persons we had a conversation with.

The prototype supported communication of the three insights and brought forward the other perspectives

We learned that several people at Kalaallit Illuutaat had pre-existing knowledge about ice algae and the melting of the Ice Sheet, and some sought out information themselves e.g., attending a lecture on ice algae. Others had observed, over the last decade, an increased darkening of the Ice Sheet and an increased number of meltwater lakes when flying over the Ice Sheet. People connected the images to aspects of their own lives. Often it was the colourful pigmentation of the algae which they would associate with previous experiences. The colouration of the algae would also spark interest in the prototype with persons initiating conversations and asking questions because they wanted to know more about the red colour of the algae. This indicated that the prototype communicated the insight *interactions* since the most central aspect of the insight, and the research of the Deep Purple Project, is the pigmentation of the algae and the resulting colouration of the ice. An image which showed the change in the Ice Sheet's albedo value using a colour gradient were highlighted and sparked questions, often the colour gradient would be connected to temperature and melting. Melting is the result of the decreased albedo thus the picture supported us in communicating how decreased albedo leads to increased melting of the Ice Sheet. All the people we talked with understood that dark ice melts quicker than clear ice, however the dark colour of the ice was associated with pollution and particles. One person connected the pictures according to the colouration of the ice, suggesting that the prototype could effectively communicate the insight *interactions* across various scales. These preliminary results suggest the importance of the colourful images in communicating the insight *Interactions* and the Deep Purple Project's research.

The prototype gave an insight into the understanding of the insight *scale*

All the people we talked with at Kalaallit Illuutaat connected and related the images to each other, confirming that our prototype appeared coherent and as an integrated whole. Most of the people we talked with had

connected the pictures according to the spatial scale, shown on the images, expressing that the images were "zooming in or out on the ice". Alternatively, some would connect the images chronologically according to how they would be present ice algae in a lecture. These preliminary findings suggest that the prototype was effective in communicating the insight *scale* and to get an insight into the other persons' understanding of the biological induced darkening of the Ice Sheet. However, it was not clear from our conversations in Kalaallit Illuutaat how the insight *systems* was communicated. The images were associated with scientific artefacts and practices e.g., Ice core samples, petri dish and tubes for blood samples. The research practice of the Deep Purple Research Project was brought up during conversation, both by us and by the other person, suggesting the insight *systems*.

Conversations gave insight into experiences with ice and the Greenlandic Ice Sheet

Conversations would unfold to centre around the different ways Greenland is polluted by trash, particles, and waste both from Greenlandic citizens but also from Western countries. The dark ice was perceived as polluted with particles from other countries. Some expressed that they were frustrated and worried about the environmental damage and how that affects the environment. Some engaged in politics and different projects working with waste in the environment. The impacts on the food resources from the sea was a reoccurring conversation topic. Some explained the significance of marine resources in their diet but also in cultural practices such as Qulliq, the Inuit oil lamp. They shared examples of how science and research activities contribute to the pollution and colonisation of Greenland and the Ice Sheet. From the conversations it was evident that the people we talked with were concerned about the melting of the Ice Sheet and how Greenland might change with the disappearing of the ice. They shared their experiences with icebergs, calving glaciers, and the Ice Sheet e.g., their sled dog travels on the ice and how the ice conditions have changed making it impossible to follow the routes previously used. People at Kalaallit Illuutaat shared descriptions and photographs of the landscapes in Greenland, their travels, and experiences on the Ice Sheet. They shared stories from their lives, culture, and language with us. We learned a lot from these conversations, and some expressed that it was interesting to learn about the ice algae and us as persons.

The conversations brought us closer to the people of Kalaallit Illuutaat

The prototype and the conversations brought us closer to some of the Habitués of Kalaallit Illuutaat e.g., we were given a hug after conversations, and we were invited to participate in other activities at the house. Our pilot study gave us experience and some valuable insight into applying images to initiate and facilitate conversations centred around the three insights of the Deep Purple Project. These experiences laid the foundation of the design of our communication product and how we facilitated the communication events in Greenland.

3.3 Design of science communication product

Based on our findings from Kalaallit Illuutaat we realised that we needed to redefine our research questions and how we defined dialogue. What characterises dialogue? How to collect observations which describes the interactions between participants, the physical objects and us? After our pilot study, we had some experience in facilitating dialogues about the Deep Purple Research Project. However, it became evident that the prototype worked well in bringing forward the other persons' perspectives and knowledge but that it was not straightforward to connect the other persons' perspectives and knowledge to the scholarly knowledge of the Deep Purple Research Project. Still, it was the prototype which supported the connection between the two perspectives since the images served as a reference point.

Transforming the scholarly knowledge from a PowerPoint presentation to a physical installation

The process didactic transposition of this study consists of both transposing the scholarly knowledge of the Deep Purple Research project into a *content* of a science communication design and transposing the *format* of a communication output of the Deep Purple Research Project, a PowerPoint presentation, into an engaging installation. The design process can be perceived as a deconstruction of a lecture into a dialogue-based design in which images included in the PowerPoint presentation becomes interactive. We wanted participants' physical interaction with the objects to support the communication of the three insights of the Deep Purple Project. To achieve this, we further developed our prototype by printing all selected images in different sizes relative to each other, reflecting the spatial scale shown on the images e.g., the drone image taken on the Ice Sheet was printed out in a size larger than the image of a hand holding a piece of ice (see Appx.). The picture of the hand holding a piece of ice were printed in a size larger than the image of ice algae taken with a microscope and so forth. The selection of images included in the prototype were changed with the addition of an image of the weathering crust, thereby including a new spatial scale of ice and algae interactions. The satellite picture of Greenland was replaced with an outline of Greenland, making it possible printing the image in an A0 size print. All images included in the final communication product is included in the appendix. The idea with the different sizes of the images was to have participants *experience* the difference of spatial scale of ice and algae interactions since participants had to interact differently with the different sized images e.g., for seeing the smallest size images participants had to apply a microscope to see the image, whereas participants could walk on image of the outline of Greenland. Furthermore, all objects were designed so participants could leave a 'trace' on the object.

The communication product 'Connecting Communities'

The final communication product 'Connecting Communities' was a physical installation consisting of two main integral components:

- Physical objects communicating the three insights identified as the central aspects of the Deep Purple research project.

- A facilitator applying the objects to facilitate a dialogue with participants about the insights of the Deep Purple Project Research projects.

The physical objects of the installation consisted of the physical components termed 'Greenland', 'Weathering Crust' and 'Ecosystem Models'. Each of the components were intended to communicate the three: *interactions*, *scale* and *systems* and function as a collective whole rather as a collection of separate activities.

Greenland

The component 'Greenland' is an outline of Greenland printed out in poster size A0 (84.1 x 118.9 cm) (Fig. 5.2). The picture is attached on a plywood sheet and placed on the floor, facing the direction from which participant approached the installation (Fig. 5.5). The space within the outline was completely white symbolising the Ice Sheet which covers appx. 80% of Greenland (Raikar, 2023). Plastic gloves and a plastic cup with purple paint were placed next to the image. The intention with the paint was to have participants paint on 'Greenland' thus colour the Ice Sheet purple, thereby giving the facilitator a possibility of connecting participants' 'trace' on 'Greenland' with the insight *Interactions.* Furthermore, the 'traces' participants left on 'Greenland' were visible to the other participants who engaged with the installation. In that way, participants communicated with each other and contributed to the installation.

'Greenland' was also designed with the intention of giving an insight into participants' perspectives on the Ice Sheet by letting the participants decide how to interact with "Greenland" and what to paint. The design intended to give participants and the facilitator an opportunity to engage with 'Greenland' together. This was supported by the image being placed on the floor with free passage all around the image ensuring that was space for several people to interact simultaneously and not being restricted to specific areas of the image. The placement of 'Greenland' on the floor also intended to give the participant an experience of looking down on the Ice Sheet, thereby having the same perspective as a satellite from space (Fig. 5.4). 'Greenland' is the largest image in the installation, reflecting that the biological induced darkening of the ice sheet can be observed from satellites, thereby communicating the insight *Scale*. Also, it is the largest scale in which the Deep Purple research team research and quantify the interactions between ice and ice algae. The Deep Purple research team has developed the interactive webpage 'Albedo – Time Series Inspector' (Deep Purple Research Project, No date-b) with satellite measurements of the albedo of the Ice Sheet across time scales, thus communicating the insight *systems*. In the way 'Greenland' gives the participant an experience of the scale and magnitude of the biological induced darkening of the Ice Sheet.

Weathering Crust

The component 'Weathering Crust' was placed on a table within the installation and consisted of a handheld microscope and three images in different sizes placed in proximity (Fig. 5.1). The three images have all been taken by the researchers of the Deep Purple Research Project using a light microscope and a handheld microscope, similar to the one in the installation. The images of the ice algae were printed in a size which

made it difficult to see what the images showed. Some of the small pictures were placed in a glass bowl next to the microscope. Others were placed on top of an image of the weathering crust. The image of the weathering crust was printed in a larger size larger than the images of algae cells (Fig 5.1, see Appendix.). The microscope in 'Weathering Crust"' was provided by the Deep Purple Project and is one of the microscopes the researchers apply in their fieldwork on the Greenlandic Ice Sheet when collecting samples of the ice algae. It is possible to adjust the magnification by scrolling on a feature on the microscope. The microscope works by connecting to a smartphone through a hot spot and display the image on the screen of a smartphone. Using the smartphone videos and photos can be taken of the enlarged image shown by the microscope. A headlamp was placed next to the microscope to provide better light conditions when using the microscope (Fig. 5.1).

The different sizes of the images intended to communicate the insight *scale* and intended to have participants experience how it is necessary to use a microscope to see the ice algae and the structure of the weathering crust which the algae inhabit and interact with. 'Weathering Crust' was designed with the intention of having participants experience how Deep Purple researchers investigates the ice and ice algae when they conduct field work on the Greenlandic Ice Sheet. The component was designed as a model of the weathering crust of the Ice Sheet which can be investigated and explored by the participants using the microscope. The facilitator has the possibility to connect participants' interactions with 'Weathering Crust' to the field work practice of the Deep Purple Project, thereby communicating the insight *Ecosystems*. Furthermore, the model is designed to communicate the insight *Interactions*, by showing that the structure of the weathering crust is a heterogenous, porous, dynamic, and constantly changing environment rather than a solid block of ice. The heterogeneity and porous structure of the weathering crust are shown on the picture and participants can explore the structure by using the microscope. The small images of ice algae in 'Weathering Crust' were also designed with the intention to create coherence in the whole installation, across components. The participants were invited by the facilitator to glue the small images of algae on any object within the installation, thereby encouraging participants to connect the different objects instead of perceiving each component of the installation as separate activities. Gluing the small algae picture permanently on objects was also one of 'traces' participants could make on the different objects of the installation.

Ecosystems models

Similar to the prototype tested at Kalaallit Illuutaat, pictures in the different sizes were placed randomly on a table in the installation, constituting the component 'Ecosystems models (Fig. 5.3). The component was designed with the intention to give participants an experience and understanding of how the Deep Purple Research Project understands the ice algae and ice as 'supraglacial ice algal systems' which they investigate using models of the interactions between ice algae and environmental variables, as described in Halbach et al. (2023). When interacting with the object "Ecosystem Models", participants are invited to connect images of ice and ice algae interactions, across a range of spatial scales, making a visual model of the ice and algae

interactions (Fig. 5. 4). During the pilot study, we discovered that by inviting a person to organise images we were giving insights to their understanding of the ice and algae and how they interact. From the way participants would arrange the images of 'Ecosystem Models' the facilitator would have the opportunity to connect participants' model to the models of the Deep Purple Research Project. 'Ecosystem Model' communicated the insight *Scale* by having the different sized images show the range of spatial scales in which ice and ice algae interactions take place and the insight I*nteractions* by letting the participants investigate how the images of dark ice and ice algae are connected.

Discourse and facilitator design

The final communication product 'Connecting Communities' consisted of both physical components (Fig. 5.6) and a facilitator. The installation was designed with an interdependence in mind, meaning both the physical components and the facilitator were an integral part of the science communication design. During science communication events we were facilitators, taking on the role of a scientists, specifically for this study a Deep Purple researcher. The facilitator was designed with the intention to engage participants a in dialogue centred around the three insights. There are many ways to understand dialogue. Some definitions define dialogue as when all participants have an equal position and when all contributions are assigned the same value (Vice, 1997). Other definitions do not take the participants' positions into account but states that all utterances are dialogical because they are a response (Vice, 1997). In this study, we applied the definition of dialogue described in the analytic framework of meaning making interactions in science classrooms developed by Scott et al., (2006). They differentiate between an authoritative and dialogic discourse with a dialogic discourse being defined as a discourse in which several perspectives are represented alongside the scientific perspective. In an authoritative discourse only, the scientific perspective is represented. According to Scott et al. (2006) a discourse is interactive when it allows for participation of more than one person and noninteractive when it excludes participation of other people (Scott et al., 2006). Furthermore, they describe two structures of interaction: the triadic structure (I-R-E triads = Invitation-Response-Evaluation), which characterises an authoritative discourse. The chain structure (I-R-P-R-P = Invitation-Response-Prompt…) often characterises a dialogical discourse (Scott et al., 2006). During the communication events, facilitator aimed for facilitating a dialogic discourse with a chain structure, since the chain structure is an indicator of a dialogical discourse (Scott et al., 2006). To assist the facilitator in implementing a dialogic discourse, we prepared a sheet with questions and phrases in Danish and Greenlandic to ask participants.

Figure 5. *Photographs showing the physical components of the installation 'Connecting Communities' and the installation setup at communication events in Sisimiut. 1) the component 'Weathering crust. 2) The component 'Greenland. 3) The component 'Ecosystem Models'. 4) Participants engaging with the 'Ecosystem Models' and 'Greenland' during science communication event. 5) The installation setup at the Ilisimasat Science Festival. 6) The installation setup at the upper secondary school, GUX. 7) The installation setup at the upper secondary school, GUX 8) A bulletin board in Sisimiut showing the programme of Ilisimasat Science Festival. Photo courtesy of the authors.*

Chapter 4 Methods

4.1 Data collection

Observational study

This study is an observational study in which we apply qualitative methods to collect data. Observational studies are studies in which one observes how people act (Aarhus Universitet, No date-c), and differs from experimental studies since there are no control or treatment groups. This means that observational studies are more flexible to explore otherwise difficult questions, but the lack of control means that there is a risk of confounding variables and observer bias of the researcher (George, No date).

Participant observation

We used participant observation as a method for collecting data. *Participant observation* is a branch of observational study that allows the researcher to be an active participant while also observing the interactions in a natural settings (Københavns Universitet, No date). When applying participant observation as a method, the researcher is actively participating by interacting with the participants and trying to collect as many observations as possible to produce a detailed description of the event (Københavns Universitet, No date; Aarhus Universitet, No date-a). To collect observation using the method of participant observation, it is recommended to make a document which can guide the data collection, helping the researcher focus on what is interesting (Københavns Universitet, No date). We made an observational guide since we were interested in specific interactions between the objects, facilitator, and participant, and we were interested in how the facilitator used the objects in the dialogue with the participant. The observation guide document was also supposed to be used for writing field notes, but early on during data collection, we experienced that blank paper was more efficient for writing faster.

Field note technique

We collected observations as handwritten field notes. Handwritten field notes are a common method within anthropology used for collection details from an observed event (Aarhus Universitet, No date-b). When setting up the installation we made a mental exercise, as described in Emerson et al., (2011), in which we wrote about the physical setting, our setup, and our own mental state to go into 'an observant state' and being more aware of the details during events. Following the guideline for handwritten field notes by Emerson et al., (2011), we used *jotted notes* during the data collection, which is a form of notetaking that relies on speed rather than accuracy, by encouraging the use of codes, abbreviations, and symbols to spend less time writing, and more time observing. After data collection, we rewrote the *jotted notes* to field notes.

4.2 Communication events in Sisimiut, Greenland

Our three communication events took place on the 25th, 27th and 28th of February 2023 in Sisimiut, Greenland. Table 1 summarises our data collection during the communication events which had a total of 25 participants in 13 groups, and the number of participants would vary between 1-4 for each of those groups. We changed our roles as either facilitator or observer between groups. The length of the conversations was not set beforehand, and they varied in length between 5-25 minutes. Following Table 1 is a description of each setting and communication event.

Group no.	Setting	Participant no.	Facilitator
1.1	Science festival	1-4	Dan
1.2	Science festival	5	Dan
1.3	Science festival	6	Caroline
1.4	Science festival	7-9	Dan
1.5	Science festival	10	Caroline
1.6	Science festival	11	Caroline
1.7	Science festival	12-13	Caroline
2.1	GUX - day 1	1-2	Caroline
2.2	GUX - day 1	3-4	Dan
2.3	GUX - day 1	5-6	Caroline
2.4	GUX - day 2	7-8	Dan
2.5	GUX - day 2	9-10	Caroline
2.6	GUX - day 2	11-12	Dan
SUM = 13	**3 settings**	**25 participants**	**D = 6, C = 7**

Table 1. An overview of data-collection during science communication events incl. the number of participant groups (First column) and setting (Second column). Number of participants in each group (Third column). The person facilitating the group of participants (Fourth column). The final row indicates the total number of groups, settings and participants and the amount of dialogues Dan (D) and Caroline (C) facilitated.

When approaching participants and initiating dialogues, participants were informed about the study and their anonymity, and they had to accept participating in this study for the participants and our dialogue being included in the study. Each participant was introduced to the study and the participants were made aware that we were collecting observations for research. During each conversation, one of us would facilitate the dialogue with the participants (Facilitator) while the other noted down observations without engaging with the participants (Observer). After engaging with a participant group, the facilitator and the observer would write down their reflections and additional observations.

Communication event 1 at Ilisimasat Sisimut Vidensfestival 25/02/2023

The first communication was at the Ilisimasat Science Festival held at the cultural centre, Taseralik, in Sisimiut (Fig. 5.5). Taseralik facilitates different cultural events such as cinema, theatre, exhibitions,

conferences, events etc. The Ilisimasat Science Festival in Sisimiut were arranged by DTU Arctic. The festival took place over 5 days with various events incl. lectures, and informal meetings between researchers and citizens taking place at different venues in Sisimiut. The festival was promoted through bulletin boards in the town of Sisimiut (Fig. 5.8) and on Facebook. At Taseralik a few booths were set up advertising education programs. Our installation was placed at the entrance of Taseralik, and it was the first thing people saw as they entered. In this setting, the setup of our installation consisted of 'Weathering Crust' placed on a table, and 'Ecosystem Models' placed next to 'Greenland' on the floor (Fig. 5.5). The participants of this communication event were a heterogenous group with different backgrounds and age groups from children to pensioners being represented. Participant groups varied in size between 1-4 people for each interaction (Table 1).

Communication event 2 at GUX 27/02/2023

The second communication event was at the upper secondary school, GUX, in Sisimiut (Fig. 5.6). We started introducing ourselves in the classroom, the project and inviting students to participate. The installation was placed in a separate classroom. Students would volunteer to partake in our communication product. The setup consisted of two tables, with 'Weathering Crust' being placed at one table and 'Ecosystem Models' at another. 'Greenland' was placed on the floor. All the components of the installation had space around them so they could be accessed from all directions (Fig. 5. 6). The participants of the communication event 2 were all students at the secondary school, GUX, in Sisimiut and participants participated in groups of two (Table 1).

Communication event 3 at GUX 28/02/2023

The third communication event took place at upper the Secondary School, GUX, in Sisimiut (Fig. 5.7). All participants were students at the school, however, they were from a different class than the participants from the previous communication event. We started by introducing ourselves, and the project and inviting them to participate. The setup was placed in a chemistry lab close to the classroom. Here our setup was the same as the previous day and the students volunteered to partake in our activities (Fig. 5.7). The participants participated in groups of two (Table 1).

4.3 Data analysis

Thematic analysis

To analyse our collected observations during science communication events we used *thematic analysis* as defined and described by Braun and Clarke (2006) to look for patterns (themes). The search for themes requires the researcher to assign codes to data extracts. A data extract is a chunk of data that the researcher has separated from the other data, while a code is a short description of a data extract (Braun & Clarke, 2006) In the coding process, the research question and the researcher assigning codes determining which codes are assigned to a given data extract. When all data extracts have been given a code, the researcher combines codes to create themes. The theme is therefore a researcher's interpretation of a pattern of codes with the codes and data extracts being interpretations of the data. Throughout the thematic analysis, researchers move between levels of abstraction, themes and codes looking for nuances and descriptions of the data, actively interpreting the dataset (Braun & Clarke, 2006).

1. Familiarizing oneself with the data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report

Figure 6. The six phases in a thematic analysis (Braun & Clarke, 2006).

Because thematic analysis is a flexible method it is applicable for many research paradigms and purposes, but it is also difficult to report properly due to the many conscious choices to make, which is important because flexibility makes the many *thematic analytics* different from each other. To make it more systematic and thorough, Braun and Clarke defined six phases in *thematic analysis* which we have used to guide our data analysis (Fig. 6). The phases are not in an exact linear process, and some phases happen simultaneously (Braun & Clarke, 2006).

We approached our data analysis from an explorative perspective, meaning that we did not have an *a priori* assumption of the data. We conducted an inductive thematic analysis in which we through recursive rounds of coding created themes which responded to our research questions. First, we familiarized ourselves with the data by transcribing our field notes verbatim, including filler words, pauses, laughter and sounds, creating a single coherent document. We re-read this document while taking notes for initial ideas for codes.

Coding process

Initially, in the coding process, we pooled all our observations from our communication events with each observation constituting one data extract. We sorted our data extracts in relation to the three insights of the Deep Purple Project, meaning that if we found a data extract to reflect a communication of the three insights, we linked that data extract to the particular insight. Often the communication of an insight would be

reflected implicitly, meaning that the participants' experience, understanding and response to an insight were not always explicitly stated by the participants. We chose to interpret our observations in a semantic manner, and we found it necessary to use multiple codes for a single data extract to have a descriptive analysis of the interactions. Data extracts which did not reflect a communication of either of the insights were grouped together. After assigning the data extracts to the three insights, we conducted two rounds of inductive coding. We would code separately and compare codes after each round of coding. If there were any differences between the codes we assigned to the data extracts, we would agree on how specific data extracts should be coded.

Developing a model during the coding process

During the coding process, Figure 7 emerged from the inductive coding. The figure illustrates the interactions between actors (participants, objects, and facilitators) within the installation. Our data analysis showed that we had observations of three different actors simultaneously interacting with each other during our communication events (Fig 7). We used the figure as an analytical tool to group the codes from our inductive data analysis. We did this by asking ourselves questions of how the codes provided insight to the interactions between the objects, participants, and facilitator e.g., does this code say something about how the participants interacted or not interacted with the facilitator? How did the participants interact with each other? How did the context influence the interactions between the participant, object, and facilitator?

Merging codes into themes

We merged the codes to create 14 categories, which were then merged into 11 preliminary themes. Finally, we revised and merged the 11 themes during the writing process into 4 distinctive themes. Each of the 4 themes describes different aspects of the actors and their interactions with each other. We present the four themes of our thematic analysis in the following results chapter as four distinguishable themes, each with selected quotes. Quotes included in the thematic analysis have been translated into English and edited for readability. This editing entailed omitting filler words, eliminating irrelevant words or sentences, and adding words for additional information e.g., what objects either the participant or the facilitator is referring to.

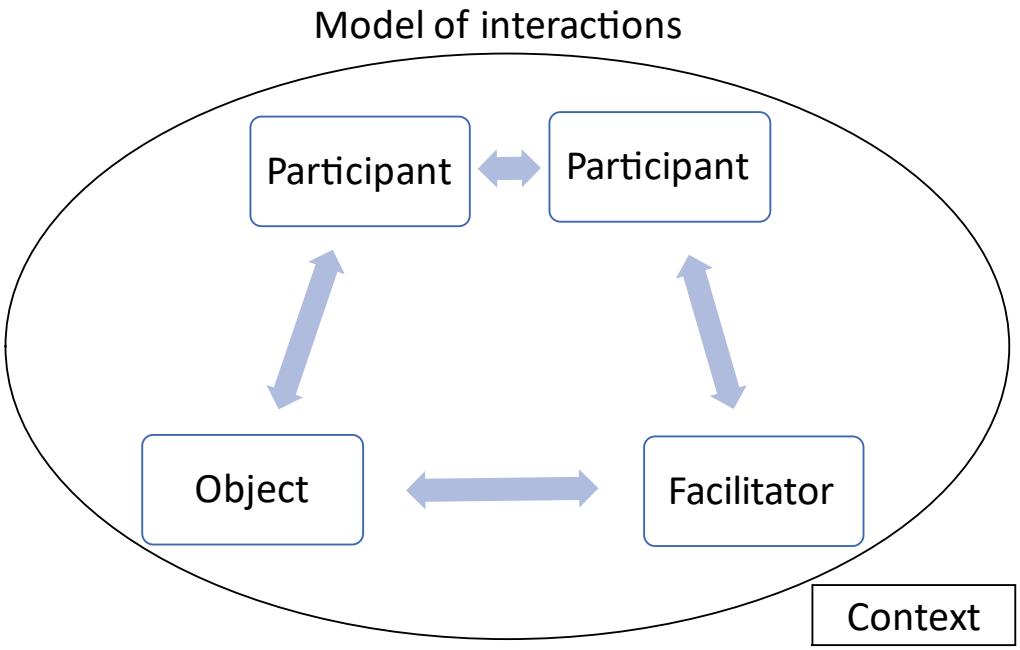

Figure 7. Model illustrating the interconnectedness of interactions between participants, object, and facilitator during our communication events in Greenland. Both the object and the facilitator are components of the communication product 'Connecting Communities'. The circle symbolises the context in which the interactions between actors take place. The model is developed from our thematic analysis.

Chapter 5 Results

5.1 Communication events at GUX Sisimiut, Greenland

Recall, that our communication design was designed using the framework of discourse by Scott et al., (2006). In the two communication events we delivered, the patterns in communication were markedly different. These different patterns did not affect the analysis at the level of themes and codes, but we will revisit the implications of the patterns in the discussion. The interactions we had with participants at GUX, Sisimiut were different from the ones we had during the Ilisimasat Sisimiut Science Festival. The dialogue we had with students during our communication event at GUX Sisimiut could be characterized as having an interactive authoritative discourse, resembling a question-and-answer routine with us primarily asking questions and students answering. The conversations were still functionally dialogic since students' perspectives and ideas were acknowledged by us as facilitators and the objects but the interanimation was generally low since students only interacted with the objects and shared their perspectives when explicitly asked or encouraged by us, thus we were guiding the dialogue. We did not change our approach to the facilitation of the interactions between communication events; we asked the same initial questions and set up the installation in the same way. We had more experience to draw on at GUX Sisimiut from our

communication event at the Ilisimasat Sisimiut Science Festival. However, at the Ilisimasat Sisimiut Science Festival we experienced some participants having a high level of interanimation with asking questions, exploring different ways of interacting with the objects and taking initiative in the dialogue with us and when interacting with the objects, so the dynamic between the facilitator (us) and the participants was the facilitator following the participant. Contrary, the dynamic between the facilitator and the students differed from our experiences with the participants at the Ilisimasat Sisimiut Science Festival with the students following the facilitator. In the discussion session, we will unfold possible explanations for the dynamics between us and the students during our communication events at GUX Sisimiut.

5.2 Analysis

From our thematic analysis, we have constructed four themes. All four themes describe different aspects of the observed interactions between the participants, facilitator, and the objects during the communication events in Greenland. First, we present three of the themes with each unfolding how either the participants, facilitator or the objects interacted and engaged with each other during the events. Following, we present a cross-cutting theme which encompasses the varying ways of verbal and non-verbal communication observed during the events. The four themes are *The four different aspects of facilitating a dialogue-based science communication product*, *The 'Engaged' Participant*, *Objects have agency*, and *Verbal and non-verbal communication.*

Theme 1 The four different aspects of facilitating a dialogue-based science communication product

This theme describes *the different ways* we *facilitated* during the communication events. These different ways of facilitating derive from our data analysis as patterns in our coding and should not be understood as 'ways of facilitating' we were consciously aware of while we were engaging with the participants in the situation. We observed four distinguishable ways of facilitating: (1) disseminating scholarly knowledge, (2) making an effort to establish a good relationship with the participants, (3) bringing forward the participants' perspectives, (4) connecting the participants' perspectives together with the scholarly knowledge of the Deep Purple Research Project. In the following section, we describe the different ways we observed ourselves facilitate by providing concrete examples from our data extracts.

Disseminating scholarly knowledge

One of the identified ways of facilitating was the dissemination of scholarly knowledge, specifically the three insights of the Deep Purple Research Project. The facilitator provided information or instructions to the participants, attempting to guide and support them in understanding the scholarly knowledge. This is shown in the following example:

> **Q1.** "*Caroline explains how the ice melts faster and involves the image that illustrates the dark and white ice gradients on a large scale. Caroline: "There is a person here. What do you think that is" while pointing at the dark part of the image."*
> (Dialogue 2.1, lines 512-513, authors' translation)

In the above the facilitator Caroline is disseminating scholarly knowledge by explaining how the ice is melting faster. The facilitator was observed disseminating scholarly knowledge through dialogue by asking the participants questions, as seen in the above example. When participants responded we sometimes observed the facilitator assess the participant's response and understanding of the disseminated scholarly knowledge. Following assessing the response of the participant, the facilitator would continue disseminating the scholarly knowledge of the Deep Purple Project as seen in the following example:

> **Q2.** "*Participant 3 responds to Dan: 'The coloured ice is melting quicker.' Dan evaluates and confirms that is correct. He connects it to the image of the albedo of the Ice Sheet, points to the image and explains how you can find the ice algae."*
> (Dialogue 2.2., lines 605 – 608, authors' translation)

This quote exemplifies how the facilitator, Dan, expresses an assessment of the participant's understanding of the albedo concept by stating that their response is correct. Following, the facilitator elaborates on the participants' response and connects it to the image of the albedo value of the Ice Sheet and the ice algae. This exemplifies how the facilitator was sometimes observed to assess the participants' responses whilst disseminating scholarly knowledge. Other examples of the facilitator disseminating scholarly knowledge include the facilitator instructing the participant to engage with the objects in a certain way e.g., when the facilitator instructs the participants how to use the microscope in 'Weathering Crust'.

Bringing forward participants' perspectives and knowledge.

From our data, we found a pattern in how the facilitator made an effort to bring forth the participants' perspective and knowledge. This section describes the ways the facilitator invited participants to share their knowledge and perspectives. This differs from the above section which describes how the facilitator would bring forward the scholarly knowledge and perspective of the Deep Purple Project when disseminating.

> **Q3."** *Caroline: 'what image catches your eyes?' Participant 6 points to the image of the different coloured snow: 'this one'. Caroline: 'how come you choose that image?' Participant 6: 'I don't know, the green colour?' Caroline explains what is shown in the image. Participant 6 points to the black coloured ice on the image of two gloves holding ice cores and asks: 'What is that?'. Caroline: That is algae have you seen those something like that before?' Participant 6 says no. Caroline: 'Do you want to try and colour the ice like the algae?' Participant 6 says yes."*
> (Dialogue 1.3, lines 163 – 174, author's translation)

The quote exemplifies the various ways we observed the facilitator bringing the participant's perspective forward. In the above the facilitator Caroline initiates the dialogue by asking the participant which image

stands out to them, thereby starting the dialogue from what has caught the participant's attention, in the above example, the coloured snow. In the example above the participant asks a question about the dark ice shown on one of the images, when replying the facilitator asks if the participant has seen the dark ice before, thus bringing the participant's experience and knowledge of dark ice into the dialogue. Thereafter, the facilitator invites the participant to paint on the object 'Greenland', thus bringing forward the participant's perspective by inviting them to leave a mark on one of the objects of the installation which the dialogue on the ice algae and darkening of the Ice Sheet can developed from.

Sometimes participants did not respond to the facilitator's efforts to bring forward their perspectives e.g., often when the facilitator asked participants an open question specifically about their feelings about the melting of the ice sheet, they would not give a response. Instead, we observed participants sharing their perspectives and knowledge when the facilitator framed the questions in relation to the objects, as exemplified in Quote 3. How the objects brought forward participants' perspectives is described in the theme 'Objects have agency'.

Making participants feel comfortable

In the above, we have described two ways of facilitating the *disseminating scholarly knowledge* and *bringing forward the participants' perspectives*. Both ways describe how we facilitated the directional flow of information between the facilitator and the participants by bringing forward both the scholarly knowledge of the Deep Purple and the participants' knowledge at the communication event. Moreover, we observed the facilitator making an effort to make the participants feel comfortable in the situation. This aspect of facilitating is therefore concerned with the social situation in which the exchange of knowledge between participants and facilitator is situated. During the communication event, we observed the facilitator establishing a comfortable social environment by introducing themselves in Greenlandic, acknowledging the participants' presence, and showing appreciation for the participants' participation and input. Furthermore, we observed the facilitator express admiration and interest in the participants' work, knowledge, and experience by using both verbal and non-verbal expressions incl. body language. Humour was also used by the facilitator when engaging with participants to create a comfortable social situation, as exemplified in the quote below:

> **Q4.** "*Caroline:" If you want, you can glue these small images wherever you want, also on me haha!"*
> *[…] The participants laugh and starts gluing the images on some of the images laying on the table, though not anywhere else*."
> (Dialogue 2.5, lines 877-880, authors' translation)

The quote shows how the facilitator jokes about themselves which makes the participants laugh, thus reducing the formality of the installation and the social situation. The quote exemplifies how humour was sometimes used by the facilitator in the interaction between the facilitator and participants.

All the above describes various ways in which the facilitator made an effort to make the participants feel comfortable in the social situation of the communication events. From our analysis, we found a central aspect of facilitating a dialogue-based science communication product and engaging with participants was to make participants comfortable in the social situation.

Making connections

The fourth aspect of facilitating, which we observed during our communication event, describes how the facilitator made various connections. The facilitator made connections between the participants' perspectives and input and the scholarly knowledge of the Deep Purple Research Project embedded in the objects or disseminated by the facilitator. Furthermore, the facilitator was observed to connect the objects of the installation and finally, the facilitator was observed to make a connection between themselves and the participant. This way of facilitating is distinguishable from the previous three, as it addresses how the facilitator is making connections, such as a connection between what the participant is saying together with what a Deep Purple researcher might do, or connections between the activities in the installation.

> ***Q5*** *"Participant 12: "It is interesting, how the melting is affecting the coast, especially as the ice-algae is flowing with the water, do you know if they can survive there? […] Caroline: "That is so well said, and it is exactly what a researcher might ask" as she seems to be excited about the participant's question."*
>
> (Dialogue 1.7, lines 418-420, authors translation)

In the example above, the participant asks a question, and we see that the facilitator responds by comparing the question to a researcher's way of questioning. We also see that the facilitator connects the participants' engagement with the objects to the researcher's systematic approach:

> **Q6** "*Dan explains that researchers use that microscope to investigate the ice. He shows the microscope and explains that participant 11 and 12 have been working just like the researchers."*
>
> (Conversation 2.6, lines 1018-1021, authors' translation)

Here the facilitator, Dan, explains that the way participants use the microscope is similar to researchers, thus connecting the participants with the researchers. The two examples above show how the facilitator connected the participant engagement with the installation to a researcher, either by what they said or with what they did. Another way the facilitator seemed to create connections, was by connecting the three objects:

> **Q7.** "*Caroline: "We can get a little closer to them [the ice algae] with the microscope we have brought with us" and shows the participants the table with the microscope.*"
>
> (Dialogue 2.3, lines 687-688, authors' translation)

This exemplifies how the facilitator was transitioning from one activity to another, by making a connection between the objects of the installation. In this example, participants and the facilitator had been talking about 'Ecosystem Models' when the facilitator made a transition between the components of the installation by inviting participants to engage with 'Weathering Crust' by inviting participants to take a closer look at the ice algae using the microscope. However, we observed that sometimes the facilitator did not make a clear connection between activities and objects.

In this theme we have identified patterns in our observations of ourselves whilst facilitating dialogue-based science communication during the communication events in Greenland. These patterns have been defined into four distinguishable ways of facilitating We will further unfold these ways of facilitating in the discussion section.

Theme 2 The 'Engaged' Participant

This theme describes the various ways in which the participants engaged with the facilitator and the objects of the installation during the communication events in Greenland. It is apparent from our analysis that we learned about participants who engaged with the installation e.g., their work, their previous experiences and knowledge. Additionally, our analysis shows that there was a spectrum of ways participants engaged with the installation 'Connecting Communities.' This spectrum ranged from participants being unresponsive to taking initiative when engaging with the objects and the facilitator. In the following, we describe and give examples of the various ways participants engaged or *did not* engage with the facilitator and the objects of the communication product 'Connecting Communities'.

The difference between interacting and engaging

During our communication events in Greenland, we perceived people as participants if they spent a considerable amount of time looking at the installation 'Connecting Communities', enquiring about the installation and/or investigating the objects. In the following example, a group of participants were interacting with the installation by spending time looking at and enquiring about the installation however they did not respond to the facilitator's invitation to engage with the installation:

> **Q8.** *"Dan approaches the participants in English and invites them to participate in the activities. Participants do not respond but look at him. Participant 1 asks 'What are you doing?' Dan answers: 'We are trying to talk about some stuff we brought.' Dan invites participants to participate in the microscope activity. Dan shows them a piece of ice. Participants go back and forth. They look at Dan but do not engage with the objects or in dialogue."*
> (Dialogue 1.1, lines 2 – 11, authors' translation)

The quote shows the distinction between participants who would *interact* but not *engage* in the communication product when invited by the facilitator. The above quote is a part of a longer interaction between the facilitator and participants which exemplifies how we observed some participants *interacting* by going back

and forth from the installation, spending time looking at the objects and the facilitator and by asking questions, however, as seen in the quote above, the interaction did not lead to participants engaging with the objects or in dialogue with the facilitator.

The following example shows the other end of the observed spectrum of the ways participants would engage with the communication product. The participant initiated an interaction with the facilitator by asking a question, engaging in a dialogue with the facilitator, engaged with the objects of the installation, asked questions, took initiative, and shared their knowledge, reflections, and experience with the facilitator:

> **Q9.** *"Participant 12: 'What is this, temperature?' [Refers to the image of the albedo value of the ice sheet]. [..] Caroline explains to Participant 12 that the image shows albedo and that it is related to temperature, and she explains that ice algae reduce the albedo. Participant 12 explains and points to the outside. [she has observed that the dark snow on the road melts slower than white snow in Spring and that is contradictory to the concept of albedo Caroline is explaining]. […] Participant 12 jokes and they laugh […] Caroline explains that similar to how the scientists put things into systems, they [Participant 12 and 13] can make a system. […] Participant 12: "Can I cut in this?" [the image showing the albedo value of the ice sheet]."*
>
> (Dialogue 1.7, lines 350 – 369, authors' translation)

The quote above shows how participant 12 initiated the dialogue with the facilitator by asking a question about one of the images of the installation. The participant also engages in dialogue with the facilitator by asking questions and contributing with their own experience and observations of dark snow and ice melting slower than white snow. This contradicts the concept of albedo which the facilitator is explaining, thus the participant contributes with a different perspective on albedo and melting of ice. Furthermore, the participant jokes which is also a contribution and way of engaging in the social situation. Additionally, to engaging with the facilitator in dialogue, the participant also engages with the objects when invited by the facilitator. As seen in the example above, the participant asks if she can engage with the object in an unintended way by cutting in one of the images, thereby showing initiative. The above quote exemplifies a participant who engages in the communication product by taking initiative, sharing their perspectives, asking questions, and joking with the facilitator.

The two examples above describe the opposite ends of the spectrum of how participants would engage with the installation 'Connecting Communities'. Ranging from the first example of the group of participants who did not engage to the example above of a participant engaging, we observed different ways participant would engage with the installation within this spectrum. In the following we will describe the multiple ways in which we observed participants engage.

Different ways participants engaged with the facilitator

During our communication event, we observed various ways in which the participants would engage in dialogue with the facilitator ranging from not responding to the questions put by the facilitator to initiating a dialogue with the facilitator. We observed that participants participated and contributed in different ways to the dialogue with the facilitator. From our analysis it became clear that participants engaged in dialogue with the facilitator by answering the questions posed by the facilitator, sharing their own experience and knowledge of the ice, the ice sheet and ice algae and by sharing their reflections and thoughts on the objects and the way in which they have engaged with the objects.

Examples of how the participants engaged with the facilitator

Some participants engaged with the objects but not in dialogue with the facilitator. We observed some participants responding with silence or with incomprehensible sounds when the facilitator asked them questions to initiate a dialogue. Some participants also exhibited body language which indicated that they did not want to engage in dialogue with the facilitator by having closed body language and not looking at the facilitator even though they would engage with the objects. However, most participants were observed to engage in dialogue with the facilitator. How participants would engage in the dialogue differed with some participants engaging by answering the facilitator's questions. The following shows an example of participants engaging in dialogue with the facilitator primarily by answering the questions asked by the facilitator:

> **Q10.** *"Dan asks if they have been to the ice sheet? Participant 8 replies that she has been to the ice sheet in Kangerlussuaq. Dan kneels and points to 'Greenland' and asks if Kangerlussuaq is located at a specific point. Participant 8 points to the 'Greenland'. Dan asks how it is like on the ice sheet. Participant 8 says that there are almost no plants and that there is cold. Dan asks if they have seen dark ice. Participant 8 responds: 'Grey.'"*
> (Dialogue 2.4, lines 747 -755, authors' translation)

The above quote exemplifies some of the dialogues we observed between the facilitator and participants which were characterized by the facilitator asking questions and the participants replying to the questions. Other participants were observed to engage in dialogue with the facilitator by contributing with their own knowledge and experiences, and instead of having to ask questions to continue the dialogue, the facilitator asks elaborating questions to what the participant shared [Q9].

Even though we engaged with a variety of participants in different settings we observed a progression in the dialogue between the facilitator and the participants. Often the facilitator would initiate dialogue by asking the participants what objects caught their eye and why. The facilitator would then invite participants to engage with one of the objects [Q3]. If participants engaged with the objects they would arrange images, paint on the large-scale outline of Greenland and use the microscope to look at the small-scale images and the dialogue between the facilitator and participants would be centred around the way participants engage with the objects. This progression is exemplified in the following quote:

> **Q11."** *Dan invites the participants to organize the images and shows how they can move the images around. Participant 7 and 8 arranges the images while they speak in Greenlandic. They giggle. Dan asks about the organization of the images. Participants 7 and 8 giggle and replies: 'seen from above, what you can take.' Dan gesticulates with his hands that they are zooming in. Dan highlights the small microscope images of ice algae and uses it as a transition between the objects 'Ecosystem Models' and 'Weathering Crust'. Dan instructs Participants 7 and 8 in using the microscope*."
>
> (Dialogue 2.4, lines 774 – 784, authors' translation)

The above shows how we often observed the dialogue between facilitator and participant unfold. In the example the facilitator Dan invites participants to engage with the objects and the participants organize the images. Following their arrangement of the images, the facilitator asks participants if they can explain how they have arranged the images, exemplifying many of the dialogues we observed between the facilitator and participants with the facilitator asking participants questions about their reflections, how they understood the objects and the way they have either placed, painted or other ways engaged with the objects. As exemplified above we often observed that when participants and the facilitator had talked about the participants' way of engaging with the objects, the facilitator would invite the participants to engage in another object in the installation e.g., the microscope and then the dialogue would progress in a similar manner with the participants engaging with another object and the facilitator asking participants to explain the way they engage with the objects.

How participants engaged with objects

Above we described the various ways participants engaged in dialogue with the facilitator, and in the following section we describe how participants engaged with the objects of the installation. We observed various ways participants engaged with the objects, ranging from participants not engaging with the objects to participants engaging with the objects by taking the initiative to engage with the objects in unintended ways. The two examples below illustrate this range of ways to engage with the objects, from no interaction with the objects to using the objects in unintended ways.

> **Q12.** *"Dan invites participant 5 to look at the images on the floor. Participant 5 responds: `Interesting´. Dan explains how the images can be moved. Dan: `There is no right or wrong´. Participant 5 asks: `Are you making a poster?´. Dan: `We are trying to understand how we can understand it in various ways´. Dan changes activity. […]. Participant 5 does not interact with the images. Participant 5 talks about water on the ice: `It is not that I don't want to drink it. I love to hike. I have my own tourist company. I am not afraid of It.´ Dan: `It sounds like you think the water is alive? ´. Participant 5: `It sounded like I was afraid of those animals. I am not´".*
>
> (Dialogue 1.2, lines 55 – 72, authors' translation).

The above exemplifies a dialogue between the facilitator and a participant where the objects are not included, despite the attempt from the facilitator. The facilitator invited the participant to engage with the objects and the participant expressed that the objects were interesting but did not interact with them beyond that. Instead, the participant engages in a dialogue with the facilitator centring around the participant's own experience and the organisms inhabiting the ice. However, the participant could still use the objects as a point of reference, that is interacting with the objects, by using 'Greenland' to show and explain their background whilst engaging in a dialogue with the facilitator.

Most participants would engage with the objects, either by painting on 'Greenland', arranging the images or looking through the microscope, which is how we designed the objects. Furthermore, some participants are extending this engagement by interacting with the objects in an unintended way.

> **Q13. "***Participant 12: `Can I cut in this image? ´ [the image showing the albedo value of the ice sheet]. After a few seconds of consideration, Caroline says: `yes´ (and seem excited about the proposition) while smiling and nodding. Caroline gives scissors to participant 12 who cuts the image in half. Participant 12 is squatting down, pointing, asking about the different image, and moving them around."*
>
> (Dialogue 1.7, lines 368-372, authors' translation)

In this example, the participant engages with the image of the object 'Ecosystem Models' and cuts one image in half, so it better comforts their arrangement of the images. Here the object is the centre of attention, but the participant is interacting in an unintended way, by cutting the image.

What is an engaged participant?

In the above, we have described the varied expected and unexpected ways in which participants were observed to engage and *not* engage with the objects and the facilitator of the installation 'Connecting Communities. Despite the participants engaging to a varying degree in the installation, it is evident from our data analysis that from all the dialogues we had with the participants who engaged in the installation we learned something about them regardless of how much or how little the participants engaged with the objects or in the dialogue with the facilitator. Our analysis expanded on our understanding of what an active, engaged participant means in dialogue-based science communication. Our analysis cannot provide any insights into *why* participants decided to engage or not in the ways they did, however, our analysis suggests that *how* the participants decide to engage is just as important as *if* they decide to engage. We will discuss the implications of these findings in the discussion section.

Theme 3 Objects have agency

This theme describes the ways the objects are interplaying with the participant and facilitator during the communication event, and in this sense, we understand the objects as active actors in the dialogue, just like the facilitator and participants are actors in the dialogue. In the following, we give examples of the ways the objects played an active role by supporting and initiating dialogue between the facilitator and

participant, providing a shared experience, being a point of reference, bringing forward participants' perspectives and supporting meaning making. Furthermore, we found patterns in the way the dialogue between the facilitator and participants would change depending on the objects they engaged with.

Objects initiated and supported the dialogue between the facilitator and participant

We observed that the objects both initiated dialogue and that the dialogues unfolded between the participants and the facilitator was centred around the objects as seen in the following example: the objects were the centre for our dialogues, providing topics to discuss for the participant and facilitator.

> ***Q14**: Dan invites participant 7, 8 and 9 to arrange the images. Dan includes the small microscope images. Participant 7: 'All of these are related, right?' Participant 9: 'Somehow we are moving closer, and closer, so I would somehow arrange them according to that.' Dan is moving the images and suggesting different ways to arrange the images, while participants 7 and 9 are watching and thinking. Participant 7 moves an image and starts arranging the other images: 'I am not sure'. Dan asks: 'This one?' and suggests the image with different microbial habitats. Participant 7 answers 'Something where you zoom in – the small microscope image.' Participant 8: 'Are these black areas all algae?' Dan responds: 'All the black colour is ice algae, very colourful, they live in the ice.' Pointing at the image of the Greenlandic Ice Sheet with people on it. Participant: 'Ah okay, so it is very zoomed out.'*
>
> (Dialogue 1.4, lines 223 – 236, authors' translation)

This quote starts with the facilitator inviting the participants to arrange the images which reflects how we started most dialogues. The objects were often used in this manner multiple times in the same dialogue, and participants' ways of engaging with the objects were used to develop the dialogue. The quote continues with one participant who expressed that the images were related and that they were "Moving closer, and closer" which means that the participant noticed that the images showed different spatial scales. After that, the participants and facilitator were working together to arrange the images and Participant 8 asked: "Are these black areas all algae?", referring to the image (see Appendix), to which the facilitator confirmed their understanding. As seen in the above example the dialogue between the facilitator and participants is centred around the images and, ice and ice-algae which exemplifies how the objects played an active part in the dialogue between the facilitator and participants. The above quote also exemplifies how we often observed the facilitator and participants being engaged in arranging the images, thereby sharing an experience. It shows how one of the participants was investigating the object ´Ecosystem models´ by arranging the images in different scales. The continued reflections and questions asked by the participants seem to reflect a meaning-making process which unfolds between the participant and the images. This example illustrates how we observed the objects participate in the communication event, as active actors, similar to how the participant and the facilitator were actors.

Objects provided a shared experience and assisted in finding common interests

The concept of objects as actors is strengthened by how the objects gave the facilitator and participant a shared experience, and that they assisted in finding common interests between the facilitator and participants.

> ***Q15*** *"Participant 11 puts the paint on the glove, and paints on 'Greenland'. Then they talk about how people are interacting with the ice. Participant 11: `People are falling on the ice´ Caroline and the participant laughs a bit. Caroline: `That's funny because we have called our presentation for researchers on slippery ice.' Participant 11: `I have made a similar presentation, when I was a student in Kangerlussuaq, it was just called students on slippery ice. ´ The participant explains their interest in art and culture, and that they had a few scientific courses from where they remembers seeing images that were similar to our images."*
> (Dialogue 1.6, lines 316 – 324, authors' translation)

Here the participant and the facilitator were initially engaging with the object 'Greenland,' and talking about how people interact with the ice sheet. The participant says "people are falling on the ice," Caroline responds by talking about a presentation we named "Scientists on slippery ice," and the participant shares that they have made a presentation with a similar name. The participant proceeds to explain more about their interests. For context, the facilitator had similar interests as the participants' interests. This coincidental similarity between facilitator and participant in having the same name for their presentations, and having similar interests becomes interesting when we later discuss the social dynamic in the situations. We see that the dialogue started with the act of painting on the object 'Greenland.' Therefore, the object 'Greenland' is understood as the actor which created the initial opportunity to find those similarities between the facilitator and the participant.

Objects brought forward participants' perspectives

Through the dialogues we had with the participants we got insights into participants' background, experiences, knowledge on ice, the ice sheet, microbes, ice algae, albedo, and melting. Many participants shared their experience of how it looks and feels being on the Ice Sheet, their observations and their knowledge of coloured ice and snow. Furthermore, some participants shared their observations on how the landscapes, ice and snow cover have changed over the years. Participants told us that they acquired knowledge of ice, snow, weather and the Ice Sheet from television, reports, work, education, and by sharing information with friends. We observed that the objects brought forward the participants' perspectives on ice and the Ice Sheet which often led to a dialogue unfolding between the facilitator and the participants as seen in the following example:

> **Q16.** *"Participant 12 starts to explain more about how she has placed the little microscope images of algae on 'Greenland': 'I have placed the markings where I have seen them [the ice algae] but it could be all along the coast. I have placed 3 [small images of the ice algae] where the American base is since I associate it and the algae with something dirty. […] You*

can see that the ice sheet has been reduced those places.' Participant 12 points on the places she has put markings in the South and Southwest. Caroline: 'Thanks! I have learned something new!' Participant 12: 'Me too, so exciting.'

(Dialogue 1.7, lines 392 – 399, authors' translation)

The quote above shows how the objects brought the participant's perspective and understanding of the ice algae and dark ice forward. The participant engaged with 'Greenland' and the small microscope images of the ice algae by gluing the small images of ice algae on 'Greenland' to mark the places along the coast where they had observed ice algae and where the ice sheet had been reduced. Furthermore, the quote shows how the objects gave insight into the participants' understanding of ice algae, dark ice and ice sheet melting and how the participant connected the ice algae to military activities by being dirty. As shown in the above quote the participant understands ice algae as something dirty, however, also connects the ice algae with the melting of the ice sheet. The quote shows how the objects are used by the participants to share their experience, understanding and knowledge with the facilitator.

Different objects bring different perspectives forward

We observed that the objects would bring participants' perspectives forward, however, it differed between objects what participants would share and bring forward. Participants would connect their background, and their experiences of being on the Ice Sheet with 'Greenland,' whereas 'Ecosystem Models' and 'Weathering Crust' brought forward participants' associations, knowledge and understanding of ice, melting, albedo, microbes, dark ice, and how all of those are connected. The following quote exemplifies how 'Greenland' brought forward participants' background, associations with the Ice Sheet and experiences of being on the Ice Sheet. The second half of the quote exemplifies how the dialogue changes when participants engage with 'Ecosystem Models' which brings forward participants' understanding of ice, albedo, and ice algae:

Q17. [Participant 9 and 10 engaging with 'Greenland'] *Participant 10 marks the route between Kangerlussuaq and Sisimiut with paint. Participant 9 paints the route of the Thule expedition along the West Greenlandic coast. They also paint a star on the Ice Sheet at the same latitude as Disco Island. Participant 9 draws a sledge and writes the names of the towns Ilulissat and Qeqertarsuaq. [they explain that their grandfather was from Qeqertarsuaq]. Caroline explains that the idea with 'Greenland' is that they can do [colour the ice] like algae. Caroline asks "Have you been on the Ice Sheet? Participant 10 replies: 'Yes, in 2019'. Caroline says 'Cool, I would also like to go to the Ice Sheet, did you see coloured ice?' Participant 10: 'Yes, by sand'.* […]

[Participant 9 and 10 engaging with 'Ecosystem Models'] *Caroline asks: 'What do you think happens here?' Participant 10 replies: 'The ice melts quicker when it is dark'. Caroline: 'Yes! What do you know about algae?' Participant 10: 'They live in the Ocean and in lakes. Does this image show different timepoints?' and points to the image showing the albedo*

value of the Ice Sheet at two different time points. Caroline says yes and explains the albedo effect."

(Dialogue 2.5, lines 822 – 855, authors' translation)

As seen in the quote above both objects brought forward participants' thoughts, experience, knowledge, and understanding of ice algae, dark ice, melting and the Ice Sheet as well as the participants' background. Starting from the objects, we observed a dialogue unfolded between the participants and the facilitator, with the facilitator asking questions about the participants' reflections on the objects and the way they engaged with them e.g., why they have marked a location of a town with paint. The above quote exemplifies how the dialogue unfolding between facilitator and participants changed depending on the objects since it differed between objects what participants would bring forward when engaging with the different objects. In the quote above 'Greenland' brought forward participants' experience with being on the Ice Sheet, their family background and knowledge of the expedition route of the Thule expedition led by Knud Rasmussen. Whereas the object 'Ecosystem Models' brought forward participants' knowledge and understanding of dark ice melting faster than clear ice, and that algae live in the Ocean and lakes. The observed change in the dialogue between the facilitator and participants is an example of the ways the objects were observed to be active actors during the communication events. In the following, we will unfold what perspectives each object brought forward.

'Greenland'

'Greenland' is a large outline showing the whole ice sheet. Participants were invited to paint on 'Greenland' with purple paint using a plastic glove. As seen in Q17, most participants would paint and mark places they had a relation to when engaging with 'Greenland'. Many participants would paint on the West Coast of Greenland especially the locations of towns which they knew of, lived in, or where they and their family came from [Q17]. Participants also marked expeditions routes they either had participated in or knew of e.g., Knud Rasmussen's Thule expeditions [Q17]. From participants' engagement with the object 'Greenland', a dialogue on the participants' experiences and observations of the ice sheet would often unfold [Q10 and Q17]. A few participants would paint places in which they have observed the ice sheet being reduced [Q16] or where they thought the ice sheet melted fast. Participants' experiences with being on the Ice Sheet ranged from being part of their work to never having seen the Ice sheet. Furthermore, participants would ask questions about the purple paint on 'Greenland' from which the facilitator could connect the paint with the ice algae and invite them to engage with the object. We also observed several participants respond to other participants' paintings on the object 'Greenland' with participants either continuing other participants' paintings, asking questions about other participants' paintings or choosing to paint where others did not.

'Ecosystem Models'

The object 'Ecosystem Models' consisted of 9 images in varying sizes showing dark ice, ice algae and the ice sheet at various scales. Participants were invited to arrange the images according to how the participants

would connect and relate the images with each other. Participants' arrangements of the image would bring forward their knowledge of dark ice, microorganisms, ice, albedo, coloured ice, melting and the Ice Sheet in the dialogue unfolding as exemplified in Q17. Furthermore, we observed participants associate the images of 'Ecosystems Models' with observations from their own lives. Several participants recognized the images of the ice algae as microorganisms, bacteria, and cells. However, most participants had not heard about the ice algae living and colouring the Ice Sheet.

Dark ice

When arranging the images of 'Ecosystem Models', several participants understood the dark colour of the ice sheet being caused by inorganic materials soil, sand, and dust. The dark ice was, for several participants, perceived as dirty and polluted [Q16]. One participant expressed weariness about drinking dark ice [Q12] and another participant shared their concerns with airborne pollution from large cities such as New York land polluting the ice which is the drinking water reserve in Greenland. Some participants would bring forward their observations of coloured and melting ice e.g., one participant had observed the dark ice next to the road was melting slower in Spring, thereby contradicting the principle of albedo [Q9]. However, several participants showed an understanding of dark ice melting faster than clear ice [Q17] and some would connect the dark-coloured ice with ice algae.

Melting of the ice sheet

Starting from the participants' and facilitator's engagement with the images of 'Ecosystem Models' a dialogue about the melting of the Ice Sheet and possible consequences unfolded. Several participants expressed that they heard about the fast melting of the Ice Sheet, saw places where the Ice Sheet has been reduced [Q16] and saw glaciers calving. When asked about their perspectives on the melting of the Ice Sheet participants mentioned Denmark being flooded, other expressed concerns about the melting of the Ice Sheet but also that the melting could lead to, in the participant's perspective, positive outcomes such as the growth of trees. The following exemplifies one of the dialogues being centred around the melting of the ice sheet following the participant engagement with the objects:

> **Q18.** *"Caroline explains the history of ice-algae and asks: `How are you [people in general] interacting with the ice? ´. Participant 12 expresses her worries for the future, the melting ice, but adds that it can also be positive, saying that `maybe there will start to grow trees? ´".* (Dialogue 1.7, lines 403 – 411, authors' translation)

In the above example, the participant shares their reflections on the melting of the ice sheet both concerns and potential positive outcomes. For the participant, a positive outcome would be the growth of trees in Greenland. However, in other cases, we observed that when asked about their feelings about the melting of the ice sheet, participants would not respond or did not know how to respond.

Colour on images of 'Ecosystem Models'

We noticed that the colour on the images of 'Ecosystem Models' was an important feature of the objects as the participants often responded to the colour, either by being the first thing that caught their attention, by asking questions or by participants associating the colour on the image to their own experiences. Many participants responded to the colour of the images by asking questions relating to the colour of the ice or snow or expressing interest in knowing why the ice or snow was coloured. Especially the image showing a visual representation of the change in the albedo value of the Ice Sheet using a colour gradient (see Appendix) led to participants asking what the colour gradient on the Ice Sheet meant, with some suggesting temperature and others connecting it to cities. Furthermore, participants made multiple associations to the coloured ice and snow shown on the images (see Appendix) e.g., one participant associated the red colour of algae with bacteria contaminating dried fish, and another participant associated the red-coloured snow (caused by snow algae) with blood from animals when hunting.

Scale, opposites, and chronology

Most of the participants arranged and connected the images of 'Ecosystem Models' but only some participants verbally expressed that the images were interacting with each other [Q14]. However, how the participants connected the images differed. When invited to arrange the images of 'Ecosystem Models' we observed that the participants overall would arrange the images in three ways according to: *scale, opposites, chronology*. When arranging the images according to scale, participants noticed that the images showed the ice at different scales, and some described the images as "zooming" in or out on the ice [Q14]. Even though we observed three ways participants would connect the images, the scale of the ice was the aspect most participants would arrange the images according to sometimes by combining scale and chronology. Furthermore, the scale could represent different things such as specificity with the small scales representing something less specific than the large scales. Alternatively, some participants connected the images according to a perceived chronology e.g., they would describe the process of a research study or how knowledge of the ice algae could be disseminated in a presentation. Participants would also link the images by defining opposing categories e.g., dirty/clean ice, dark/clear ice, hot/cold ice, something you can take/not take. These observations indicate that the objects communicated with the participants as seen in [Q14].

'Weathering Crust'

Participants were invited to engage with a microscope applied by the researchers from the Deep Purple Research Project in their fieldwork on the Ice Sheet. When engaging with the microscope participants were meant to look at an image of the weathering crust of the Ice Sheet finding small microscope images of the ice algae printed only visible when looking through the microscope. Most participants engaged with the microscope and used the microscope to look at the images of the ice and ice algae. The dialogue unfolding was often centred around participants' understanding and association with the image of the ice algae. Some participants recognized the small microscope images, some recognized them as microorganisms including

both bacteria and algae, and others saw fingerprints. Some responded by mentioning the red colour of the algae. Some participants associated the microscope with a school activity and others expressed surprise when the small images of ice algae were within the frame of the microscope.

In the theme 'Objects have agency' we describe how the objects in the installation 'Connecting Communities' have played a central part during the communication events. We observed the objects initiate and support the dialogues between the facilitator and the participant by situating the dialogue around the objects. Furthermore, the objects gave the facilitator and the participant the opportunity to share an experience together e.g., by painting the object 'Greenland'. We also saw examples of participants relating their fieldwork on the ice sheet with the objects, thus making a connection between the research of the Deep Purple Project and the participant.

There were examples of the objects facilitating a meaning making process when some participants engaged with the objects, participants connecting the images according to the scale shown on the images, both examples indicating that the objects communicated the scholarly knowledge of the Deep Purple Research Project to the participants. Moreover, we found that the objects brought participants' perspectives and knowledge forward. We observed that the dialogue differed depending on the objects participants engaged with. When participants engaged with the object 'Greenland' participants' backgrounds and experiences with the ice sheet were brought forward, whereas when engaging with the object 'Ecosystem Models' participants shared their knowledge on albedo, melting, microorganisms and dark ice. The dialogue between the facilitator and the participants was centred around participants' association with the images of ice algae when engaged with the object 'Weathering Crust'. The change in the dialogue between the facilitator and participants indicates that the objects also communicated with participants in some ways, thus we understand the objects as active actors in the communication product. Objects as active actors and their influence on participants engagement with the installation will be further unfolded in the discussion section.

Theme 4 Verbal and non-verbal interactions

This theme describes how we understand our verbal and non-verbal interactions with the participants during the communication events in Greenland. The verbal and non-verbal interactions we observed are overarching for all the themes in our analysis. In this sense, it is considered a 'cross-cutting' theme that describes the simultaneous interactions between objects, participants, and the facilitator during the communication event. We observed both verbal and non-verbal expressions being ways of communicating with non-verbal interactions including mimicking, facial expressions, gesticulations, impression of the body language, physical touch and physical distance between the facilitator and the participant. We observed that these varying ways in which the participant interacted influenced how the facilitator responded to the situation. Usually, the participants' verbal expressions were in harmony with what was non-verbally expressed though sometimes we observed the verbal and non-verbal expressions of the participants were contradictory:

> **Q19.** *"At this time of the Dialogue the participants seem hesitant and waiting. Participant 8 is not looking at Dan when he is talking. They are swaying while standing, touching the*

table. Dan asks the participants about their experience with the activities. Participant 7 responds: 'Fun, then we know something about algae.'"

(Dialogue 2.4, lines 805-809, authors' translation)

Here the participants are initially described as hesitant and inactive by the observer, based on the participants body language. In contrast, when the facilitator asked the participants about their experience of participating, they verbally expressed that it was fun to participate. The quote exemplifies instances where the non-verbal and verbal meanings are conflicting. In this manner, the participants' non-verbal ways of communicating are included in our interpretation of the interactions with the participants and expand our understanding of the verbal expressions we observed during our communication events. Furthermore, *the absence* of response and *silence* communicated just as much as the expressed non-verbal and verbal interactions and influenced our interactions during our communication events, despite *silence* and *absence* being difficult to observe, interpret and describe.

Language

Our communication events took place in a Greenlandic context where Greenlandic, Danish, and English are the most spoken languages. Most of the participants preferred speaking Danish with us except for two dialogues which we facilitated in English. During the communication events, we tried in some instances, saying a few phrases in Greenlandic. There are attempts from the facilitators to say phrases in Greenlandic, which some participants responded to in Greenlandic, and in other instances it seems to have been incomprehensible for the participant.

Language influenced our interactions with participants in various ways, with some of the influences being distinguishable in the coding of our observations, we observed speaking Danish or English were in some instances a barrier to communicating with participants.

Q20. "*Dan invites the participants to arrange the images in a system. Participants 3 and 4 pick up the images to have a closer look. They speak Greenlandic with each other. (Observer's note: My impression is that they are talking about the images in Greenlandic). Dan asks about their reflections […]. Participant 4 is moving their hands around, gesticulating. Participant 3 attempts to make a response to Dan in English but gives up and explains that it is difficult to articulate*."

(Dialogue 2.2, lines 588 – 596, authors' translation)

In the quote above, the participants discuss in Greenlandic with each other whilst engaging with the images. When the facilitator asks about their reflections the participant finds it too difficult to explain in English. therefore, the facilitator was unable to get an insight into the participants' meaning making process. It exemplifies some of the issues with the facilitator and participant not being fluent in the same languages. However, we observed language and the "difference in language" to influence the interactions between participants and the facilitator in various way which was not only negative but also led to a dialogue about the participant's work and knowledge as shown in the following example:

> **Q21.** "*Dan: `How do you say, you are the next football player´ [In Greenlandic]. Participant 5 answers. Dan: `That is difficult´. Participant 5: `That is difficult´. Dan and participant 5 talk about how to say, `talented football player´. Dan asks about the participants' use of language when guiding tourists. Participant 5 talks about his language skills.*"
> (Dialogue 1.2, lines 77-84, authors' translation)

The above exemplifies how the difference in language leads to the participant being the one knowing more than the facilitator, representing the scientist, thereby changing the dynamic between the facilitator and the participant. In the example, the facilitator asked how to say a sentence in Greenlandic, and expressing it was difficult which was difficult for the facilitator to do, and the participant agreed by repeating that it was difficult. In the quote, we see an example of the facilitator being in a position of learning, and the participant in a position of teaching.

The verbal and non-verbal ways of communicating is a theme that describes how the dialogue between participant and facilitator was influenced by the different ways to communicate. We found that both verbal expression words as well as non-verbal expressions such as body language and silence constitute the dialogue between participant and facilitator and are important in understanding the communication between the two. Furthermore, we observed examples of the influence of language in our interaction with the participants as different language backgrounds were in some instances a barrier in the dialogue but could also lead to further dialogue and seemed to change the dynamics between the facilitator and the participant of who was teaching or learning.

Chapter 6 Discussion

We begin the discussion by revisiting our overarching research question *How can the Deep Purple Research Project create meaningful outreach for Greenlandic citizens?* (RQ1) Throughout our study we have investigated this question through our two sub-questions *What aspects of the scholarly knowledge of the Deep Purple Research Project are relevant for citizens of Greenland* (RQ2) and *How can the relevant aspects of the scholarly knowledge of the Deep Purple Research be embodied in an engaging science communication design?* (RQ3). First, we will discuss our findings from our data analysis in relation to RQ3, unfolding how our science communication design embodied the relevant aspects of the scholarly knowledge and how our science communication design, the installation 'Connecting Communities' was engaging. The second section of the discussion will be a discussion of our RQ2, and whether the identified relevant aspects of the scholarly knowledge, the three insights were relevant for Greenlandic citizens. Based on our discussion of RQ3 and RQ2, we address our main research questions RQ1 and unfold what meaningful outreach is in a Greenlandic context. Subsequently, we discuss the limitations of this study and the methods we have applied in relation to the interpretivist research paradigm this study is situated within. Following, we present a set of recommendations for international natural scientists who want to communicate their research in Greenland. Finally, we discuss the implications of this study.

6.2 Dialogue

Aim of our science communication design

The overall objective of our science communication design was to communicate the scholarly knowledge in a dialogue-based communication format. We wanted to explore an alternative to the deficit model and design a science communication event, in which dialogue both functions as a way to communicate the scholarly knowledge from the Deep Purple Research Project and as a way to bring forward and include participants' perspectives on the darkening of the ice sheet. A central objective of our science communication design was that Greenlandic citizens had the opportunity to engage with the elements within the installation including both physical objects and the facilitator, representing the scientist. Our initial understanding of an 'engaged' participant was a participant who was engaged in a verbal dialogue about the scholarly knowledge of the Deep Purple Research Project in which "*[…] non-scientific forms of knowledge, such as cultural and experiential knowledge, are considered to have equal value as scholarly knowledge*" (Reincke et al., 2020, p.2), reflecting the lay expertise model of science communication (Tayeebwa et al., 2022). We applied the framework of Scott et al., (2006) on discourses of meaning making interactions in science classrooms, giving us a more practical approach to facilitate dialogue between the participants and the facilitator.

Different actors communicated simultaneously

Our analysis shows that participants engaged in different ways with our science communication design as described in the theme 'the 'Engaged' Participant'. During science communication events we observed the different actors communicating simultaneously and in various ways. We observed communication within a participant group, between participant groups, between the facilitator and the participants, between the objects and participants and between the facilitator and objects. During the coding process of our observations from the science communication events, Figure 7 emerged, visualising the different communication taking place within the installation. The communication between several of the actors was non-verbal e.g., the communication between objects and participants. Furthermore, non-verbal communication was also found to influence the verbal communication taking place e.g., between the facilitator and the participants. Thus, one of the central findings from our science communication events is that non-verbal communication is a significant aspect of the communication and interactions taking place within the installation. This means that we had to expand on our initial understanding of what it means to communicate scholarly knowledge using a dialogue-based format. This reflects the experience of Horst (2013) states that their experiences with designing and exhibiting spatial installations communicating research-based knowledge, led them to reconsider dialogue as being more complicated than they had anticipated, and that shifting from theory on engagement to actual practicing it was more complex as initially expected (Horst, 2013).

Dialogic discourse during science communication events

During science communication events we observed a dialogic discourse between the participants, facilitator, and the objects. Both the facilitator and the objects brought forward participants' perspectives which were represented alongside the scientific perspective during science communication events. Furthermore, the dialogue between participants and the facilitator had chain structures of Prompt-Response-Prompt-Response. Thus, we argue that our science communication design engaged participants in a dialogic discourse on the scholarly knowledge of the Deep Purple Research Project. When participants engaged with the installation, participants' perspectives were both expressed verbally and non-verbally.

Non-verbal communication central part of dialogue

The central finding that non-verbal communication was a significant part of dialogue between the participants, facilitator, and object is in accordance with recent literature in which non-verbal communication is found to be an important contributor to face-to-face dialogues (Bavelas & Chovil, 2006). Scott et al., (2006) also emphasise the importance of non-verbal communication since they found non-verbal communication changed the meaning of verbal communication, thus it is required to include both verbal and non-verbal communication in an analysis of discourses on scientific topics. In an ethnographic case study on knowledge construction in the context of a workgroup environment participants were observed to share perspectives both through verbal and non-verbal expressions (Holford, 2015). Holford (2015) describes the verbal and non-verbal interactions as two movements taking place simultaneously. In this way, non-verbal

expressions can be perceived as meaningful utterances (Peña-Alves, 2020) influencing the verbal dialogue (Bultitude & Sardo, 2012). An example of non-verbal communication influencing the dialogue, during the science communication events, was when the facilitator asked a question and participants were silent or when participants shrugged. The shrug and the silence can be understood as a response, like verbal expressions since they also provide information. We observed the facilitator interpreted and responded accordingly to both verbal and non-verbal responses of the participants, thus the non-verbal communication influenced the social interactions taking place during science communication events. This effectively means that non-verbal communication such as silences, gestures etc., should be included in the chain structures as prompts and responses. The non-verbal communication, within the installation, was not separate from the verbal communication but a part of a larger process of creating understandings and connections between the scientific perspective and participants' perspectives.

Different patterns in dialogue between contexts

Across the three science communication events, we observed different patterns in the discourse between the two contexts of the Ilisimasat Sisimiut Science Festival and the upper secondary school, GUX in Sisimiut. At GUX, participants engaged with the facilitator in ways that reflected a teacher-student dynamic, thereby framing the discourse to be more authoritative in character with the structure of the discourse resembling triads of Invitation-Response-Evaluation in more instances than observed in the discourse in the context of Ilisimasat Sisimiut Science Festival. Scott & Mortimer (2006) state that an interactive dialogical discourse is not common in science classrooms, and that the asymmetry in the roles of teacher and students is inherent for the school institution, resulting in students sometimes replicating a teacher-student dynamic even when the teacher is not present. We speculate that the school context might have influenced the dynamic between the facilitator and the participants during the science communication events at GUX since we experienced that it was more challenging to engage the participants in an interactive dialogic discourse, whilst they were 'students' within the institutional context of school. Still, we analysed all of our observations across contexts because we also observed sections of an interactive dialogic discourse during science communication events at GUX.

Tension between discourses

Scott et al., (2006) state that meaningful understanding of scholarly knowledge must entail *both* authoritative and dialogic interactions. They see authoritative and dialogic communicative approaches being connected, since one discourse gives rise to the other, supporting meaningful learning. Therefore, the two discourses should not be perceived in terms of a dichotomy but as there is a *tension* between the two in meaning making interactions and dialogue (Scott et al., 2006). Within the science classroom, there has to be a suitable balance between authoritative and dialogic discourse which can support students in making sense of scientific concepts (Scott et al., 2006). Within our installation there were also dual objectives in the sense that the installation both needed to communicate the scholarly knowledge of the Deep Purple Research

Project *and* to facilitate a dialogue in which participants' perspectives were represented, thus the installation needed to reflect a certain degree of 'openness'. In their reflections on the design and exhibition of a dialogue-based spatial installation communicating research, Horst (2011) states that there is an inherent tension between the objective of communication research and the objective of stimulating dialogue and engagement by allowing for multiple interpretations and inclusive models of communication (Horst, 2011). In our study, we saw this tension reflected in the discourse observed during science communication events. In the following sections of the discussion, we will discuss how we observed this tension between the objectives of communicating research and facilitating dialogue being expressed in different aspects of the communication taking place within the installation. In the final section of the discussion, we will synthesise these observations and reflections in a discussion of how dialogue-based installations can be a meaningful way of communicating the research of the Deep Purple Research Project.

In the above section of the discussion, we unfolded our argument of non-verbal communication being an essential part of the dialogue in our science communication product. The non-verbal communication during our communication events included the physical objects of our installation 'Connecting Communities'. The non-verbal communication happening between participants and the physical objects was found to influence the way participants engaged during our science communication event. This finding holds similarity to the discourse analysis by Holford (2015) who found that the physical object and participants were constantly shaping each other. In the context of our installation, we observed indications of the objects being significant in shaping the interactions and communication taking place during science communication events, and we will unfold these observations in the following section.

6.3 Objects

There is an extensive amount of literature across a range of disciplines that investigate human-objects interactions from various perspectives. Several studies, across different disciplines, investigate this relationship from an object-oriented perspective e.g., in trans-contextual communication (Budach, Kell, et al., 2015) learning within a museum context (Achiam et al., 2016; Paris, 2002), organizational studies (Ewenstein & Whyte, 2009), ethnography studies (Budach, Patrick, et al., 2015) amongst others. It is beyond the scope of this discussion to outline the body of literature on human-objects relationships and interactions, however, in this section of the discussion we have an object-centred focus, discussing the research question "*How can the relevant aspects of the scholarly knowledge of the Deep Purple Research be embodied in an engaging science communication design?"* (RQ3) by drawing on different literature which centralizes objects and their materiality giving them agency in shaping social interactions, activities, language, meaning-making and establishing social bonds across temporal and spatial contexts (Budach, Kell, et al., 2015; Budach, Patrick, et al., 2015). According to Budach, Kell, et al. (2015) it is an almost self-evident truth that objects influence an interaction. However, there is not much literature within the field of

science communication on how non-human objects and their materiality influence information transfer reflecting a tendency to perceive science communication as being disembodied (Davies & Horst, 2016).

Objects were active actors during science communication events

Our results indicate that the physical objects included in the science communication design had agency by actively influencing the communication taking place within the installation and by embodying the three insights. Moreover, the objects communicated the scholarly knowledge to participants, whilst also bringing forward their knowledge and perspectives. The perspectives of the participants were brought forward non-verbally through the 'traces' participants made on the objects and verbally when participants formulated their reflections in dialogue with the facilitator. Because the objects brought forward participants' perspectives, they influenced the dynamic between the facilitator and the participants, resulting in an interactive dialogic discourse. Furthermore, we argue that our results show that the objects enabled the participants and the facilitator to engage in a shared meaning making process.

In Figure 7 non-human objects are placed as a central actor during science communication events, indicating that both human and non-human actors were actively influencing the communication taking place during science communication events. A similar figure is presented by Morrissey (2002) who analysed museum visitors' dialogue when engaging with a skull. Similar to Figure 7, the physical objects were placed as active actors with double arrows suggesting a two-way communication between the human actors and objects (Morrissey, 2002, p. 290). This finding reflects the central positions of Actor-Network Theory (ANT), developed by Latour, Callon and Law in the 1980s (Irish & Romkey, 2021). ANT describes humans and non-humans, situating them in a 'flat' ontology which describes humans and non-human actors without distinguishing between the two. Instead, ANT perceives the world as a heterogeneous assemblage of *actors*, consisting of both humans and non-humans, in continuously changing *networks*. An actor is a 'relational effect', thereby discarding the traditional perception of non-human objects as passive entities (Jóhannesson & Bærenholdt, 2009). This perspective centralises objects in social interactions with objects both influencing humans and being influenced by the humans interacting with them. Thus, we understand that within the installation 'Connecting Communities' both human and non-human objects were simultaneously influencing each other during science communication events.

Objects embodies knowledge, culture and scientific practice

The objective of this thesis was to explore how we could transpose scholarly knowledge of the Deep Purple Research Project into an interactive installation consisting of physical objects that would embody the relevant aspects of the scholarly knowledge, the three insights *interactions, scale, system.* The notion that physical objects can embed knowledge and culture is a position reflected across a range of disciplines and literature (Budach, Kell, et al., 2015). Within museum studies, concrete objects represent abstract ideas and different realities (Paris, 2002). In product design, a central understanding is that physical objects

communicate and that their communicative aspects are just as important as their function (Lenau & Lindegaard, 2008). Through the manipulation of an object's shape and material, symbolic and sensory information can be written into the object, making the objects carriers of communication. However, the cultural context and environment in which the objects are situated, also determine the communication (Lenau & Lindegaard, 2008). In this way, knowledge and information are not only in the mind but is equally embedded in the surroundings in signs, tools, and artefacts, and objects can share and communicate this knowledge and information by making it tangible through sensory modality (Achiam et al., 2014). An example of how we observed the objects embody knowledge, during science communication events, was when participants left a permanent 'trace' on the objects e.g., by painting on 'Greenland'. We found that participants would respond to the 'traces' made by other participants influencing how they made sense of the objects. This aspect of our science communication design exemplifies how participants' understanding of knowledge was embedded in the objects and could be communicated through 'traces', to other participants sometimes influencing participants' response and way of engaging with the objects e.g., one participant expressed that they painted on the object 'Greenland' in relation to where other participants have not painted. Others said that where other participants had painted was in accordance with where they had observed dark ice. Another stated that the way the images of 'Ecosystem Models' were connected, by a previous participant, reflected their understanding of the images. This finding suggests that knowledge and information can be embodied and communicated through the sensory modality of the physical objects within the installation. However, a central objective of this study was to design objects which embodied *scholarly knowledge*, the three insights of the Deep Purple Research Project, in a way which would allow participants to access and engage with the scholarly knowledge embodied in the objects.

Achiam et al., (2016) applied didactic transposition to understand what kind of scientific engagement objects could prompt and support by looking to the scientific community for whom the objects in question are sources of information. Their findings are significant because they show that objects prompted activities and reflections amongst students that were recognizable from the viewpoint of the scientific discipline (Achiam et al., 2016). Additionally, they found that students' inquiry was prompted by the features of the objects and the way students related to them since the features of the objects 'suggested' the students' ways of engaging with the objects. The specific nature of the objects together with a research question posed by the educator prompted authentic scientific activities amongst the students (Achiam et al., 2016). The study by Achiam et al., (2016) is situated within the educational context of a museum. However, there are similarities between their approach and this study incl. the application of didactic transposition to investigate the transfer of scholarly knowledge between contexts and the investigation of how objects can engage participants in scientific reasoning. Our results indicate that objects would prompt participants to engage in activities and reasoning that held similarities to the insights identified as the relevant aspects of the scholarly knowledge of the Deep Purple Research Project in the *a priori* analysis (Chapter 2).

Examples of how participants engaged with the insights

An example of some of the observations we made that indicated that the objects embodied and communicated the insights was when participants would arrange the images of the installation and relate the images of 'Ecosystem Models' in a systematic manner, thus reflecting the insight *system*, which had the objective of engaging participants in constructing a model by connecting the different images of ice and algae interactions, similar to the researchers of the Deep Purple Research Project [Q14]. However, none of the participants expressed that they had created a model of ice-algae interactions. Similar to the findings of Achiam et al., (2016) it was the educator, in this study the facilitator, who had to articulate a connection between the participants' organisation of the images and the practice of the Deep Purple researchers. However, it was the objects which prompted participants to reflect upon how the images were related. There were indications of 'Ecosystem Models' communicating all three insights since most participants would connect and arrange images according to the spatial scale shown on the picture with some expressing that they understood that the images were related e.g., by "zooming in or out" [Q 14]. However, some participants would relate the different spatial scales of ice, shown in the images, to chronology and specificity e.g., the images showing large spatial scales would be the beginning of a presentation or that the small spatial scales showed something specific. Others would relate the images according to a dichotomy e.g., dark/clear, or dirty/clean ice. The above exemplifies how we observed different indications of the insights being embodied within the objects. Our results show that participants engaged in various ways with the objects, however we saw a pattern, across participants, in how they would engage with the objects suggesting that the objects prompted participants to engage with them in specific ways with different objects 'suggesting' different things e.g., the object 'Greenland' which represented a satellite image, 'suggested' to many participants to paint the locations of different towns. Because we saw a pattern in the way participants would engage and understand the objects, we argue that this can be perceived as specific knowledge and information embedded in the objects, which can be accessed when engaging with the objects. This can be perceived as a way objects communicated non-verbally with the participants during science communication events.

Participants created their own understandings of the scholarly knowledge embedded in the objects

Despite there being indications of the insights being embedded and communicated by the objects, participants' responses and understandings were not identical with the scientific understanding of the Deep Purple researchers e.g., some participants would connect images relating to the dark ice with being dirty and several participants would connect the dark ice with pollution e.g., air-borne or from a military base [Q 16]. This distinction holds similarities with the Deep Purple Research Project since they perceived light-absorbing particulates as both including particles and ice-algae. This is an example of how the scientific perspective is expressed differently than within the original research context. A central understanding of the theory of didactic transposition is that scholarly knowledge is produced, organised, and represented according to the needs and practice of the research context (Bosch & Gascón, 2006). This means that it is expected that

when the scholarly knowledge is transposed into another context it will appear differently. Yet, this does not mean that a transposed version of the scholarly knowledge is worse than the original version of the scientific practice or knowledge (Chevallard & Bosch, 2014).

Similar to the findings of Achiam et al., (2016), we found that the objects prompted participants to engage with aspects of the scholarly knowledge of the Deep Purple Research Project providing them with an understanding which likely would not have been available to them through mental representations alone. By engaging with the objects, participants had the opportunity to engage with aspects of the scholarly knowledge through their own trajectories of inquiry. The idea that installations can embody and communicate research-based knowledge which participants can access by engaging with physical objects is central to the work of Horst (2013). The installation by Horst (2011) is an example of a science communication design in which the scholarly knowledge, in their case social science, is embodied in an interactive installation consisting of physical objects with the objective of engaging visitors in dialogue by presenting them with different arguments and perspectives on the social responsibility of science. Horst (2011) applied a process of 'translation' of research-based knowledge from journal papers into physical interactive elements and then observed what meaning these elements produced when visitors met them. Furthermore, the objects of their installation had the objective of enabling visitors to *experience* the scientific perspective instead of having it explained (Horst, 2021). This objective is similar to the objectives of the science communication design of this study, described in Chapter 3.

Scientific images as communicators within the installation

Central to all the communication outputs of the Deep Purple Research Project is the use of pictures and other visual models and representations (Deep Purple Research Project, No date-e). In the following, we will discuss the 'scientific images' transposed from the Deep Purple Research Project, since they were a central aspect of our science communication design and how they engaged participants. According to Davies & Horst (2016), visual representations are a vital part of science culture and communication regardless of format, content, and context. Scientists and communicators are often advised to use visual representations to communicate research and the resulting omnipresence of images in communication means that they are often taken for granted in the experiences and analysis of communication processes, appearing as neutral representations of scholarly knowledge (Davies & Horst, 2016). However, images are used to make claims and convince audiences. Even photographs which seem 'natural' are, according to Davies & Horst (2016) composed, framed, and interpreted. The seeming objectiveness of scientific images (Kjærgaard, 2011) makes them powerful and persuasive when communicating scholarly knowledge (Davies & Horst, 2016). The position of Davies & Horst (2016) and Kjærgaard (2011) reflect that objects, such as images and visual representations, can embed information and communicate a scientific perspective. According to Kjærgaard (2011), images are crucial to the way we present, observe, and interpret things (Kjærgaard, 2011).

Despite being powerful in communicating science, 'scientific' images are a product of the scientific culture they are produced within and some of their meaning may be lost as they travel to different contexts (Davies & Horst, 2016). When receiving any kind of information through science communication, whether through images or other means, people will always bring their preexisting knowledge, about that science to bear upon it (Davies & Horst, 2016). It is therefore worthwhile unpicking how visuals are used within science communication. How are the visuals produced? Where do they come from, how do they travel and how are they read and interpreted by different audiences? (Davies & Horst, 2016). These questions are similar to questions central to didactic transposition theory. This emphasises how images and visual representations are also important aspects to consider when transposing scholarly knowledge to other contexts.

We hypothesize that our transposition of the images in a PowerPoint presentation by the Deep Purple Research Project into an interactive installation changed the way participants engaged with the scholarly knowledge embedded in the images. We found that the images were effective in engaging participants in dialogue about the scholarly knowledge. As Kjærgaard (2011) states, images lure in audiences. We observed the images sparking curiosity e.g., participants would choose images because they wanted to know more about a colour shown on the images. Furthermore, participants were engaged in making sense of the images by sometimes relating them to their own previous knowledge and experiences. This finding reflects the position of Davies & Horst (2016) and Kjærgaard (2011) who states that the meaning of scientific images changes in different context since people always bring upon their own experience and pre-existing knowledge in their interpretation of the image. By presenting the images of the Deep Purple Research Project in an interactive science communication format participants' pre-existing knowledge, experience, and interpretation of the images were brought forward both verbally in dialogue with the facilitator and non-verbally through the objects of the installation.

Objects changed the way participants and facilitator communicated by bringing forward participants' perspectives

Besides being effective in communicating the scholarly knowledge of the Deep Purple Research Project we found that the images of our installation held agency by bringing forward participants' understanding, knowledge and experience, thus actively influencing the dialogue between the facilitator and participants resulting in an interactive dialogic discourse between the facilitator and the participants. This reflects a different dynamic than possible when applying communication approaches reflecting the deficit model of science communication (Reincke et al., 2020). The agency of the physical objects within the installation 'Connecting Communities' consisted of influencing the discourse between facilitator and participants and enabling ways they could engage. The idea that objects can transform the way humans interact with each other is also central to the analysis by Peña-Alves (2020). They state that objects call to us functionally, stimulating our cognition and providing us with a new pathway of action, thus through object-mediated communication non-humans become the centre of communication and push the conversation forward.

Budach, Kell, et al. (2015) also state that objects change the way people communicate and influence the social interactions taking place. In their ethnographic study, they analysed verbal and non-verbal expressions within a group of Inuit women who 'talked around objects'. Budach, Kell, et al. (2015) found that the physical objects and their materiality influenced the way the participants communicated and gave rise to specific forms of talk and structured the narratives shared amongst participants, thus having co-agency in influencing the social interactions and dialogue (Budach, Patrick, et al., 2015).

Participant's perspectives were brought forward

Our results show that by centre the dialogue around objects participants' perspectives were brought forward and we were given insights into the participants' experience and knowledge of the ice sheet, their understanding of the scholarly knowledge of the Deep Purple Research Project, and their background. We gained these insights through the 'traces' participants made on the objects when they engaged with them. These could be permanent 'traces' when participants painted on the objects or less permanent when they arranged the images. These 'traces' are non-verbal, though as Peña-Alves (2020) we understand non-verbal communication as meaningful utterances. Participants' perspectives were also brought forward when they articulated their reflections and understanding of the objects in dialogue with the facilitator, thus participants' perspectives were expressed verbally and non-verbally within the space of the installation. This ability was a significant part of the objects' agency and therefore the objects can be understood as 'semiotic resources' since the participants and the facilitator had different cultural backgrounds and language abilities (Budach, Kell, et al., 2015).

Skjervedal (2018) found that photographs were powerful in bringing forward Greenlandic citizens' perspectives and giving insights into the lives of the participants of her study. They investigated meaningful engagement in relation to public participation in the extractive industry in Greenland and by including photographs Skjervedal (2018) describes how the visual representations guided the conversations they had with participants which "*opened a window to a knowledge and understanding*" (p. 14) they otherwise would not have acquired. This understanding consequently influenced their research focus and approach. Skjervedal's experiences hold similarities to our experience and research approach. During our pilot study at Kalaallit Illuutaat (Greenlandic house), we found that the visual representations of the Deep Purple Research Project supported and guided conversations and brought forward the perspectives, knowledge, experiences and understanding of the people at Kalaallit Illuutaat. We used our experiences to further develop the visual representations resulting in the installation 'Connecting Communities'. In addition to giving insights into participants' understanding and experience of the ice sheet and the scholarly knowledge, we observed physical objects support an interactive dialogic discourse between facilitator and participants. Furthermore, we observed a pattern in the way the dialogue between the facilitator and participants would progress with the dialogue being centred around the way participants engaged or understood the objects, thus the objects served as a point of reference, guiding, and structuring the dialogue.

Objects enabled new dynamics within the space of the spatial installation

We found that objects both communicated and shaped interactions. According to Peña-Alves, 2020, humans and objects speak and convey new impactful information to interpret and respond. If the object presents knowledge in a way which does not exclude other ways of knowing but instead allows for multiple perspectives, then visitors of a museum exhibit may begin to engage in the evaluation of that presentation against their own perspectives, resulting in a shared authority (Roberts, 1997). In the context of our science communication design, we observed the objects engage several participants in evaluating the scientific perspective against their own. Similar to our findings and experience during science communication events, Skjervedal (2018) found that the use of photographs motivated the engagement of young Greenlandic citizens by capturing their interest and giving them an opportunity to express themselves in a non-verbal way. By using photographs instead of conventional interviews Skjervedal (2018) found that young Greenlandic citizens actively engaged and brought forward their own perspectives. Based on her findings Skjervedal (2018) argues that by using photographs as a way for participants to express themselves, the uneven power in the relationship between the researcher and the citizens was levelled since the images supported the dialogue and gave insights into otherwise inaccessible knowledge. However, a key difference between our study and the study by Skjervedal (2018) is that we applied images from the Deep Purple Research Project and not the participants' photographs.

We found that the images were effective in engaging participants in an interactive dialogic discourse about the scholarly knowledge of the Deep Purple Research Project with the images both engaging participants in making sense of the scholarly knowledge and bringing forward their understanding and perspectives. Therefore, we argue that the images enabled and supported a different dynamic between the facilitator and participants, than found in lecture formats, since the participants' perspectives were represented alongside the scientific. Additionally, it was not only the dialogue between the facilitator and the participants that the objects influenced. The 'traces' participants left on the objects made their perspective visible for other participants to engage with and make sense of, thus the objects enabled a non-verbal dialogue between participants. This aspect of our science communication design meant that the installation developed continuously as participants engaged with the objects making participants, to some extent, co-creators of the installation (Horst, 2021).

Objects facilitated a shared meaning making process between participants and the facilitator

We argue that the objects had agency in enabling the participants and facilitator to engage in a shared meaning making process structured by the objects Because the physical objects had agency in communicating the scholarly knowledge and bringing forward the participants' perspectives, we observed an interactive dialogic discourse between the facilitator and the participants. During science communication events we observed the objects being a shared activity which the facilitator and participants could engage in. This

shared activity can be characterised as a shared meaning making process which was centred around the objects. With meaning making process we draw on the definition by Zittoun and Brinkmann, 2012:

> "'*Meaning making' designates the process by which people interpret situations, events, objects, or discourses, in the light of their previous knowledge and experience. 'Learning as meaning making' is an expression emphasizing the fact that in any situation of learning, people are actively engaged in making sense of the situation – the frame, objects, relationships – drawing on their history of similar situations and on available cultural resources [..]* " (Zittoun & Brinkmann, 2012, p. 1809)

During science communication events, we observed several participants being engaged in interpreting and making sense of the objects by drawing on their previous experience and existing knowledge to understand the objects. Simultaneously, the facilitator was engaged in 'making sense' of the participants' engagement with the objects, and their verbal and nonverbal responses, seeking to understand their perspective. These observations reflect the findings of the analysis of visitor's dialogue centred around physical objects within a museum context (Morrissey, 2002). Morrissey (2002) states that when encountering physical objects visitors are actively engaged in creating knowledge. Furthermore, they have an opportunity to collaborate in a dialogue of inquiry in which knowledge is not transmitted from one person to another but constructed and continuously negotiated and renegotiated whilst they engage with the object (Morrissey, 2002). The knowledge construction and negotiation which happens when people engage with physical objects changes the social dynamic (Rowe, 2002). Meaning making is a social process in which both non-verbal and verbal modes of communication, including physical objects, contribute to the creation of social meaning (Budach, Patrick, et al., 2015). Thus, we argue that the objects enabled participants and the facilitator to engage in a meaning making process in which they sought to understand the perspectives brought forward through the objects. As we argue above, the physical objects allowed participants to create new understandings of the scientific perspective embedded in the objects and evaluate it against their own. The objects also allowed for participants' perspectives to be brought forward both non-verbally through 'traces' and verbally when they articulated their understanding and reflections, giving the facilitator insights into participants' perspectives and giving the facilitator the possibility of creating new understandings of the scholarly knowledge of the Deep Purple Research Project and the ice sheet.

In the above, we have discussed our empirical results using literature from different disciplines to unfold how the physical objects of the installation were engaging. We argue that the physical objects were actors alongside the facilitator and participants because the objects actively influenced the communication taking place within the space of the spatial installation, thus having agency. Our results indicate the agency of the objects involved the objects embedding aspects of the scholarly knowledge of the Deep Purple Research Project which they communicated non-verbally to the participants. Additionally, the images brought forward the knowledge and perspectives of the participants both non-verbally through the 'traces' participants made on the objects and verbally when participants shared their reflections verbally with the facilitator.

Because the objects brought forward participants' perspectives, they supported participants thus objects supported an interactive dialogic discourse. Furthermore, we argue that the dynamic observed between participants and facilitator can be understood as a meaning making process, structured by the objects. Despite the objects of the installation 'Connecting Communities' having agency and influencing the social situation, during science communication events, the objects could not stand alone. The facilitator was an integral part of the science communication design. Our results show that the facilitator was key in engaging participants in an interactive dialogic discourse and connecting participants' perspectives with the scholarly knowledge of the Deep Purple Research Project. In the following, we will discuss our observations of the facilitator during science communication events in relation to our third research question: *How can the aspects be embodied in an engaging science communication design?* (RQ3). Our findings are discussed in relation to the analytical framework of discursive interactions by Scott et al., (2006), didactic transposition and science communication literature.

6.4 Facilitator

Our results show that our science communication design gave participants an opportunity to express their reflections, understandings, experiences, and knowledge while they engaged with the installation. As discussed in Chapter 6.1, this finding indicates an interactive dialogic discourse between the facilitator, representing the scientists, and the participants, Greenlandic citizens.

The facilitator during science communication events

Our analysis indicates that the facilitator was engaging participants in dialogue, communicating the scholarly knowledge, and bringing forward the participants' perspectives. Moreover, the facilitator had the responsibility for the social situation and supporting participants when engaging with the objects. In these ways, we found the facilitator to be the connecting aspect of our science communication design since the facilitator connected participants' perspectives to the scholarly knowledge of the Deep Purple Research Project and supported participants in understanding the installation as a whole.

It required know-how to establish an interactive dialogic discourse

The analytic framework of Scott et al., (2006) is developed within the context of science classrooms, however, we still see similarities in their centralisation of the teacher as being the one opening the discourse to include students' perspectives. Furthermore, Scott et al. (2006) state that the teacher needs to have insights into the students' understanding as well as 'know-how' to be able to engage students in dialogic interactions. In the context of our science communication design, we observed the facilitator use different approaches to engaging participants, described in the thematic analysis (Chapter 5.2), indicating that the facilitator also needed `know-how´ to engage participants in a dialogic discourse. Our results and experience from our pilot study at Kalaallit Illuutaat and science communication events in Sisimiut indicate that the facilitator's 'know-how' included knowing how to communicate the scholarly knowledge of the Deep

Purple Research Project, establishing a comfortable social situation, knowing how to invite participants to express their perspectives either verbally or nonverbally. Additionally, the facilitator supported participants in making sense of the objects and the scholarly knowledge.

Communicative approaches used by the facilitator included dissemination and an authoritative discourse

During science communication events, we observed the facilitator disseminate the scholarly knowledge and evaluate participants' responses against the scientific perspective of the Deep Purple Research Project, reflecting an authoritative discourse. This finding seems contradictory to the objective of including multiple perspectives in the dialogue. However, Scott et al., (2006) argue that meaningful understanding of scholarly knowledge must entail *both* authoritative and dialogic interactions. They see authoritative and dialogic communicative approaches being connected, since one discourse gives rise to the other, supporting meaningful learning. Therefore, the two discourses should not be perceived in terms of a dichotomy but as there is a *tension* between the two in meaning making interactions and dialogue (Scott et al., 2006). The installation had the two objectives of both communicating the scholarly knowledge of the Deep Purple Research Project and bringing forward the participants' perspectives on the biologically induced darkening of the ice sheet. As stated by Horst (2011) there is an inherent tension within installations which have dual objectives of both disseminating scholarly knowledge and engaging participants in dialogue. We observed and experienced this tension during science communication events as the facilitator had to both bring forward participants' perspectives, experiences and understanding but also to introduce and communicate the scholarly knowledge and perspective of the Deep Purple Research Project. Because the facilitator had to support participants' understanding of the scientific perspective, an authoritative discourse was also needed as a communicative approach during science communication events. Horst (2011) had a similar experience when designing and exhibiting a dialogue-based installation, communicating research-based knowledge since they found that participants had to have the scientific perspective presented to have something to respond to. This finding is also reflected in Reincke et al., (2020), who state that scientists who engage in dialogue-based science communication have the responsibility of communicating the scholarly knowledge in an accessible way but also to listen and learn from the input of others.

Bringing forward participants' perspectives

Our findings show that the facilitator had to balance between the objectives of disseminating the scholarly knowledge in a way that was understandable to participants as well as to bring forward participants' understanding and perspective, without valuing one perspective over the other. This was difficult since science itself is an authoritative discourse with its structured view of the world (Scott et al., 2006), with knowledge claims being based on verifiable empirical data (Treagust et al., 2014) and due to the perception of science as 'rational' and 'objective', and scientists holding authority as the 'knowledge makers' in society (Garvin, 2001). To bring forward the participants' perspectives alongside the scientific perspective, we observed the

facilitator making an effort to present the physical installation as an open interactive space and to engage with participants in a dynamic in which the participants' responses directed the dialogue instead of a predetermined learning outcome. We observed the facilitator express interest and appreciation about the participants' perspectives and contributions both verbally and non-verbally, even when participants' perspectives differed from the scientific view. These ways of facilitating might have allowed the participants' perspectives to be brought forward alongside the scientific. Reincke et al., (2020) highlight the importance of scientists or 'experts' establishing a dynamic, when communicating their research, in which the objective is not about reaching a consensus but more about learning from each other, showing appreciation and respect for one another (Reincke et al., 2020).

Listening is also emphasised as an important aspect of two-way communication in Barendse et al., (2021). They define the role 'Listener' as someone who tries to understand their audience by actively listening with empathy. The 'Listener' tries to understand what is of importance and relevance to the people they communicate with. This understanding is used in communication activities which aims to make science topics relevant and relatable by integrating the needs, activities, and interests of the public (Barendse et al., 2021). During science communication events, we observed the facilitator engage with participants in similar ways as described in the listener role by Barendse et al. (2021). We observed the facilitator making an effort to bring forward the participants' perspectives and try to understand these e.g., by asking elaborating questions and repeating them to make sure it was understood correctly. Furthermore, our analysis shows that the facilitator was making connections between the scholarly knowledge of the Deep Purple Research Project and the participants' perspectives e.g., the questions they asked, the way they reasoned and the way they engaged with the objects. In this way, we saw the facilitator integrate the participants' perspectives in the communication, similar to the 'Listener'.

To make connections between the scholarly knowledge and participants' verbal and non-verbal responses, the facilitator needed to understand the participants' perspectives and to ensure that participants understood the scholarly knowledge. To achieve this, we observed the facilitator continuously adapt their approach to facilitating in response to the participants. This resonates with Scott et al., (2006) who emphasise that a teacher, engaging with students in dialogic discourses, needs to have insight into students' way of understanding, needs to know how to respond to students and adapt their teaching accordingly. This adaptation is a spontaneous and situated process, meaning that, how the interactions unfold cannot be planned or foreseen (Scott et al., 2006).

Social aspect of the science communication design was important

To bring forward the perspectives of the participants, Reincke et al., (2020) emphasises the social aspect of the science communication and state that scientists need to create a safe and comfortable environment in which participants feel confident to express themselves and listening is a significant part of that. During

science communication events, we observed the facilitator making an effort to make the situation comfortable for participants by creating a more informal atmosphere using humour and relating to the participants on a more personal level, rather than a professional level. This indicates that the social aspect of the science communication design was important. In a study done by Bultitude & Sardo (2012), they found the social aspect to be an important factor in participants' experience and engagement in science communication activities. Bultitude & Sardo (2012) analysed three different cases of science communication events in informal settings and identified three key factors determining participants' engagement. One of these factors was the experience of meeting a "real scientist", understood as someone being an expert and knowledgeable within their field. Participants were surprised to experience the scientist as approachable during individual interactions since they expected scientists to be remote and intimidating. The meeting had been an important factor in their enjoyment and engagement of the science communication activities (Bultitude & Sardo, 2012). Based on their analysis of the participants' responses Bultitude & Sardo (2012) conclude that the opportunity to meet a scientist in person in a new dynamic had the potential of re-engaging people who do not perceive themselves as scientific interested. From the perspective of the scientist engaging in dialogue-based science communication in an informal context, Horst (2021) describes how their design of an interactive dialogue-based installation communicating science allowed them to express different aspects of themselves in the situation than normally expected from a social scientist: "*I performed a particular friendly version of myself and felt compelled to talk to visitors and try and engage them in the interaction*" (Horst, 2021, p. 476). During the science communication events of this study, we did not perceive ourselves performing as facilitators. However, Horst's (2021) description of their experience of engaging in their interactive dialogue-based installation, shows that the different dynamic in dialogue-based science communication is not only experienced amongst the participants of a science communication event, as found in Bultitude & Sardo (2012) but also influences the way the scientist experiences and engages in the social situation.

As discussed above, our findings show that communicating scholarly knowledge dialogue-based in the format of an interactive installation requires more than communicating the scientific concepts in an understandable and accessible way. Additionally, engaging and establishing a dialogic discourse with participants requires more than asking them questions. Our results and discussion show that the facilitator needed to engage with the participants in another dynamic that is not normally found in standard communication strategies, in which the participants responses, both verbal and non-verbal, set the topic of the dialogue and influence the communication taking place. This means that the facilitator needed to apply many different approaches to engage participants in the science communication design, which goes beyond what is required in communication formats often applied by scientists, who are often more used to inform, defend or debate (Houtman et al., 2021). The facilitator had a supporting role and made an effort to make the social situation comfortable, highlighting the importance of the social aspect of the science communication design. The standard communication strategies applied amongst researchers are depersonalized and disconnected, therefore not meeting the requirements of a dialogue-based communication format (Houtman et al.,

2021). Furthermore, scientists are not usually trained to effectively communicate their scholarly knowledge outside an academic context (Jucan & Jucan, 2014). We will unfold this when discussing the research question: "*How can the Deep Purple Research Project create meaningful outreach for Greenlandic citizens?*" (RQ1) in section 6.5 of the discussion.

The science communication design of the installation produced engagement in several ways including verbal and non-verbal ways of communicating. In the above, we have discussed how the different actors were engaged and communicated within the spatial installation. As Horst (2011) states the objective of spontaneously engaging passing people in a science communication installation, making them participants in a dialogue, may seem trivial. However, according to Horst (2011), researchers cannot take engagement for granted and each specific case must be understood both on behalf of the groups involved, the citizens, the researchers communicating, and how the scientific community engage with citizens. In the following, we will address our second research question *What aspects of the scholarly knowledge of the Deep Purple Research Project are relevant to Greenlandic citizens?* Thereby discussing how we can understand the engagement on behalf of the Greenlandic citizens, the participants in the installation. Following, we will discuss how we can understand the engagement from the perspective of a researcher within the spatial installation and relate that to the broader engagement of international natural scientists in local communities and society in Greenland.

6.4 What aspects of the scholarly knowledge of the Deep Purple Research Project are relevant to Greenlandic citizens

One of the objectives of this study was to identify what aspects of the scholarly knowledge of the Deep Purple Research Project are relevant for Greenlandic citizens (RQ2). Recall from the *a priori* analysis, we identified these aspects as the three insights (Chapter 2). To investigate whether the insights, were relevant to Greenlandic citizens, we designed an interactive installation. To reflect on whether the insights of the Deep Purple Research Project were relevant to Greenlandic citizens, it is important to consider that the study design of this study does not give us insights into how participants experienced the dynamic with the facilitator or how they experienced an interactive dialogic discourse. This limitation is similar to other science communication studies (cf. Horst, 2021 and Achiam et al., 2016). During science communication events, similar to Horst (2021) we could only observe what participants did and said and make our interpretations of those observations based on our perspective. Understanding participants' engagement meant that we had to piece together activities, verbal, and non-verbal expressions of participants such as gestures and body language, which are described by Achiam et al. (2016) as temporally detached from one another yet connected(Achiam et al., 2016). We do not know participants' motivations or what reflections and emotions participants experienced whilst engaging with the installation. Like Horst (2021), we assume that if participants stayed and interacted with the objects or the facilitator, the installation was somehow positive, interesting, or relevant to them. Some participants verbally expressed that the installation was an

"interesting" or an "exciting" experience and some participants stated that they had learned something about ice algae. Also, since participation in our installation was spontaneous and there was no set time frame for participants' engagement, we argue that when participants chose to spend time with the objects and the facilitator, and additionally bring forward their perspectives, they were engaged.

The science communication design allowed for participants' perspectives to be expressed alongside the scientific both non-verbally through 'traces' in the objects and verbally in dialogue with the facilitator. Also, the dialogue between participants, facilitator and objects had a similar progression across participants. The dialogue started from participants selecting an aspect of an object which caught their attention and the facilitator continuously responding and adapting to participants' verbal and non-verbal utterance to bring forward the participants' perspectives. Because of this dynamic within the space of the spatial installation, participants had the possibility to influence the topic of dialogue, so it would be relevant, interesting, and important to them. We observed participants connect the scholarly knowledge of the Deep Purple Research Project to their own experiences, work, or daily life, thereby making it relevant to their lives. The perspectives participants brought forward in the dialogues, both during science communication events and during our pilot study at the Kaalaallit Illuutaat, the Greenlandic House, reflect that many of the participants had observed dark areas of the Greenlandic Ice Sheet and some had observed an increased darkening of the Ice Sheet. Some participants expressed that the conditions of ice and the Ice Sheet important to them with some participants actively seeking out knowledge on the conditions of the ice from reports. Others shared observations with friends, and some had a full-time job documenting changes in the landscape of Kangerlussuaq, including the Ice Sheet. Another participant worked as an aircrew flying over the Ice Sheet weekly. They had observed an increased darkening of the Ice Sheet across a decade. Several participants had experienced being on the Ice Sheet incl. participating in scientific expeditions. We found that participant's perspectives on the biologically induced darkening of the Ice Sheet were based on observations and experience. These findings suggest that the scholarly knowledge of the Deep Purple Research Project is relevant to Greenlandic citizens, and we believe that participants' observations and experiences hold great potential for the Deep Purple Research Project and other research studies. Research projects, investigating the Ice Sheet, are restricted to conducting fieldwork in summer and have data gaps due to the large surface area of the ice sheet (Winkel et al., 2022), thus the citizens' observations through their work as guides or air crew could contribute with valuable insights.

We observed participants engaging in making sense of the scholarly knowledge of the installation and making connections to their knowledge and experience. Furthermore, they express their perspectives. Therefore, we argue that our results indicate that the scholarly knowledge embodied in the installation was relevant to Greenlandic citizens. As stated by Bultitude & Sardo (2012), we did not unrealistically expect participants to change their behaviour or attitude towards the biologically induced darkening of the ice sheet, or research in general, after engaging with the installation. Our focus was not on how much the

Greenlandic citizens learned about biological induced darkening from engaging with the spatial installation 'Connecting Communities', instead, the focus is what the natural scientists, can learn from communicating their research through dialogue within the space of an installation. The overall objective of the science communication design and this study is to explore what constitutes meaningful outreach in a Greenlandic context, which is the focus of the following section of the discussion.

6. 5 How can the Deep Purple research project create meaningful outreach for Greenlandic citizens?

We will now revisit our overarching research question of this study *How can the Deep Purple research project create meaningful outreach for Greenlandic citizens?* In this section of the discussion, we will situate our findings and experience with designing and exhibiting the installation 'Connecting Communities' to the fly-in/fly-out research practice in Greenland and the new national research strategy by Naalakkersuisut (2022). Following, we will discuss how the format of our science communication design can be a part of existing communication networks and research infrastructure in Greenland and why that is important in relation to creating meaningful outreach.

How the installation made the scholarly knowledge of the Deep Purple Research Project accessible for Greenlandic citizens

We argue that our science communication design was accessible for Greenlandic citizens in terms of what it requires to participate *and* in terms of making the scholarly knowledge of the Deep Purple Research Project accessible, thereby reflecting the third goal of Greenland's national research strategy (Naalakkersuisut, 2022). Participation was spontaneous and there was no set time frame or expectations for the duration of participants' engagement. This meant that participants could determine to what extent they wanted to engage with the installation and for how long. The spontaneity and flexibility of our science communication design might have been important in making the scholarly knowledge accessible for Greenlandic citizens. Streicher et al., (2014) attribute the success of their inclusive science communication design, 'knowledge°rooms' to its placement within a local community, making it easy to access, and because it was respectful of the time and knowledge of the visitors. Accordingly, community members in Nunavut, Arctic Canada also emphasised competent research communication being characterised by being respectful of the time and resources of community members (Henri et al., 2020). Some community members suggested researchers to set up a booth in the community to discuss the research face-to-face (Henri et al., 2020). This suggests that the 'pop-up' installation format of this study was important in making the science communication design accessible. During our science communication events, we observed the installation 'Connecting Communities' making it possible for a heterogeneous group of participants to engage in a range of ways with the scholarly knowledge of the Deep Purple Research Project. Because we observed participants engage with the installation, we argue that the science communication design was accessible. Furthermore,

we argue that the flexible and interactive aspect of the science communication design made the scholarly knowledge accessible to participants.

Our science communication design was interactive and designed in a way that allowed for participants' perspectives to be represented alongside the scientific perspective of the Deep Purple Research Project through the dialogic discourse and in the objects of the installation, resulting in the installation changing as participants engaged with it. Within the installation, participants had the opportunity to set the topic of the dialogue, discuss the aspects of the research that were relevant to them and determine how the communication and interactions unfolded since the facilitator continuously adapted their communication approach according to responses of the participants. Because the installation gave participants the opportunity to influence and determine the communication taking place within the installation, we can similar to Horst (2011; 2021) understand participants as co-creators of the science communication taking place within the installation. This aspect of our science communication design reflects position within the field of inclusive science communication since inclusive science communication includes diverse publics and their multiple ways of knowing in a dialogue about scientific topics (Canfield et al., 2020). Inclusive science communication is highlighted as one path to increase access and engagement in STEMM (Canfield et al., 2020). Furthermore, when asked about best practices for research communication, community members in Nunavut, Arctic Canada highlighted the importance of researchers listening to community perspectives and concerns, which is not possible to do using one-communication formats (Henri et al., 2020).

Barendse et al. (2021) state that to address the disconnect between science and society it is important to have science communicators who actively works toward making science and research accessible. Because our installation made the scholarly knowledge of the Deep Purple Research Project accessible to Greenlandic citizens, in the ways described above, we argue that our science communication design is a meaningful way to do outreach in a Greenlandic context since it reflects central aspects of the national Greenlandic Research Strategy. Naalakkersuisut states in their national research strategy that scientists shall to a larger extent include Indigenous and local knowledge in their research projects and that the research results must be widely accessible and contribute to the development of Greenlandic society in a local and global context (Naalakkersuisut, 2022, p. 9). In the case of our study, we have not investigated how local and Indigenous knowledge can be included in international research projects, such as the Deep Purple Research Project, since this is beyond the scope of this study. However, the interactive dialogue-based science communication format of this study allowed the facilitator to establish connections between the participants' knowledge and the scholarly knowledge. We see the installation as having potential as a way to mix science and non-science and allow for different social worlds to meet and mingle (Horst (2021). Therefore, we see our science communication design and approach as an alternative to the fly in/ fly out practice in Greenland in which researchers do not engage or communicate with Greenlandic citizens (Mercer et al., 2022), since skilled science communication focuses on improving and increasing understanding between researchers

and participants (Berditchevskaia et al., 2017). Developing an understanding and empathy for each other's perspectives is an important starting point in effective knowledge transfer (Berditchevskaia et al., 2017). We see our science communication design 'Connecting Communities' being a meaningful way to communicate research-based knowledge since we observed the facilitator and the participants engage with each other in a meaning making process, trying to understand each other's perspectives being brought forward in the installation.

Language

An essential aspect of dialogue-based science communication, and for making research accessible in a Greenlandic context, is language. We were advised by the different actors who worked with science communication in Greenland to communicate in Greenlandic, English, and Danish (in the specific order). According to Naalakkersuisut (2022) it is important for Greenland to be acknowledged as a nation with their own official language Kalaallisut(Naalakkersuisut, 2022). However, we were not capable of speaking Kalaallisut and we did not have the resources to hire a translator, limiting us to speaking Danish and/or English with the participants during science communication events. We tried to learn sentences so we could present ourselves and invite people to participate in the installation in Kalaallisut, however often participants did not understand what we were saying. There were also examples of participants expressing that they did not know how to formulate a response when speaking English. We let participants decide if they would prefer to talk in English or Danish and most participants chose Danish. Still, our results are influenced by the different language backgrounds, especially considering we spoke Danish, potentially leading to an asymmetry between us and the participants, which is further complicated by the colonial history between Denmark and Greenland. Based on our experience, we strongly recommend hiring a translator to make research accessible to all Greenlandic citizens.

The researcher in dialogue-based science communication

Our study shows that the facilitator's ways of facilitating and ability to establish a dialogic discourse were essential in establishing connections between the participants and the scholarly knowledge of the Deep Purple Research Project. Our science communication design had the objective of communicating the scholarly knowledge of the Deep Purple Research Project *and* facilitating dialogue. Horst (2011) states it can appear as if there is an inherent tension between these two objectives of dialogue-based science communication installations both during the design process and exhibition of the installation. On one hand, the installation had to ensure that participants understood the scholarly knowledge communicated, thus reflecting a question about how to effectively communicate scholarly knowledge. On the other hand, the installation should allow for multiple interpretations and dialogue-based communication (Horst, 2011). According to Horst (2011), the installation should be designed to effectively communicate the research-based knowledge, since they found that it was necessary that the installation represented a scientific perspective participants could respond to. Instead, it is the way the installation is *used* that determines its inclusiveness and

interpretative openness (Horst, 2011). In the case of our study, we designed the physical objects of the installation, which were transposed from the Deep Purple Research Project, to represent the scientific perspective and it was the facilitator who had to balance between making sure participants understood the scholarly knowledge, bringing forward participants' perspectives and connect the two. We experienced this tension as facilitators, and we saw it reflected in the data in the ways the facilitator had to adapt between many different communicative approaches incl. a more authoritative discourse when disseminating the scholarly knowledge or evaluating the participants' perspectives against the scientific. We found both during science communication events, and during our pilot study in Kalaallit Illuutaat, that the social aspect of the science communication was important to create a space for dialogue. We engaged with participants by bringing ourselves forward as persons, reflecting the experience of Horst (2021). In section 6.4 of this discussion, we argue that it required more than communicating the scholarly knowledge in an effective and accessible way to engage participants in dialogue. This finding is in accordance with the science communication literature on dialogue-based science communication (Nisbet, 2018). Researchers are usually trained to communicate their research to other researchers (Jucan & Jucan, 2014), in a way that does not meet the requirements for dialogue-based science communication (Houtman et al., 2021; Reincke et al., 2020).

The science communication literature has suggested several obstacles for researchers applying dialogue-based science communication. One of those obstacles is the lack of training and competencies to communicate their research dialogue-based (Reincke et al., 2020). Another study states that scientists are more used to debate and defend their findings rather than engaging in a dialogue, and therefore scientists need to "unlearn" old practices (Houtman et al., 2021). The obstacles are also found to be attributable to the lack of institutional support for science communication (Rose et al., 2020). Furthermore, allowing for multiple understandings and interpretations of a given scholarly knowledge might be conflicting for researchers. An analysis of collaborations between artists and scientists found that researchers spoke for a larger collective of researchers which they felt a responsibility towards when disseminating their research (Halpern, 2012). Within sustainability science, scientists are encouraged to change their perception of their peer community to include non-scientists (Spangenberg, 2011). It would be interesting to look further into how international natural scientists, such as the researchers of the Deep Purple Research Project, could extend their peer community to include Greenlandic citizens in terms of creating meaningful outreach. This reflects the position of Streicher et al., (2014) who state that science communication should be made *with* local communities and not *for* them.

Horst (2013) states that the format of interactive installations communicating scholarly knowledge can be viewed as an experiment in which researchers can learn about engagement and dialogue in practice. This statement describes our experience conducting this study since our understanding of dialogue and engagement developed from designing and facilitating the science communication events, as we have unfolded in

the above sections of the discussion. However, we acknowledged that the unpredictability, that is an inherent aspect of the science communication design of this study, makes it a vulnerable space for a researcher since it is not possible to foresee what will happen. As Horst (2011) states engaging people spontaneously is not a trivial task, and in our experience, it is a vulnerable position to invite strangers to engage in spontaneous dialogue and to ask for their perspectives. This position also stands in great contrast to the common 'expert role' of researchers (Reincke et al., 2020) with them usually being the ones invited to share their perspectives. Thus, we acknowledge that the experimental 'hands-on, face-first' approach we have applied in this study might not be for everyone.

Difference in local contexts

Another aspect important to consider when assessing how the science communication design of this study is a meaningful way to communicate the scholarly knowledge of the Deep Purple Research Project is the local context. There are large local differences in Greenland in terms of the presence of researchers and number of research activities taking place. For example, in the town of Kangerlussuaq, numerous research activities take place due to the town's location and accessibility to the Ice Sheet influencing the town's development in relation to population composition, infrastructure, activities, events, employment and business opportunities (Qeqqata Kommunia & Naalakkersuisut, 2023). Other towns and settlements in Greenland are less involved in research and have been frequented less by researchers. This is important to consider, since outreach designed for one community does not translate to other communities without adjusting to the local context (Rink & Reimer, 2021). This means that an essential aspect of creating meaningful outreach means designing outreach with the local context as a reference point. The most effective strategies and tools for research communication are to evolve and adapt to changes in the communication networks of the local community (Henri et al., 2020). Thus, it is important that researchers engage and communicate with local communities through existing communication networks, information-sharing pathways, and technological capabilities within a community (Henri et al., 2020). Therefore, researchers need to understand these communication networks by spending time in the communities. This also applies to natural science researchers, whose research does not include Greenlandic citizens as research participants (Rink & Reimer, 2021). A part of the characterisation of fly in/fly out research practice is that international researchers do not spend time in the communities but travel directly to remote locations such as the Ice Sheet (Mercer et al., 2022) as in the case of the Deep Purple Research Project. Therefore, we argue that to design meaningful outreach it is necessary to understand the existing communication taking place in the local context and, if possible, to spend time in the local community to understand the communication already taking place.

Supporting existing communication networks

In this study, we spent two months in the community of Sisimiut in Greenland to gain a better understanding of the local context and create connections with local citizens. In Chapter 4 we described how we changed

our approach to reach out to the citizens of Sisimiut after talking with the previous director of the cultural centre, Taseralik, in Sisimiut, Arnajaraq Støvlbæk. Instead of arranging our own science communication events, we exhibited our science communication product as part of existing initiatives and local institutions incl. the Ilisimasat Science Festival, arranged by DTU Arctic, and at the upper secondary school, GUX. Streicher et al., (2014) emphasise that inclusive science communication must take place within the communities with the researchers and science communicators being temporarily part of the local community. Similar to us, the researchers were present at local events without an agenda or role to build up relationships and invite community members to engage in their science communication product (Streicher et al., 2014). Building up relationships with members of the community enabled Streicher et al., (2014) to get to know the potential users of their science communication design, make them appear trustworthy, and make their science communication initiative known to the community members.

As we have described in the introduction, changes are happening in the 'communicating networks' in Greenland on multiple institutional and organisational levels to make research conducted in Greenland more accessible to Greenlandic society e.g., Greenlandic Science Week which serves as a platform in which researchers can create outreach activities to connect with Greenlandic citizens (Greenland Science Week, 2023). A central answer to the question "*How can the Deep Purple Research Project create meaningful outreach in a Greenlandic context*" (RQ1) is that meaningful outreach entails creating communication products which support and fit into existing communication networks and institutions in Greenland, since it makes research more accessible (Henri et al., 2020). When research is accessible to Greenlandic citizens and society, the knowledge produced from research can contribute to the development of Greenlandic society (Naalakkersuisut, 2022). As we have described in our *a prori* analysis, The Deep Purple Research Project communicates their research in a range of ways using different formats and platforms, however, none of these are within the communication networks in Greenland or a part of existing initiatives arranged by local institutions. We propose didactic transposition theory as a useful tool transform communication outputs so they can be transposed into the existing communication networks in Greenland. In this study, didactic transposition theory guided both the process of establishing an overview of the scholarly knowledge and identifying what central aspects of the scholarly knowledge were relevant as content in a science communication design. Furthermore, didactic transposition was a useful tool to assess the format appropriate for communicating the scholarly knowledge of the Deep Purple Research Project in a Greenlandic context. We see that our developed science communication design 'Connecting Communities' is applicable to the existing networks of communication in Greenland and can contribute to initiatives such as Greenland Science Week. Based on our experience and findings with designing and facilitating dialogue-based science communication, we argue that this communication format is useful in engaging international researchers and Greenlandic citizens in exchanging perspectives and making connections.

6. 6 Limitations

Recall, that the objective of this study was to explore how to design and collect data of a concrete case of dialogue-based science communication to provide experiences and reflections on how an interactive installation can be applied to engage researchers and citizens in dialogue.

Instrumental case study and interpretivist research paradigm

Our findings are empirical based and offer novel insights and we argue that our results. In an instrumental case study, the researcher is interested in understanding something that goes beyond the particular case, thus the study of the particular case is used as a means to a larger goal (Fraenkel et al., 2012). We consider this study an instrumental case study, since we want to explore what meaningful outreach is in a Greenlandic context by studying the case of the Deep Purple Research Project and from this particular case formulating a set of guidelines which can be applied by other international scientists conducting research in Greenland. This study is situated within the interpretivist paradigm, therefore we do not claim that our results are 'objective' but our interpretation of social situations (Treagust et al., 2014). Because interpretivist studies are perceived as a 'sense-making process' of the researcher, the quality of the study depends on the researcher's integrity, sensitivity, and skills of the researcher as well as the researcher's ability to reflect and be transparent on personal values and biases rather than methodological rigidity (Treagust et al., 2014). The objective of this study is not to measure and generalize about Greenlandic citizens' behaviour during dialogue-based science communication events. Instead, this study aims to give a nuanced and reflexive description of the social interactions within the specific spatial and temporal context of the science communication events in Greenland and how we experienced and interpreted them. We acknowledge that the social interactions taking place during science communication events might have been influenced or biased by our age, gender, linguistic competence, professional affiliation, and nationality as Danes. We have described our positionality on page 5. There are some limitations to the methodology of this study which are common to other observational studies, and in the following sections we describe these and how we tried to minimize them.

The Hawthorne effect, written field notes and recall bias

A common bias in observational studies is the *Hawthorne effect,* when participants change their behaviour because they are being observed which can influence the validity of the study (Aarhus Universitet, No date-c). We chose to use field note techniques for our observations instead of filming and recording participants in order to minimize the influence of the Hawthorne effect because we thought that a camera or microphone setup would be more intimidating to the participants than handwritten notes. However, field notes are known to be limited in other aspects such as recall bias (Emerson et al., 2011), which we minimized by writing field notes immediately after the science communication events, and by writing jotted notes during the data collection (described in methods). Another common issue with field notes is that data may be

incomplete because of the relatively slow handwriting speed that needs to collect complex data in the form of both verbal and non-verbal interactions (Emerson et al., 2011). To address this potential issue for the data-collection process, we developed a structured paper with things to pay attention to, as it was recommended for this format (Københavns Universitet, No date) but we learned that it was disturbing the writing process and therefore quickly abandoned the structured paper and instead wrote on blank paper. As a final preparation before the data collection, we gained experience with handwriting techniques by observing events in Sisimiut with the purpose of improving our speed and accuracy of writing notes in hand.

Active/passive observer

Another common problematique of observational studies relates to choosing to be either an active or passive observer during data collection (Aarhus Universitet, No date-d). An active observer participates from the same starting point as the participants which will lead to participants perceiving the researcher to a lesser extent as observing them. However, it can be more difficult to collect systematic field notes from the event whilst actively engaging with the participants. As a passive observer, the researcher does not participate to the same extent as the participants, making it easier to collect field notes (Københavns Universitet, No date). During our data collection, one of us was a passive observer, while the other was facilitating the dialogue with the participants, thus there were both an active and a passive observer.

Limited in terms of participants' perspectives

As we have discussed, our study is limited since we have not conducted interviews or surveys of how participants experienced participating in the installation. We have no insights into their motivations, emotions, and thoughts. We can only interpret what we observed participants do and say or *not* do or say. Our interpretation is based on our perspectives. Still, it is important to include Greenlandic citizens' experience of the dynamics during dialogue-based science communication and whether they see a potential for dialogue-based science communication in a Greenlandic context, and we call for further research on what constitutes meaningful and relevant science communication in the perspective of Greenlandic citizens (cf. Henri et al., 2020).

6.7 Recommendations

The following recommendations are developed for international researchers who wish to communicate their research in Greenland using dialogue-based communication formats. The recommendations are based on the findings of this study, and our experiences of designing and exhibiting our science communication design. Furthermore, the following recommendations are developed in relation to the research strategy from Naalakkersuisut (2022), the valuable feedback and advice we have received from various actors in Greenland and other recommendations developed for researchers wishing to engage and communicate with Arctic communities (Gbetholancy, 2022). It is important to note that these recommendations may not apply to all local communities in Greenland since there are local differences between settlements, towns, and cities in

Greenland, meaning it is essential to be aware of the local context and use it as a reference point for designing meaningful outreach and science communication. The following recommendations are structured in a chronological fashion, suggesting approaches to different stages of designing an outreach event.

Prior to science communication events:

- Identify the central aspects of your research and explore how they can be relevant and of interest to the local community.
- When you have identified the content of your science communication, design the format of the science communication with the local community as a primary reference by:
    - Spending time in the community.
    - Exploring existing communication networks: how do community members communicate and what media/platforms do they use? E.g., in some Greenlandic towns, bulletin boards at bus stops or in front of supermarkets are used for reaching community members, sharing information and invitations to events. Many towns also have their own Facebook group which serves as an online bulletin board.
    - Seek out existing initiatives, actors and institutions and design your outreach so it is a contribution to their work.
    - Employ a professional translator who can translate technical and scientific terms and concepts to Kalaallisut and potentially other dialects.

During communication events:

Considerations:

- Think of other ways of knowing and understanding a scientific phenomenon as equally valid as the scientific understanding.
- Think of establishing a dialogue as the overall objective of the communication instead of a specific learning outcome.
- Think of the other person as a co-creator of the dialogue meaning letting them also have a say in what the dialogue should be centred around and how the dialogue should unfold.
- Consider non-verbal ways of communicating as meaningful utterances containing important feedback and information you might need to respond to or address.
- Be open to the dialogue unfolding in unexpected ways and think of that as a learning opportunity.

- Spend as much time, practice and thought on the relational and social aspects of your science communication design as on the scientific topic itself.

Actions to take:

- Start the dialogue from the perspective of the other person.
- Bring forward the scientific perspective and aspects of the scholarly knowledge in relation to what the other person says and expresses interest in.
- Ask the other person questions about what interests them or how they understand a given phenomenon.
- Be flexible in using different approaches whilst engaging in the dialogue depending on the other person's verbal and non-verbal responses.
- Show genuine interest in the other person.
- Be respectful of the other person's time and ways they want to engage with you.

Use of visual representations:

- Include intuitive objects which can facilitate a shared activity or initiate discussions.
- Design objects which are interactive and allow for different interpretations and consider how objects can make these interpretations visible.
- Make it possible for the other person to contribute to the science communication product.
- Instead of only considering verbal language, experiment with objects which can communicate aspects of the research through sensory interactions.

Following communication events:

- Use your experience to improve your design and your approach to dialogue.
- Seek feedback from others and share experiences with others.

6.8 Implications

The findings and recommendations of this study hold the potential for framing future dialogues between researchers who conduct research in Greenland and Greenlandic citizens and to the ongoing change of the research practice of international scientists in Greenland by providing an alternative to common communicative approaches used by researchers. Furthermore, the findings of this study can also contribute to the literature on dialogue-based science communication. Additionally, since communication is seen as the basis for developing partnerships in science (Henri et al., 2020) we see this study has potential implications for collaborative research methods in a Greenlandic context (Hansen & Ren, 2021a), since effective research

partnerships should be built upon communication approaches that foster cooperative inquiry and learning (Henri et al., 2020). Thus this study is relevant to a range of studies including, but not limited to, community engagement (Chambers et al., 2021), participatory research (Rink & Reimer, 2021), public participation practices (Skjervedal, 2018) and in a broader context the extension of peer communities within sustainability science (Spangenberg, 2011). To better understand the implications of this study, future studies could address how researchers perceive dialogue-based science communication and their capabilities of applying it as a communicative practice. What limits and constraints do researchers experience since they do not engage with local communities? Is it only a question of tradition or are there any systematic constraints or other obstacles? To create meaningful outreach in a Greenlandic context it is essential to include the Greenlandic citizens in designing the outreach and science communication that benefit their communities and society (cf. Henri et al., 2020). Within the context of Greenland, it is crucial to investigate how science and polar exploration have contributed to the colonisation of Greenland and how this is linked to present structures within the current research practice. Thus, a change in research practice requires efforts across sectors and institutions, from researchers themselves but also academic institutions and local Greenlandic institutions and stakeholders (Holm et al., 2011).

Chapter 7 Conclusion

In this study, we have explored how dialogue-based science communication can be applied as a communicative approach to communicate scholarly knowledge to Greenlandic citizens and for international researchers to engage with communities in Greenland. We did this by designing an interactive installation in which we took on the role of a scientist and initiated dialogues with citizens. From conducting this study, we have learned that a dialogue-based format is a meaningful way to communicate scholarly knowledge since it allows for multiple perspectives to be represented alongside the scientific perspective, thus we see that dialogue-based science communication has the potential of creating new ways of understanding for both scientists and citizens. Furthermore, we have learned that meaningful outreach in Greenland contributes to existing communication networks, infrastructure and initiatives made by local Greenlandic actors and institutions, thereby supporting the ongoing changes of anchoring research in Greenland. With this approach, researchers can connect with Greenlandic citizens, and thus contribute to resolving the issues of the fly in/fly out research practice. However, as we have described throughout this study, there are several obstacles for researchers when communicating their research using a dialogue-based format. Therefore, the next step is to investigate how the researchers of the Deep Purple Research Project can change their communicative approach to include more dialogue-based communcation formats and contribute to existing institutions, initiatives and networks in Greenland. This study can serve as an example to learn from and be inspired by.

References

Achiam, M. (2014a). *Didactic transposition: From theoretical notion to research programme* Paper presented at ESERA, Neveshir, Turkey.

Achiam, M. (2014b). Didactic Transposition: The transformation and translocation of science in museums Retrieved 13 September 2023. In *Science Museums: Affordances, Interactions, and Meanings.* (pp. 1-10). https://www.academia.edu/9154512/Didactic_transposition_The_transformation_and_translocation_of_science_in_museums

Achiam, M., May, M., & Marandino, M. (2014). Affordances and distributed cognition in museum exhibitions. *Museum Management and Curatorship*, *29*(5), 461-481. https://doi.org/10.1080/09647775.2014.957479

Achiam, M., Simony, L., & Lindow, B. E. K. (2016). Objects prompt authentic scientific activities among learners in a museum programme. *International Journal of Science Education*, *38*(6), 1012-1035. https://doi.org/10.1080/09500693.2016.1178869

Alharahsheh, H. H., & Pius, A. (2020). A review of key paradigms: Positivism VS interpretivism. *Global Academic Journal of Humanities and Social Sciences*, *2*(3), 39-43.

Allen, T. F., & Starr, T. B. (2019). *Hierarchy: perspectives for ecological complexity*. University of Chicago Press, Chicago Scholarship Online. https://doi.org/https://doi.org/10.7208/chicago/9780226489711.001.0001

Allum, N., Sturgis, P., Tabourazi, D., & Brunton-Smith, I. (2008). Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science*, *17*(1), 35-54.

Anesio, A. (2022). Recent Advances in Cryospheric Microbiology. In. Presented at the International Glaciological Society 7th June 2022: Aarhus University.

Barendse, S., Rerimassie, V., Roedema, T., & Kupper, F. (2021). “At least we’re trying”: Experimenting with roles and repertoires to foster new connections between science and society: Conduct defined experiments using best practices highlighted in showcases to determine the extent to which approaches work in different context. https://www.rethinkscicomm.eu/wp-content/uploads/2021/09/RETHINK_D1.5_Report-on-the-processes-and-results-of-the-experiments.pdf

Bavelas, J. B., & Chovil, N. (2006). Nonverbal and Verbal Communication: Hand Gestures and Facial Displays as Part of Language Use in Face-to-face Dialogue. In V. Manusov & M. L. Patterson (Eds.), *The Sage handbook of nonverbal communication* (pp. 97-115). Sage publications, Inc. https://doi.org/https://doi.org/10.4135/9781412976152.n6

Berditchevskaia, A., Regalado, C., & Van Duin, S. (2017). The changing face of expertise and the need for knowledge transfer. *Journal of Science Communication*, *16*(04), C03.

Berkner, L. V., & Marshall, L. (1965). On the origin and rise of oxygen concentration in the Earth's atmosphere. *Journal of Atmospheric Sciences*, *22*(3), 225-261.

Bosch, M., & Gascón, J. (2006). Twenty-five years of the didactic transposition. *ICMI bulletin*, *58*(58), 51-65.

Bradley, J. A., Trivedi, C. B., Winkel, M., Mourot, R., Lutz, S., Larose, C., Keuschnig, C., Doting, E., Halbach, L., & Zervas, A. (2023). Active and dormant microorganisms on glacier surfaces. *Geobiology*, *21*(2), 244-261.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Budach, G., Kell, C., & Patrick, D. (2015). Objects and language in trans-contextual communication. *Social Semiotics*, *25*(4), 387-400. https://doi.org/10.1080/10350330.2015.1059579

Budach, G., Patrick, D., & Mackay, T. (2015). "Talk around objects": designing trajectories of belonging in an urban Inuit community. *Social Semiotics*, *25*(4), 446-464. https://doi.org/10.1080/10350330.2015.1059575

Bultitude, K., & Sardo, A. M. (2012). Leisure and Pleasure: Science events in unusual locations. *International Journal of Science Education*, *34*(18), 2775-2795. https://doi.org/10.1080/09500693.2012.664293

Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science communication: a contemporary definition. *Public Understanding of Science*, *12*(2), 183-202.

Canfield, K. N., Menezes, S., Matsuda, S. B., Moore, A., Mosley Austin, A. N., Dewsbury, B. M., Feliú-Mójer, M. I., McDuffie, K. W. B., Moore, K., Reich, C. A., Smith, H. M., & Taylor, C. (2020). Science Communication Demands a Critical Approach That Centers Inclusion, Equity, and Intersectionality. *Frontiers in Communication*, *5*. https://doi.org/10.3389/fcomm.2020.00002

Chambers, C., King, L. A., Cook, D., Malinauskaite, L., Willson, M., Ogilvie, A. E. J., & Einarsson, N. (2021). "Small Science": Community Engagement and Local Research in an Era of Big Science Agendas. In D. C. Nord (Ed.), *Nordic Perspectives on the Responsible Development of the Arctic: Pathways to Action* (pp. 203-224). Springer International Publishing. https://doi.org/10.1007/978-3-030-52324-4_10

Chevallard, Y. (1989). On didactic transposition theory: Some introductory notes. Proceedings of the international symposium on selected domains of research and development in mathematics education, Bratislava.

Chevallard, Y., & Bosch, M. (2014). Didactic Transposition in Mathematics Education. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 170-174). Springer Netherlands. https://doi.org/10.1007/978-94-007-4978-8_48

Chevrollier, L.-A., Cook, J. M., Halbach, L., Jakobsen, H., Benning, L. G., Anesio, A. M., & Tranter, M. (2023). Light absorption and albedo reduction by pigmented microalgae on snow and ice. *Journal of Glaciology*, *69*(274), 333-341.

Clément, P. (2007). Introducing the cell concept with both animal and plant cells: A historical and didactic approach. *Science & Education*, *16*, 423-440.

Cook, J. M., Tedstone, A. J., Williamson, C., McCutcheon, J., Hodson, A. J., Dayal, A., Skiles, M., Hofer, S., Bryant, R., & McAree, O. (2020). Glacier algae accelerate melt rates on the south-western Greenland Ice Sheet. *The Cryosphere*, *14*(1), 309-330.

Cuffey, K. M., & Marshall, S. J. (2000). Substantial contribution to sea-level rise during the last interglacial from the Greenland ice sheet. *Nature*, *404*(6778), 591-594.

Davies, M. (2011). Concept mapping, mind mapping and argument mapping: what are the differences and do they matter? *Higher education*, *62*, 279-301.

Davies, S. R., & Horst, M. (2016). Images, Spaces, and Emotions: Non-discursive Aspects of Science Communication. In S. R. Davies & M. Horst (Eds.), *Science Communication: Culture, Identity and Citizenship* (pp. 159-185). Palgrave Macmillan UK. https://doi.org/10.1057/978-1-137-50366-4_7

Deep Purple Research Project. (No date-a). *About*. Retrieved 5 August 2022 from https://www.deeppurple-ercsyg.eu/about

Deep Purple Research Project. (No date-b). *Albedo - Time Series Inspector*. Aarhus University. Retrieved 4 December 2022 from https://fsn1995.users.earthengine.app/view/albedoinspector

Deep Purple Research Project. (No date-c). *Fieldwork*. Retrieved 5 August 2022 from https://www.deeppurple-ercsyg.eu/fieldwork

Deep Purple Research Project. (No date-d). *Home*. Retrieved 7 August 2022 from https://www.deeppurple-ercsyg.eu/home

Deep Purple Research Project. (No date-e). *Outputs*. Retrieved 4 October 2022 from https://www.deeppurple-ercsyg.eu/outputs

Denzin, N. K., & Lincoln, Y. S. (2005). *The Sage Handbook of Qualitative Research* (3 ed.). Sage Publications.

Destination Arctic Circle. (2023). *Events*. Retrieved 3 September 2023 from https://science.destinationarcticcircle.com/events/

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (2011). *Writing ethnographic fieldnotes*. University of Chicago press.

Emmeche, C. (2004). Organicism and qualitative aspects of self-organization. *Revue internationale de philosophie*(2), 205-217.

Ewenstein, B., & Whyte, J. (2009). Knowledge Practices in Design: The Role of Visual Representations as `Epistemic Objects'. *Organization Studies*, *30*(1), 7-30. https://doi.org/10.1177/0170840608083014

Feng, S., Cook, J. M., Anesio, A. M., Benning, L. G., & Tranter, M. (2023). Long time series (1984–2020) of albedo variations on the Greenland ice sheet from harmonized Landsat and Sentinel 2 imagery. *Journal of Glaciology*, 1-16.

Fischhoff, B. (2013). The sciences of science communication. *Proceedings of the National Academy of Sciences*, *110*(supplement_3), 14033-14039.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (Vol. 7). McGraw-hill New York.

Garvin, T. (2001). Analytical paradigms: the epistemological distances between scientists, policy makers, and the public. *Risk Analysis*, *21*(3), 443-456.

Gbetholancy, C. (2022). *Understanding the Role of Researchers in Engaging and Communicating Sciences with Inuit Youth* The University of Guelph]. Guelph, Ontaria, Canada.

George, T. (No date). *What Is an Observational Study? Guide & Examples*. Scribbr. Retrieved 5 January 2023 from https://www.scribbr.com/methodology/observational-study/

Gimenez, J., Baldwin, M., Breen, P., Green, J., Gutierrez, E. R., Paterson, R., Pearson, J., Percy, M., Specht, D., & Waddell, G. (2020). Reproduced, reinterpreted, lost: Trajectories of scientific knowledge across contexts. *Text & Talk*, *40*(3), 293-324. https://doi.org/10.1515/text-2020-2059

Graham, L. E. (1996). Green algae to land plants: an evolutionary transition. *Journal of Plant Research*, *109*, 241-251.

Graugaard, N. D. (2021). Arctic Auto-ethnography: Unsettling colonial research relations. In A. M. Hansen & C. Ren (Eds.), *Collaborative Research Methods in the Arctic* (1 ed., pp. 33 - 50). Routledge.

Greenland Research Council. (2023). Call for proposals: Research Promotion Grants

Conditions and criteria for funding. 10. https://nis.gl/wp-content/uploads/2023/01/Research-promotion_-call-for-proposals-2023_-eng.pdf

Greenland Science Week. (2023). *Greenland Science Week*. Retrieved 4 September 2023 from https://www.scienceweek.gl/

Guiry, M. D. (2012). How many species of algae are there? *Journal of phycology*, *48*(5), 1057-1063.

Halbach, L., Chevrollier, L.-A., Cook, J. M., Stevens, I. T., Hansen, M., Anesio, A. M., Benning, L. G., & Tranter, M. (2023). Dark ice in a warming world: advances and challenges in the study of Greenland Ice Sheet's biological darkening. *Annals of Glaciology*, 1-6.

Halbach, L., Chevrollier, L.-A., Doting, E. L., Cook, J. M., Jensen, M. B., Benning, L. G., Bradley, J. A., Hansen, M., Lund-Hansen, L. C., Markager, S., Sorrell, B. K., Tranter, M., Trivedi, C. B., Winkel, M., & Anesio, A. M. (2022). Pigment signatures of algal communities and their implications for glacier surface darkening. *Scientific Reports*, *12*(1), 17643. https://doi.org/10.1038/s41598-022-22271-4

Halkier, H. (2021). Foreword. In A. M. R. Hansen, Carina (Ed.), *Collaborative Research methods: Experiences From Greenland* (1 ed., pp. 160). Routledge.

Halpern, M. K. (2012). Across the great divide: Boundaries and boundary objects in art and science. *Public Understanding of Science*, *21*(8), 922-937. https://doi.org/10.1177/0963662510394040

Hansen, A. M., & Ren, C. (2021a). *Collaborative Research Methods in the Arctic*. Routledge.

Hansen, A. M., & Ren, C. (2021b). Collaborative research methods in the Arctic: Why and how? In A. M. Hansen & C. Ren (Eds.), *Collaborative Research Methods in the Arctic: Experiences from Greenland* (1 ed., pp. 1 - 10). Routledge.

Hauptmann, A. L. (2016, 7 July). Hit-and-run forskning i Grønland og forskningsetik. *ing.dk*. https://ing.dk/holdning/hit-and-run-forskning-i-groenland-og-forskningsetik

Hauptmann, A. L., Larsen, L. M., & Ilisimatusarfik. (No date). *SILA: Vores vision for en grønlandsk biologi bacheloruddannelse*.

Hay, D., Kinchin, I., & Lygo-Baker, S. (2008). Making learning visible: the role of concept mapping in higher education. *Studies in higher education*, *33*(3), 295-311.

Henri, D. A., Brunet, N. D., Dort, H. E., Hambly Odame, H., Shirley, J., & Gilchrist, H. G. (2020). What is Effective Research Communication? Towards Cooperative Inquiry with Nunavut Communities. *Arctic*, *73*(1), 81-98. https://doi.org/10.14430/arctic70000

Holford, W. D. (2015). Knowledge Construction as Movement via Boundary Constructions and Dialogue. 2015 48th Hawaii International Conference on System Sciences,

Holm, L., Grenoble, L., & Virginia, R. (2011). A praxis for ethical research and scientific conduct in Greenland. *Études/Inuit/Studies*, *35*(1-2), 187-200. https://doi.org/https://doi.org/10.7202/1012841ar

Horst, M. (2011). Taking Our Own Medicine: On an Experiment in Science Communication. *Science and Engineering Ethics*, *17*(4), 801-815. https://doi.org/10.1007/s11948-011-9306-y

Horst, M. (2013). Learning from Discomfort. In L. Philips, E. Gunnarson, M. Kristensen, & M. Vehvilainen (Eds.), *Knowledge and Power in Collaborative Research: A Reflexive Approach* (Vol. 6, pp. 21-41). London: Routledge. Routledge advances in research methods.

Horst, M. (2021). Science Communication as a Boundary Space: An Interactive Installation about the Social Responsibility of Science. *Science, Technology, & Human Values*, *47*(3), 459-482. https://doi.org/10.1177/01622439211003662

Hotaling, S., Lutz, S., Dial, R. J., Anesio, A. M., Benning, L. G., Fountain, A. G., Kelley, J. L., McCutcheon, J., Skiles, S. M., & Takeuchi, N. (2021). Biological albedo reduction on ice sheets, glaciers, and snowfields. *Earth-science reviews*, *220*, 103728.

Houtman, D., Vijlbrief, B., & Riedijk, S. (2021). Experts in science communication: A shift from neutral encyclopedia to equal participant in dialogue. *EMBO reports*, *22*(8), 459 - 482.

Irish, R., & Romkey, L. (2021). Using Actor Network Theory to explore sustainability issues in an engineering and society discourse. *Proceedings of the Canadian Engineering Education Association (CEEA)*. https://doi.org/10.24908/pceea.vi0.14960

Isaaffik. (2023). *Isaaffik: The arctic gateway*. Retrieved 5 January 2023 from https://isaaffik.org/

Jóhannesson, G. T., & Bærenholdt, J. O. (2009). Actor-Network Theory/Network Geographies. In R. Kitchin & N. Thrift (Eds.), *International Encyclopedia of Human Geography* (pp. 15-19). Elsevier. https://doi.org/https://doi.org/10.1016/B978-008044910-4.00657-X

Jucan, M. S., & Jucan, C. N. (2014). The Power of Science Communication. *Procedia - Social and Behavioral Sciences*, *149*, 461-466. https://doi.org/https://doi.org/10.1016/j.sbspro.2014.08.288

Kalaallit Illuutaat. (2023). *Formål og vedtægter*. Retrieved 6 January 2023 from https://www.sumut.dk/da/om-os/formaal-og-vedtaegter/

Kappel, K., & Holmen, S. J. (2019). Why science communication, and does it work? A taxonomy of science communication aims and a survey of the empirical evidence. *Frontiers in Communication*, *4*, 55.

Kjærgaard, R. S. (2011). Things to see and do: how scientific images work. In D. J. Bennett & R. C. Jennings (Eds.), *Successful Science Communication: Telling It Like It Is* (pp. 332-354). Cambridge University Press. https://doi.org/10.1017/CBO9780511760228.027

Kristensen, K. (2023, 10 januar). Grønland får sin første nationale forskningsstrategi. *Sermitsiaq*. https://sermitsiaq.ag/node/241908#:~:text=Naalakkersuisut%20lancerer%20Gr%C3%B8nlands%20f%C3%B8rste%20strategi%20for%20forskning%20i,forskningsstrategi%20med%20overskriften%20Forskning%20-%20vejen%20til%20fremdrift.

Kump, L. R. (2008). The rise of atmospheric oxygen. *Nature*, *451*(7176), 277-278.

Københavns Universitet. (No date). *Deltagerobservation*. Retrieved 7 January 2023 from https://innovation.sites.ku.dk/metode/deltagerobservation/#instr

Kaalund, N. K. L. (2021). Mellem (post)kolonialitet og videnskab: Hinrich Rinks forskningsnetværk i Grønland og idéen om en international arktisk forskningshub. *Økonomi & Politik*, *94*(2). https://doi.org/10.7146/okonomiogpolitik.v94i2.127554

Lenau, T. A., & Lindegaard, H. (2008). Objects, materiality and meaning. *Nordcode*. http://nordcode.tkk.fi/

McCutcheon, J., Lutz, S., Williamson, C., Cook, J. M., Tedstone, A. J., Vanderstraeten, A., Wilson, S., Stockdale, A., Bonneville, S., & Anesio, A. M. (2021). Mineral phosphorus drives glacier algal blooms on the Greenland Ice Sheet. *Nature Communications*, *12*(1), 570.

Mercer, J. L., Nymand, J., Culler, L. E., Lynge, R., Lund, S., Gregersen, B., Makens, B., Virginia, R. A., & Moore, K. G. (2022). Bilateral collaboration between the Greenland (Kalaallit Nunaat) and United States Research Communities – from a vision to everyday practice. *Polar Record*, *58*, Article e42. https://doi.org/10.1017/S0032247422000298

Meyer, R. (2010). Knowledge visualization. *Trends in information visualization*, *23*, 23-30.

Morrissey, K. A. (2002). Pathways Among Objects and Museums Visitors. In S. G. Paris (Ed.), *Perspectives on Object-Centered Learning in Museums* (pp. 285 - 299). Lawrence Erlbaum Associates.

Mortensen, M. F. (2010). Museographic transposition: The development of a museum exhibit on animal adaptations to darkness. *Éducation et didactique*(4-1), 115-138.

Nicolaisen, L. B., Achiam, M., & Ibsen, T. (2021). Transforming Astrophysics in a Planetarium: 'We Are Part Of The Universe, The Universe Is Part Of Us'. *Experimental Museology*, 167.

Nisbet, M. (2018). *Scientists in Civic Life: Facilitating Dialogue-Based Communication* (Engaging Scientists in the Science and Religion Dialogue, Issue. American Association of Science. https://sciencereligiondialogue.org/resources/scientists-in-civic-life-facilitating-dialogue-based-communication/

Nisbet, M., & Scheufele, D. (2009). What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, *96*(10), 1767-1778.

Novak, J. D., & Cañas, A. J. (2008). The theory underlying concept maps and how to construct and use them.

Naalakkersuisut. (2022). *Forskning - vejen til fremdrift; Grøndlands nationale forskningsstrategi*. K. Departementet for Uddannelse, Idræt og Kirke,. https://naalakkersuisut.gl/-/media/publikationer/kultur_og_forskning/2023/forskningsstrategi_dec_2022ny.pdf

Paris, S. G. (2002). *Perspectives on Object-Centered Learning in Museums*. Lawrence Erlbaum Associates.

Peña-Alves, S. (2020). Outspoken Objects and Unspoken Myths: The Semiotics of Object-Mediated Communication. *Symbolic Interaction*, *43*(3), 385-404. https://doi.org/https://doi.org/10.1002/symb.464

Qeqqata Kommunia, & Naalakkersuisut. (2023). *Rapport fra Arbejdsgruppen om Kangerlussuaqs fremtid*. Qeqqata Kommunia & Naalakkersuisut. https://naalakkersuisut.gl/-/media/nyheder/2023/04/2404_kangerlussuaq/20230421--endelig-udgave-opdateret-og-rettet--rapport-fra-arbejdsgruppen-om-kangerlussuaqs-fremtid-d.pdf

Raikar, S. P. (2023). *Greenlandic Ice Sheet*. Encyclopedia Britannica. Retrieved 4 December 2022 from https://www.britannica.com/place/Greenland-Ice-Sheet

Rasmussen, S. O., Bigler, M., Blockley, S. P., Blunier, T., Buchardt, S. L., Clausen, H. B., Cvijanovic, I., Dahl-Jensen, D., Johnsen, S. J., & Fischer, H. (2014). A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: refining and extending the INTIMATE event stratigraphy. *Quaternary science reviews*, *106*, 14-28.

Reincke, C. M., Bredenoord, A. L., & Van Mil, M. H. (2020). From deficit to dialogue in science communication. *EMBO reports*, *21*(9). https://doi.org/10.15252/embr.202051278

Rink, E., & Reimer, G. A. (2021). *A toolkit for Community Based Participatory Research in Greenland*.

Roberts, L. (1997). *From knowledge to narrative: Educators and the changing museum*. Smithsonian Institution Press.

Rose, K. M., Markowitz, E. M., & Brossard, D. (2020). Scientists' incentives and attitudes toward public communication. *Proceedings of the National Academy of Sciences*, *117*(3), 1274-1276.

Rowe, S. (2002). The Role of Objects in Active, Distributed Meaning-Making. In S. G. Paris (Ed.), *Perspectives on Object-Centered Learning in Museums* (pp. 19 - 35). Lawrence Erlbaum Associates.

Rutjens, B. T., Heine, S. J., Sutton, R. M., & van Harreveld, F. (2018). Attitudes towards science. In *Advances in experimental social psychology* (Vol. 57, pp. 125-165). Elsevier.

Schubert, N., Schoenrock, K. M., Aguirre, J., Kamenos, N. A., Silva, J., Horta, P. A., & Hofmann, L. C. (2020). Coralline algae: Globally distributed ecosystem engineers. In (Vol. 7, pp. 352): Frontiers Media SA.

Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science education*, *90*(4), 605-631.

Simis, M. J., Madden, H., Cacciatore, M. A., & Yeo, S. K. (2016). The lure of rationality: Why does the deficit model persist in science communication? *Public Underst Sci*, *25*(4), 400-414. https://doi.org/10.1177/0963662516629749

Skjervedal, A.-S. H. (2018). *Towards meaningful youth engagement: Breaking the frame of the current public participation practices in Greenland* Aalborg University]. Aalborg Universitetsforlag Ph.d. serien for Det Tekniske Fakultet for IT og Design Aalborg Universitet. https://doi.org/10.5278/vbn.phd.tech.00044

Smith, R. L., Smith, T. M., Hickman, G. C., & Hickman, S. M. (1998). *Elements of ecology*. Benjamin Cummings Menlo Parie, CA.

Spangenberg, J. H. (2011). Sustainability science: a review, an analysis and some empirical lessons. *Environmental Conservation*, *38*(3), 275-287. https://doi.org/10.1017/S0376892911000270

Statsministeriet. (No date). *Grønland*. Statsministeriet. Retrieved 3 September 2023 from https://www.stm.dk/statsministeriet/rigsfaellesskabet/groenland/

Stehr, N. (2018). *Modern societies as knowledge societies*. Springer.

Stevens, I. T., Irvine-Fynn, T. D., Edwards, A., Mitchell, A. C., Cook, J. M., Porter, P. R., Holt, T. O., Huss, M., Fettweis, X., & Moorman, B. J. (2022). Spatially consistent microbial biomass and future cellular carbon release from melting Northern Hemisphere glacier surfaces. *Communications Earth & Environment*, *3*(1), 275.

Streicher, B., Unterleitner, K., & Schulze, H. (2014). Knowledge rooms - science communication in local, welcoming spaces to foster social inclusion. *Journal of Science Communication*, *13*(2), 1 - 5.

Suldovsky, B. (2016). In science communication, why does the idea of the public deficit always return? Exploring key influences. *Public Understanding of Science*, *25*(4), 415-426.

Tayeebwa, D. W., Wendo, D. C., & Nakiwala, D. A. S. (2022). Theories and Models of Science Communication. In *Science Communication Skills for Journalists: A Resource Book for Universities in Africa* (pp. 14-22). CABI Books. https://doi.org/10.1079/9781789249675.0002

The Icefjord Centre. (2023). *Homepage*. Retrieved 3 September 2023 from https://isfjordscentret.gl/en/ilulissat-icefjord-centre/

The World Factbook. (2023). *Greenland* https://www.cia.gov/the-world-factbook/countries/greenland/#introduction

Tiberghein, A., & Sensevy, G. (2015). Didactic Transposition. In R. Gunstone (Ed.), *Encyclopedia of Science Education* (pp. 1083 - 1086). Springer Reference. https://doi.org/10.1007/978-94-007-2150-0

Treagust, D. F., Won, M., & Duit, R. (2014). Paradigms in Science Education Research. In N. G. Ledermann & S. K. Abell (Eds.), *Handbook of Research on Science Education* (Vol. 2, pp. 3 - 17). Routledge.

Turner, S., & Mccreery, G. (2015). Scientific norms/counternorms. *The Blackwell encyclopedia of sociology*.

Van der Sanden, M. C., & Meijman, F. J. (2008). Dialogue guides awareness and understanding of science: an essay on different goals of dialogue leading to different science communication approaches. *Public Understanding of Science*, *17*(1), 89-103.

Vice, S. (1997). *Introducing Bakhtin*. Manchester University Press.

Winkel, M., Trivedi, C. B., Mourot, R., Bradley, J. A., Vieth-Hillebrand, A., & Benning, L. G. (2022). Seasonality of glacial snow and ice microbial communities. *Frontiers in Microbiology*, *13*, 1760.

Yallop, M., Anesio, A., Perkins, R., Cook, J., Telling, J., Fagan, D., Macfarlane, J., Stibal, M., Barker, G., Bellas, C., Hodson, A., Tranter, M., Wadham, J., & Roberts, N. (2012). Photophysiology and albedo-changing potential of the ice algal community on the surface of the Greenland ice sheet. *The ISME journal*, *6*. https://doi.org/10.1038/ismej.2012.107

Zittoun, T., & Brinkmann, S. (2012). Learning as Meaning Making. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 1809-1811). Springer US. https://doi.org/10.1007/978-1-4419-1428-6_1851

Ørngreen, R., & Levinsen, K. (2017). Workshops as a Research Methodology. *Electronic Journal of E-learning*, *15*(1), 70-81.

Aarhus Universitet. (No date-a). *Deltagerobservation*. Retrieved 5 January 2023 from https://metodeguiden.au.dk/deltagerobservation/

Aarhus Universitet. (No date-b). *Feltnotater*. Retrieved 5 January 2023 from https://metodeguiden.au.dk/feltnotater

Aarhus Universitet. (No date-c). *Observationsstudier*. Retrieved 7 January 2023 from https://metodeguiden.au.dk/observationsstudier

Aarhus Universitet. (No date-d). *Passiv/aktiv problematik*. Retrieved 6 January 2023 from https://metodeguiden.au.dk/passivaktiv-problematik

Appendix

References for images in appendix:

A. Picture provided from the Deep Purple Research Team

B. Picture provided from the Deep Purple Research Team

C. Photo by Mourot, R. in online article '*Aristotle first spotted 'blood snow' on Mount Olympus. Today, photos show that colorful algae may be eating away Earth's glaciers.'* by McFall-Johnsen, M. Business Insider. Published 7th of January 2023. Available at: Photos: Colorful Glacier Algae Aristotle First Spotted May Be Trouble (businessinsider.com).

D. Picture provided from the Deep Purple Research Team

E. Anesio, A. (2022) *Recent Advances in Cryospheric Microbiology*, lecture notes, presented at the International Glaciological Society, Aarhus University, delivered 7th of June 2022, p. 22.

F. Mourot, R. (2022) 'Diversity in action' *Blog.* Available at: DEEP PURPLE - Blog (deeppurple-ercsyg.eu) (Accessed: December 2022).
(Right picture) and photo by Benning, L. in online article '*Aristotle first spotted 'blood snow' on Mount Olympus. Today, photos show that colorful algae may be eating away Earth's glaciers.'* by McFall-Johnsen, M. Business Insider. Published 7th of January 2023. Available at: Photos: Colorful Glacier Algae Aristotle First Spotted May Be Trouble (businessinsider.com) (left)

G. Anesio, A. (2022) *Recent Advances in Cryospheric Microbiology*, lecture notes, presented at the International Glaciological Society, Aarhus University, delivered 7th of June 2022, p. 45.

H. Anesio, A. (2022) *Recent Advances in Cryospheric Microbiology*, lecture notes, presented at the International Glaciological Society, Aarhus University, delivered 7th of June 2022, p. 14.

I. Anesio, A. (2022) *Recent Advances in Cryospheric Microbiology*, lecture notes, presented at the International Glaciological Society, Aarhus University, delivered 7th of June 2022, p. 20.

J. Wikiwand (no date) *Grønlands indlandsis.* Available at: Grønlands indlandsis - Wikiwand (Accessed: December 2022).

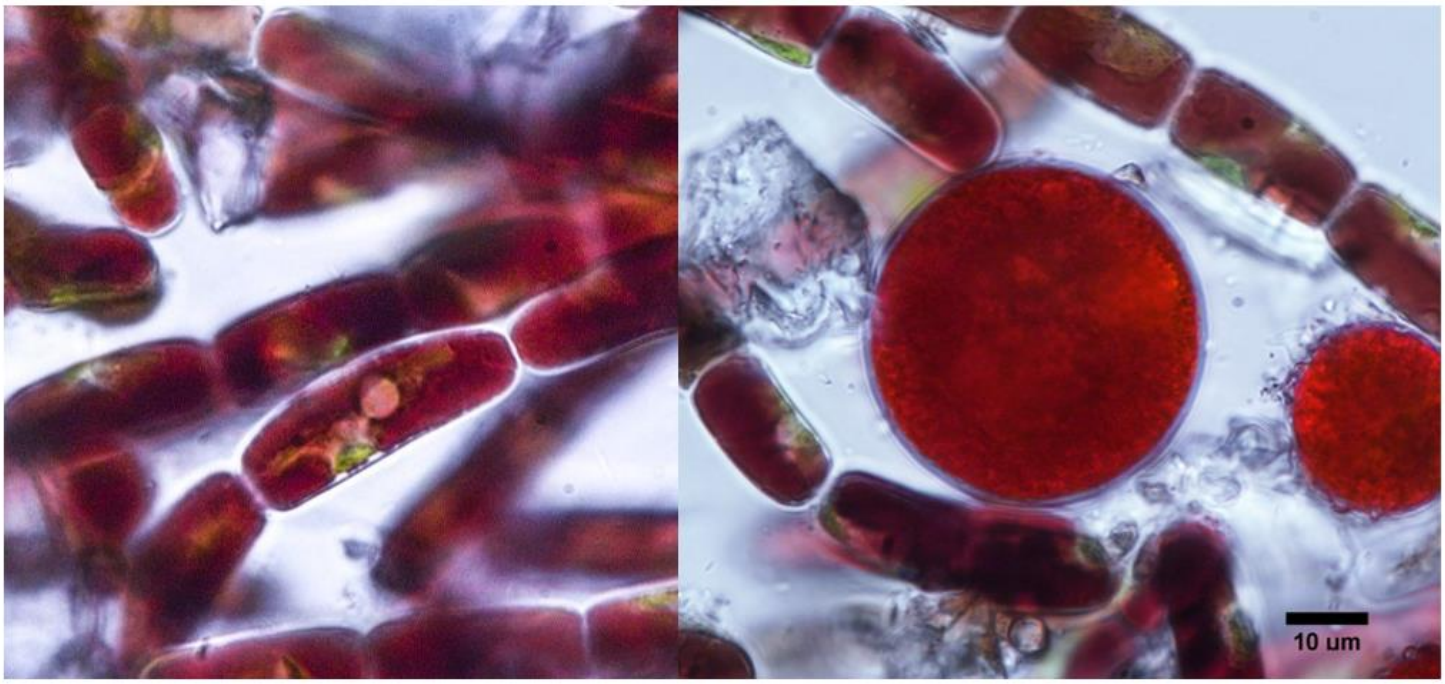

Figure A. Microscope image of the Ice algae *Ancylonema* sp. and the snow algae *Chloromonas nivalis*.

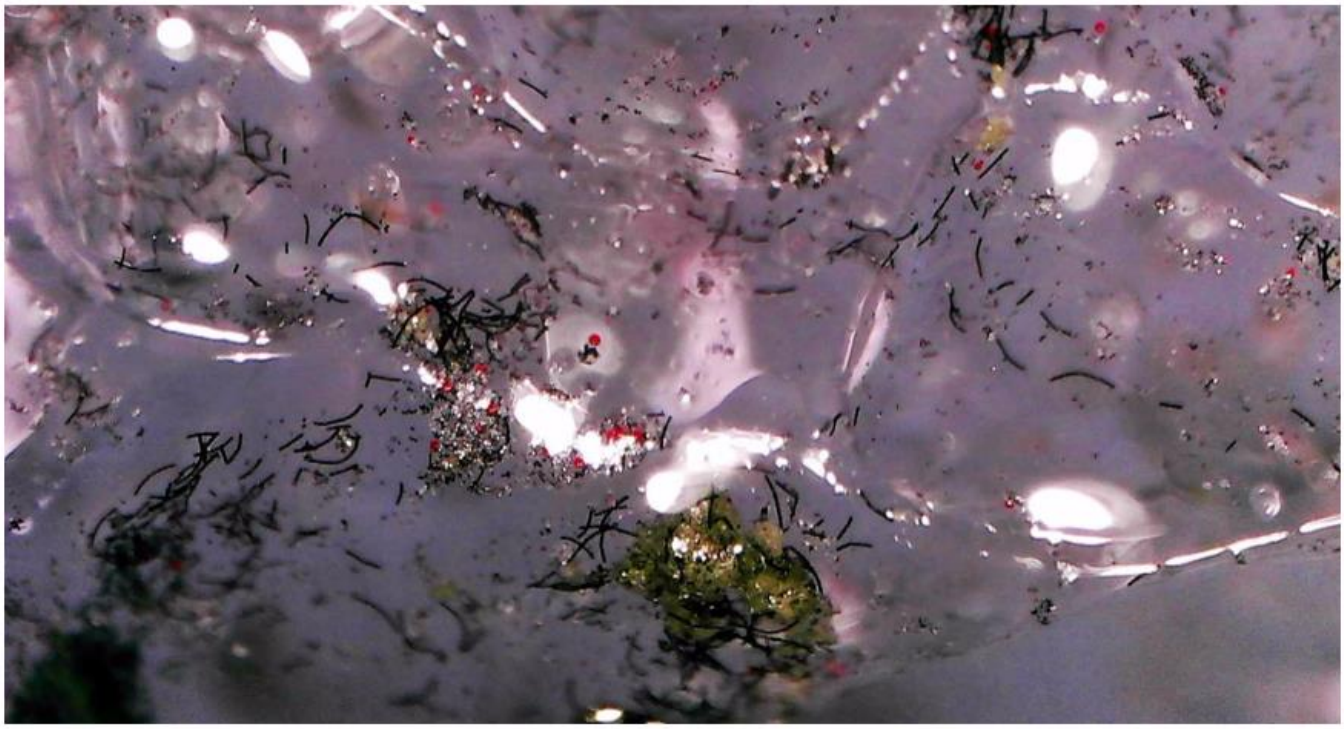

Figure B. Image of ice with microbes (*Ancylonema* sp. and *Chloromonas nivalis*).

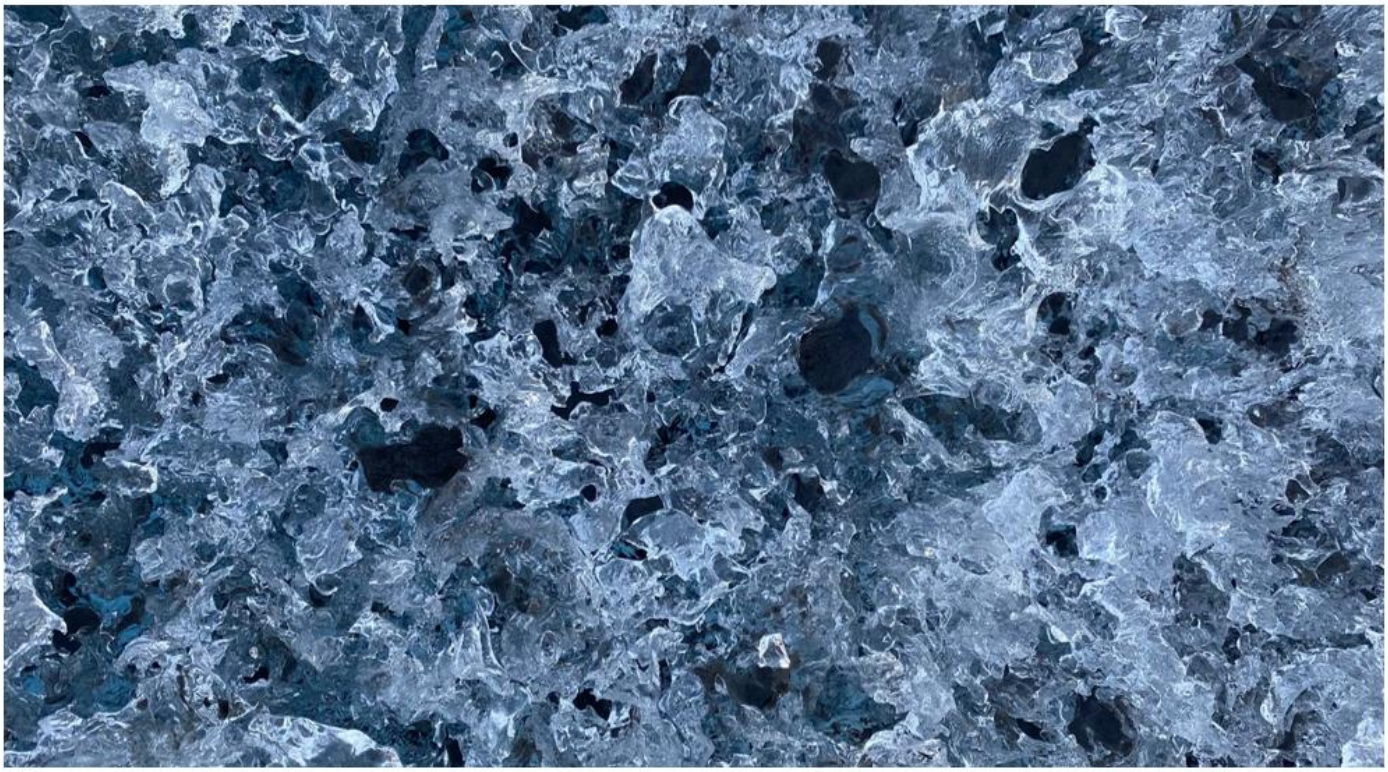

Figure C. Image of the weathering crust.

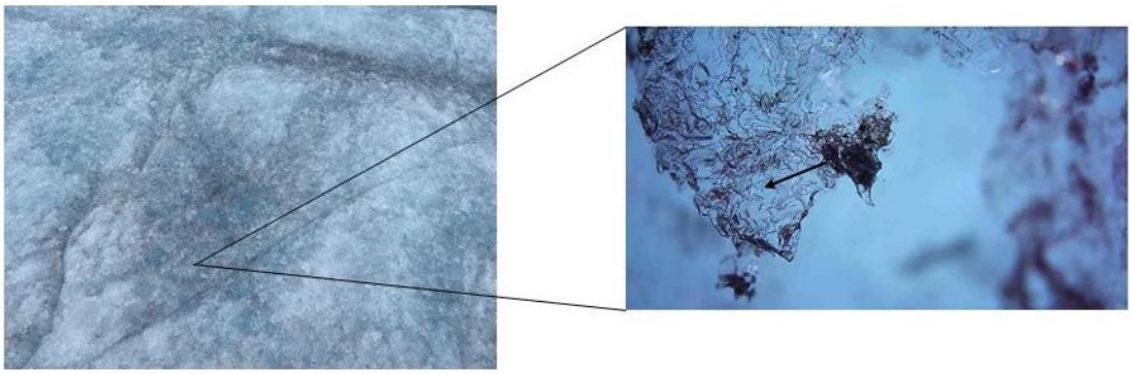

Figure D. Image of dark ice with microbes.

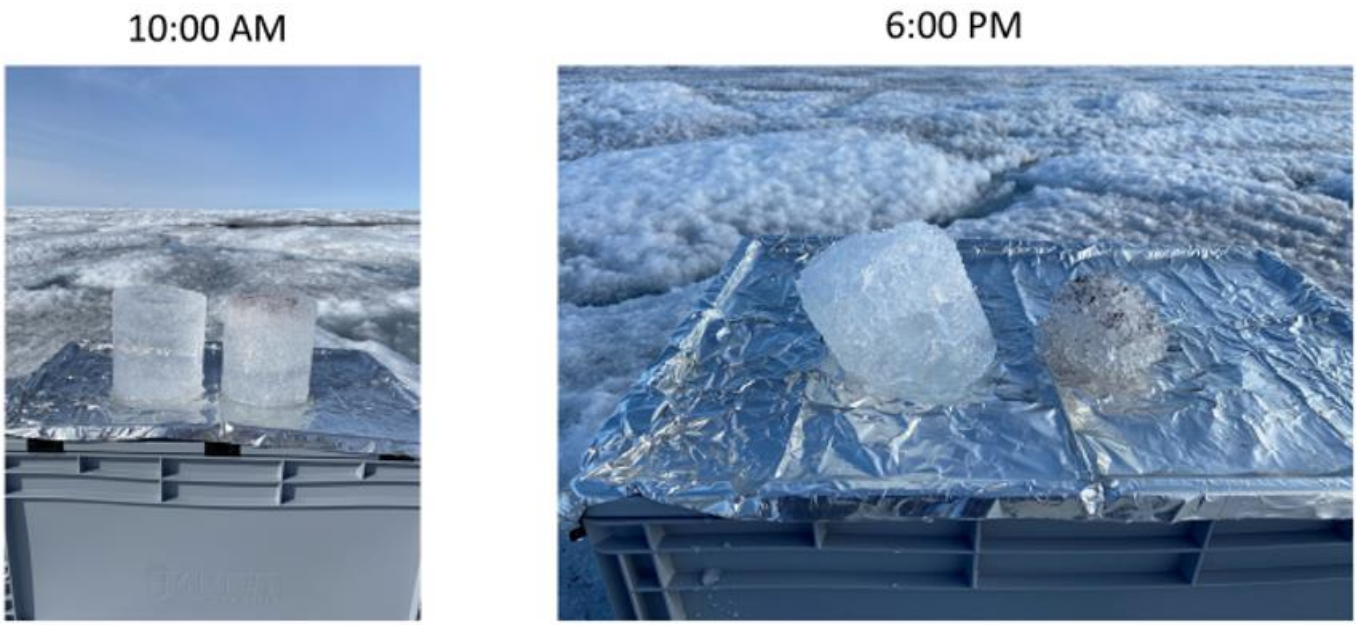

Figure E. Dark and clear ice from the Greenlandic Ice Sheet at two different time points.

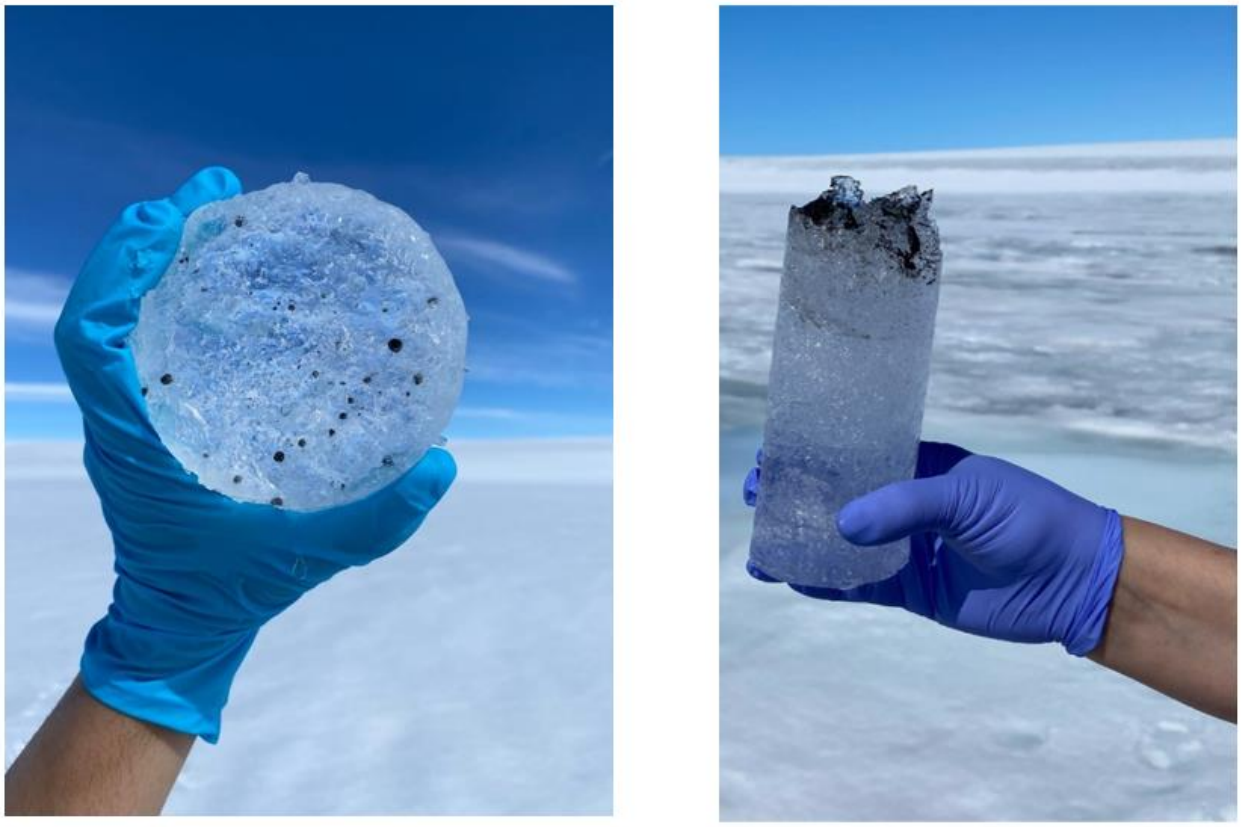

Figure F. Two ice samples with microbes.

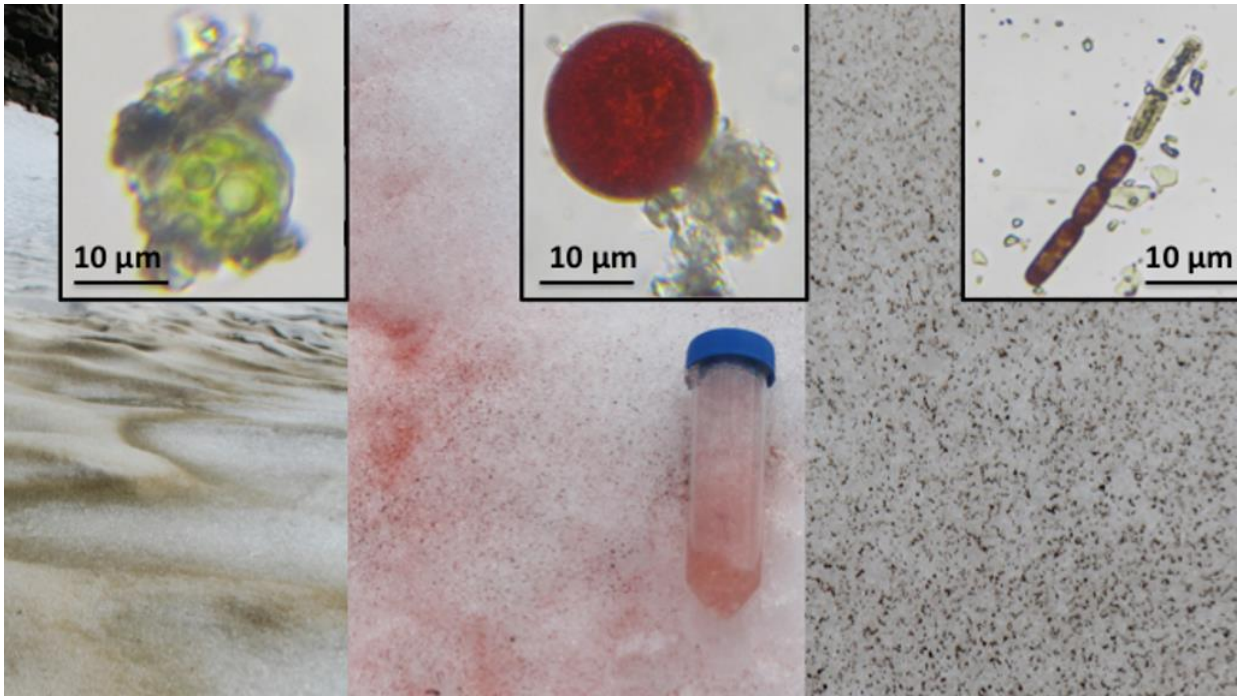

Figure G. Image showing different ice and snow algae with different pigmentation, resulting in different coloured ice and snow. (From left to right) Microscopic image of the snow algae *Chloromonas* sp (green and red pigmentation) and the ice algae *Ancylomena* sp.

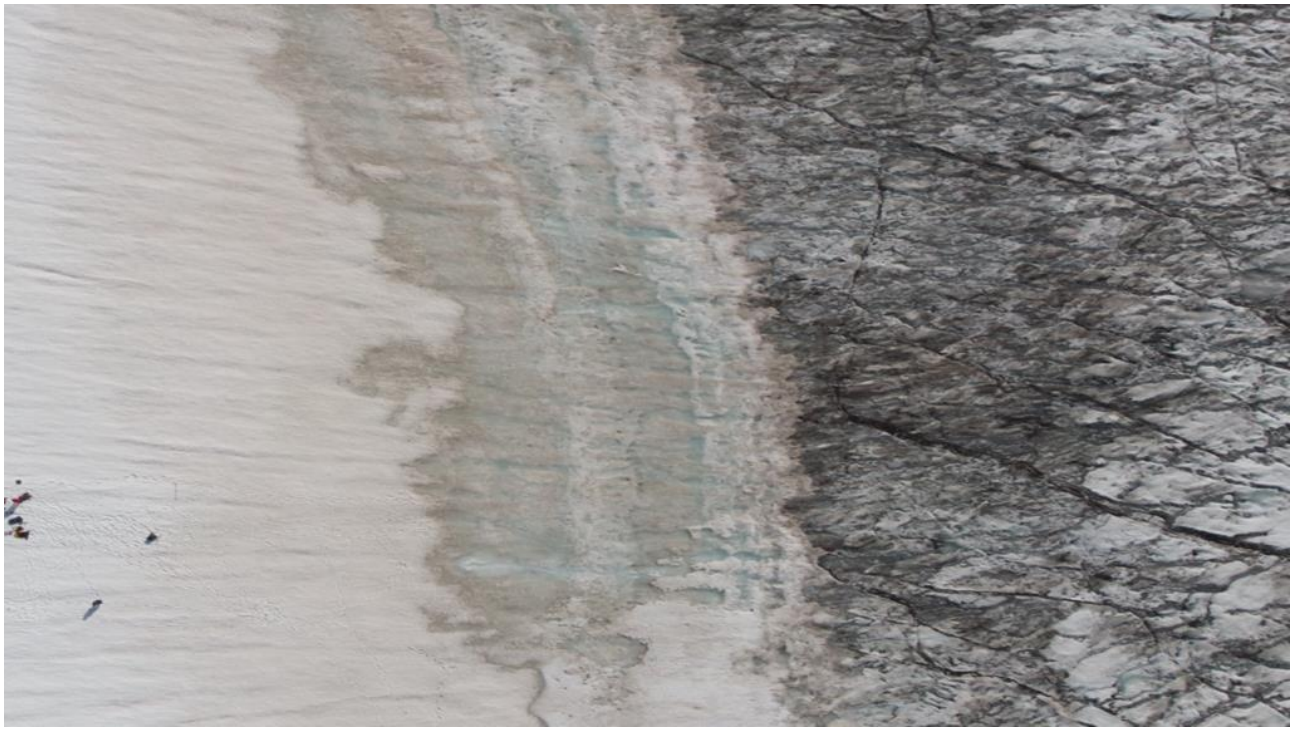

Figure H. Drone image of the Greenlandic Ice Sheet showing dark areas of the Ice Sheet. Humans for scale on the picture.

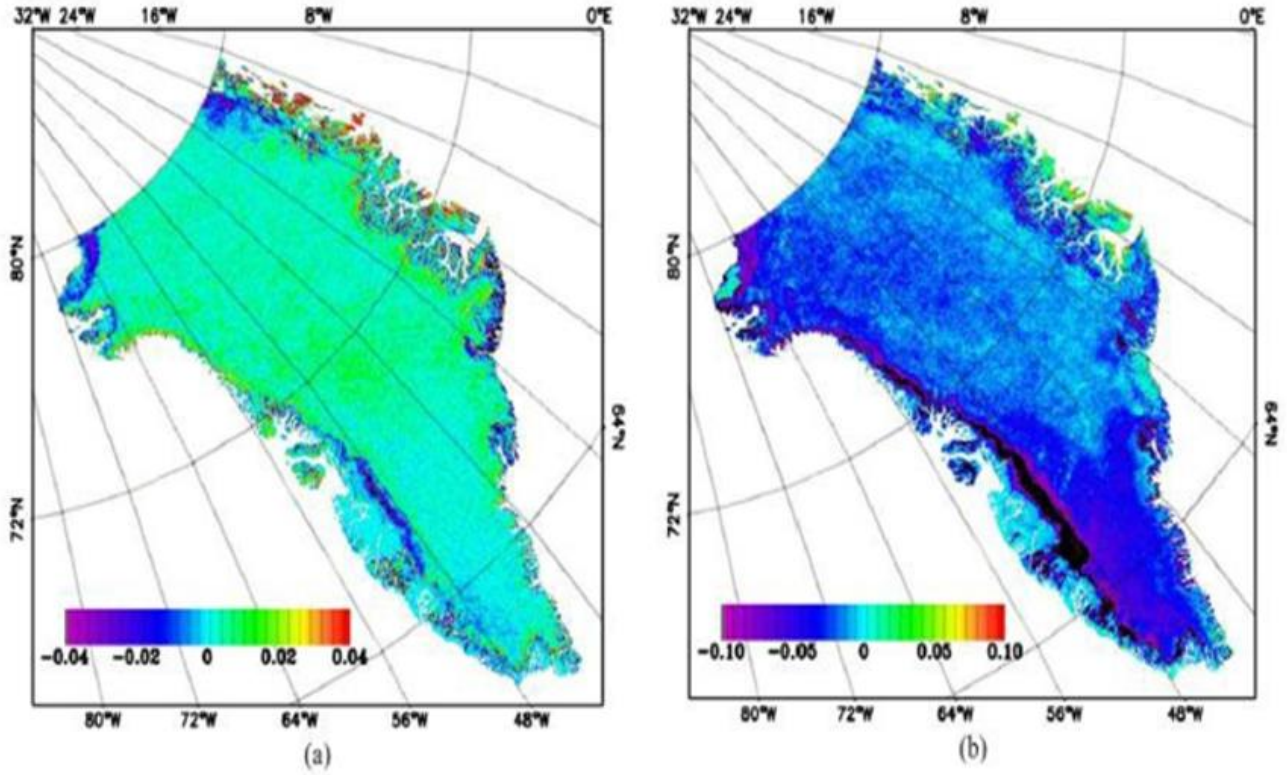

Figure I. Albedo changes 1981-2000 (left) and 2000-2012 (right)

Figure J. Satellite image of Greenland