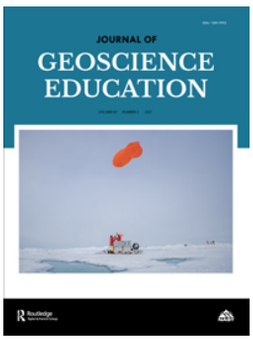

Journal of Geoscience Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ujge20

"It is not something that has been discussed": Climate change in teacher education in Greenland and Canada

Lars Demant-Poort & Paul Berger

To cite this article: Lars Demant-Poort & Paul Berger (2021) "It is not something that has been discussed": Climate change in teacher education in Greenland and Canada, Journal of Geoscience Education, 69:2, 207-219, DOI: 10.1080/10899995.2020.1858265

To link to this article: https://doi.org/10.1080/10899995.2020.1858265

Published online: 03 Feb 2021.

JOURNAL OF GEOSCIENCE EDUCATION
2021, VOL. 69, NO. 2, 207–219
https://doi.org/10.1080/10899995.2020.1858265

"It is not something that has been discussed": Climate change in teacher education in Greenland and Canada

Lars Demant-Poort[a] and Paul Berger[b]

[a]Institute of Learning, University of Greenland, Nuuk, Greenland; [b]Faculty of Education, Lakehead University, Thunder Bay, Ontario, Canada

ABSTRACT

We describe findings from an exploratory study on Greenlandic and Canadian preservice teachers' (PSTs') views on climate change teaching and teacher education programs. Greenland and Canada are experiencing more rapid warming than the global average. Climate resilience is thus of great importance and climate change needs to be taught to foster innovations and adaptation and to prepare young citizens to be engaged participants in policy debates about mitigation. Forty-five PSTs at the University of Greenland and Lakehead University answered a survey comprised mainly Likert Scale and open-ended questions. We found that PSTs need more knowledge about climate change, while, across disciplines, almost all would like to teach climate change and believe that preparing to do so should be a part of initial teacher education.

ARTICLE HISTORY
Received 15 June 2019
Revised 19 November 2020
Accepted 28 November 2020

KEYWORDS
Climate change education; Greenland and Canada; teacher education

Background

In 1987, the Brundtland Commission issued *Our Common Future*, a report on sustainable development (UN, 1987). In 1990, the Intergovernmental Panel on Climate Change (IPCC) described the *UN Framework Convention on Climate Change*. In 1992, the *RIO Earth Summit* put environmental change on the international agenda. In 1997, the *Kyoto Protocol* was signed, setting targets for cutting greenhouse gas emissions. After failing to sign an international treaty for reducing emissions in Copenhagen in 2009, the *Paris Agreement* was signed in 2015, bringing "all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects" (UNFCCC, n.d.). Article 12 in the *Agreement* states: "parties shall cooperate in taking measures, as appropriate, to enhance climate change education" (United Nations, 2015, p. 16).

The past three decades have seen accelerated environmental change. According to the IPCC's (2018) latest report, climate change is having a profound impact on ecosystems and social systems. Canada is warming twice as fast as the global average, the Canadian Arctic three-times as fast (Canada's Changing Climate Report, 2019). Greenland is also experiencing rapid warming (Orsi et al., 2017). In regions dependent on stable sea-ice for cultural practices such as travel and hunting, this poses immense challenges (Gearheard et al., 2013; Hastrup, 2015; Huntington et al., 2017; Nunavut Climate Change Center, n.d.; Poort, 2007).

Many warnings have led some educational institutions to respond by including Education for Sustainable Development courses or programs in their offerings (Boon & James Cook University, 2016; UNESCO, n.d.); however, overall, little has been done. This is especially true for climate change in K-12 schooling. Looking at curricula across countries, including Greenland, Canada, Denmark, Iceland, and the UK, climate change, when it appears at all, is most often a topic in the sciences, and many teachers are ill prepared to teach it (Bangay & Blum, 2010; Boon, 2015; Nicholls, 2016; Plutzer et al., 2016; Wynes & Nicholas, 2019).

Why climate change education for arctic teachers matters

This study explores preservice teachers' (PSTs') climate change knowledge, their perspectives on the relevance of climate change education in K-12 schooling, and their readiness to teach climate change across subjects.

Teachers in Canada follow provincial curriculum and in Greenland follow a national curriculum with learning objectives defined in a government proclamation. They are expressions of what competencies, skills, and knowledge are valued. They are also indirectly an expression of how a country views its responsibility toward citizens of the future. Neither Greenland nor Canada has standards or learning goals congruent with the scientific consensus on climate change (Greenland Home Rule, 2003; Wynes & Nicholas, 2019).

In Canada, the provinces have implemented varied approaches to teaching climate change; there is no nationwide focus on climate and some textbooks contain "statements inconsistent with the scientific consensus" (Wynes & Nicholas, 2019, p. 16). In Greenland's current national curriculum, there is no mention of climate change in the learning objectives (Greenland Home Rule, 2003).

At the time of data collection, PSTs in Greenland had no course dedicated to climate change, PSTs at Lakehead's

CONTACT Lars Demant-Poort lodp@uni.gl Institute of Learning, University of Greenland, C. E. Janssensvej 2, 3900 Nuuk, Greenland.

Thunder Bay campus could take an 18-h elective on climate change pedagogy, and the first PSTs in the new two-year teacher education program took the mandatory 36-h *Environmental Education*, a course including some climate change education.

Greenland and Canada, both countries with polar identities, are experiencing the impacts of climate change faster than many other regions around the globe. It is, therefore, especially relevant to know what PSTs know about climate change, and how well they are being prepared to teach it.

Only a third of Canadian teachers teach climate change, most spending only 1–10 h doing so (Field et al., 2019). PSTs must graduate prepared to increase this. Understanding PSTs' readiness may help strengthen climate change education in initial teacher education, leading to more climate change teaching in Greenland and Arctic Canada. This would better equip students to understand and respond to climate disruption.

Southern Canadians' lack of climate change knowledge (Field et al., 2019) also impacts Canada's polar regions, though indirectly, resulting in lower citizen support for strong climate policy that could help to limit warming. Improving climate change teaching should also help to improve this situation.

Climate change in initial teacher education

Students need teachers who can confidently bring climate change into their teaching—even in the absence of mandated curriculum. It must, therefore, be included in initial teacher education, where it is, unfortunately, still in its infancy (UNESCO, 2013), almost wholly confined to courses on teaching science (Berger et al., 2015).

Climate change affects ecosystems and social systems on a global scale (Hoegh-Guldberg et al., 2018). K-12 learning must, therefore, engage the scientific, philosophical, economic, psychological, political, and social aspects of climate change (Brownlee et al., 2013). K-12 teachers need good general knowledge about climate change and the skills to incorporate relevant aspects into their teaching.

Unfortunately, most PSTs have "a significant and alarming lack of knowledge" on climate change (Arslan et al., 2012; Berger et al., 2015; Boon, 2015; Boon & James Cook University, 2016, p. 42), perhaps unsurprising, given that even many high school science teachers hold misconceptions (Plutzer et al., 2016) and many university instructors lack formal training in climate science (Vernon et al., 2016). Climate confusion results from gaps in education systems (McCaffrey & Buhr, 2013).

The literature on climate change education in initial teacher education is not extensive. Much of it is focused on science teaching, such as Lambert and Bleicher (2013), who found that focusing on climate change led elementary science PSTs to have increased knowledge and more concern about it, Van Zee et al. (2016), who discussed ways to incorporate climate change into PSTs' methods courses, and Hufnagel (2015), who looked at emotions in a preservice elementary science course. Less literature describes preparing PSTs to teach about climate change outside the sciences.

Berger et al. (2015) described an 18-h climate change teaching elective at Lakehead University, a small university in Ontario, Canada. Students in the class came from different subject backgrounds and divisions covering K-12. Their background climate change knowledge varied widely and participants thought the course should be lengthened and made mandatory.

Vongalis-Macrow (2010) wrote that the focus in K-12 teaching should be on the dangers of climate change rather than on science. Over 90% of the Australian PSTs in her study, across disciplines, believed all teachers should teach climate change—even though many expressed uncertainties about the science.

Boon and James Cook University (2016) surveyed 87 PSTs and early childhood educators in Australia at the beginning and end of their four-year program. Most felt they should teach climate change, but even after three courses in sustainability-related topics, they reported feeling unprepared to do so.

We know of no previous work with PSTs and climate change knowledge or attitudes in Greenland. Our exploratory work at Lakehead University in Canada and at the teacher–education program at the University of Greenland adds to the body of knowledge on PSTs' understanding of climate change science, their preparedness to teach about climate change, and their attitudes toward teaching about climate change across grades and disciplines.

Purpose of the research

This research explores northern PSTs' attitudes toward, and capacities to teach, climate change, which will help initial teacher education programs better prepare teachers, leading to increased resilience in a rapidly changing part of the world, heavily impacted by climate change. We asked: "How do pre-service teachers across disciplines understand climate change and its relevance to education and teaching?"

We collected demographic information, asked climate knowledge questions, and solicited PSTs' views on climate change teaching and teacher education. We also explored whether PSTs with science teaching subjects differed from PSTs with non-science teaching subjects.

Methods

This study used survey methodology (Bryman, 2016; Evans & Mathur, 2005) with closed- and open-ended questions. Closed-ended questions were used for descriptive and demographic purposes. Questions on climate change knowledge were partly based on Boon's work (Boon 2010; Boon & James Cook University 2016) in Australia. They investigated the role of CO_2 and other greenhouse gases, scientific predictions for future climate impacts, and knowledge of the scientific consensus on climate change.

Open-ended questions investigated how PSTs feel about teaching climate change and their preparation for teaching climate change during initial teacher education. They were based on earlier work by the second author (Berger et al., 2015).

We used *SurveyXact* (an online survey tool) to administer the survey in three versions, English, Danish, and Greenlandic. An online tool was selected for ease of use by the participants (Park et al., 2019) and for ease of data collection and analysis (Evans & Mathur, 2005). The survey was created and piloted for internal and construct validity (Gehlbach & Brinkworth, 2011) in February, 2017 with 12 PSTs attending Lakehead University and the University of Greenland. The pilot revealed that PSTs were very interested in sharing reflections on the variables in the questionnaire—all of them chose to answer the comments sections in the closed-ended questions. Based on participants' responses to the pilot, we chose to include additional open-ended questions, which allowed for deeper understanding and to further avoid bias (Reja et al., 2003), then re-piloted for linguistic validity in Greenlandic, Danish, and English.

Translation to Greenlandic was challenging since it does not have the same broad scientific vocabulary as English or Danish (Demant-Poort, 2016; KIIIP/Inerisaavik, 2004). To increase linguistic validity between Greenlandic and Danish/English, we had translations to Greenlandic tested by two PSTs and by a Greenlandic linguistics lecturer in teacher education at the University of Greenland.

The Research Ethics Board at Lakehead University approved the research and the survey was distributed to Bachelor of Education students in their final years in February, 2018. The survey had 18 questions in three categories. Demographic questions determined age, teaching subjects, and location. Questions exploring knowledge and beliefs included: the main cause of the 1 °C average global temperature increase; certainty that human activity is causing climate change; the level of scientific consensus on anthropogenic climate change; consequences if we do not tackle climate change; and when serious impacts would occur. PSTs were also asked in what subjects climate change should be taught, how they had been prepared to teach about climate change, and if the preparation was adequate.

Apart from four demographic questions, five questions required responses on a Likert Scale, one was "choose all that apply," one needed a "yes/no" response, and four were open-ended (three requiring participant-generated lists); three questions were multiple-choice. For ten of the questions, there was a "comments" field. Typically, between six (13%) and ten (22%) PSTs made further comments.

The survey was disseminated through email to 282 Canadian PSTs in their final year at the Orillia and Thunder Bay campuses of Lakehead University (total number of enrolled PSTs at Lakehead University is around 650) and to 52 Greenlandic PSTs who had completed at least half of their program at the University of Greenland in Nuuk (total number of enrolled PSTs at the University of Greenland is around 170). Participation was anonymous and voluntary; the sample was a convenience sample. The response rate was 13.6% ($n = 45$); the Canadian response rate was 6.0% ($n = 17$) and the Greenlandic response rate was 53.8% ($n = 28$). All Canadian participants grew up in Ontario; Greenlandic participants grew up in communities on the west coast of Greenland, from Upernavik in the north to Nanortalik in the south.

The Greenlandic response rate was high for online surveys, while the Canadian response rate was low (Perkins, 2011), reducing the generalizability of the study. We speculate that the low response rate among Canadian PSTs may have been due, in part, to a lack of a sense of urgency about climate change. While 83% of all Canadians are concerned about climate change (Anderson & Coletto, 2017), news reports suggest that 46% of the population were unwilling to pay anything personally to mitigate effects of climate change (Connolly, 2019; Grenier, 2019), while 22% were willing to pay up to $100. It seems that many Canadians did not believe that climate change was an urgent or particularly serious matter, which may have impacted willingness to take part.

Low confidence in their climate change knowledge may also have kept many Canadian PSTs from participating. The second author has experienced PSTs' low confidence in their knowledge about climate change to be a barrier to recruiting in earlier research (Berger et al., 2015), something described elsewhere with a similar sample (McNeal et al., 2014). While we know of no other research that looks at the level of climate change knowledge of Canadian PSTs, recent work shows that most Canadian teachers have weak knowledge of climate change science. Field et al. (2019) found much stronger knowledge of climate change among teachers in a convenience sample than in a representative sample, again suggesting that people without much knowledge may decline invitations to take part in climate change research.

Finally, we speculate that the timing of the survey, during the busiest time at the end of the Canadian program, may have meant that those without special interest in climate change prioritized other things.

For the Greenlandic population, the substantially higher response rate might be due to a greater feeling of personal relevance, as the majority of the population in Greenland are aware of changes to the environment. Agneman and Minor (2018) found that 82% of the Greenlandic population are concerned or somewhat concerned about climate change. The high level of concern may be fueled by personal accounts of changes to nature, such as to sea ice (Gearheard et al., 2013; Poort, 2007). Experiencing less sea ice and longer periods of drought, particularly in the south of Greenland where agricultural production is concentrated, might have encouraged more PSTs to respond to the survey in Greenland. The higher response rate in Greenland might also be the result of a face-to-face invitation by the first author, whom PSTs knew as an instructor in the program. People may be more willing to participate in survey research when it is conducted by a colleague (Saleh & Bista, 2017) or a "high-power" researcher (Pan et al., 2014).

Participants

Nine of the Canadian participants were studying to teach Grades 7–12 and indicated teaching subjects including English, History, Chemistry, French, Mathematics, Biology, Physics, Environmental Sciences, Geography, Social Sciences,

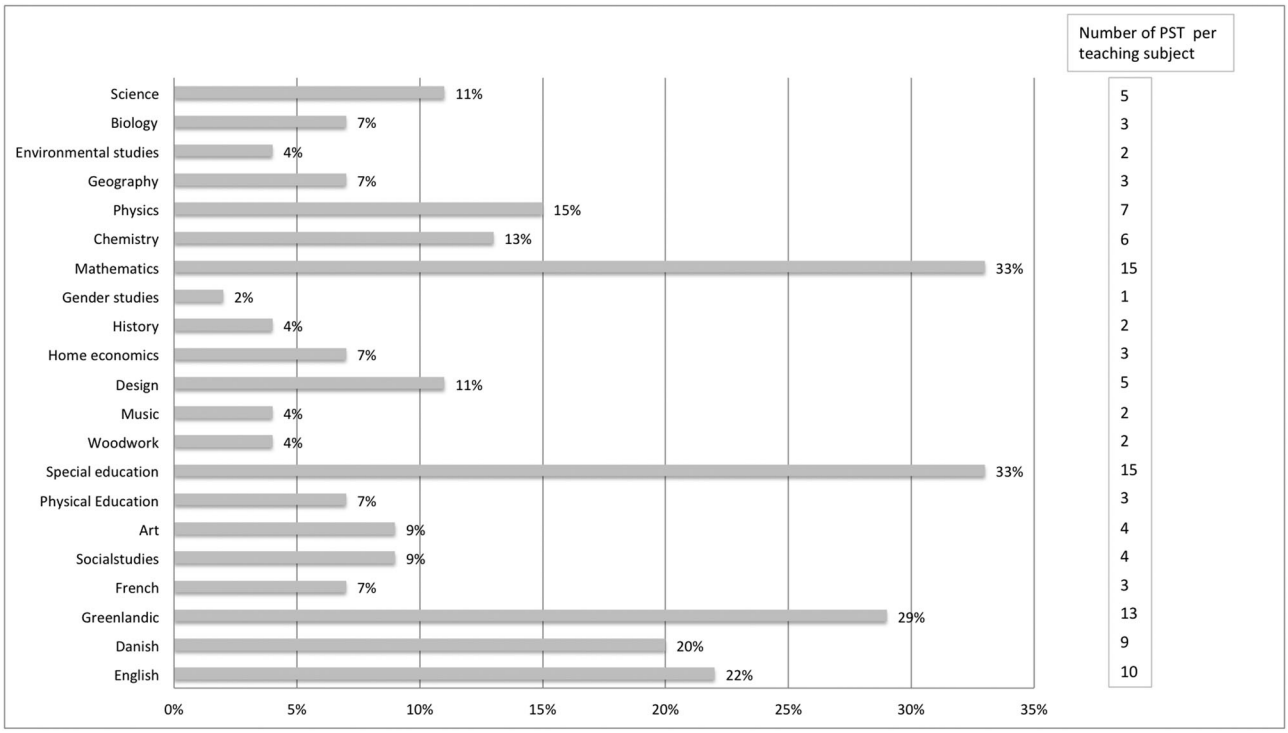

Figure 1. Pre-service Teachers' teaching subjects presented in the study.

and Science. Two were studying to teach Grades 4–9 and indicated the teaching subjects French and Geography, though in the Ontario school system they may well teach all subjects. Six were studying to teach Grades K-6 and will likely teach all subjects. "Teaching subjects" are subjects that teachers have more specialized knowledge in and, depending on the school system, may be the only subjects they teach.

Two of the Greenlandic participants were studying to teach Years 8 – 10, with teaching subjects including English, Danish, Special Education, and Social Studies. Five were studying to teach Years 1–7 and 21 to teach Years 1–10, with teaching subjects including Greenlandic, Mathematics, Special Education, Danish, Art, Physics, Family Studies, Music, Physical Education, Carpentry, Crafts, Science, and Social Studies.

Seventeen surveys were completed primarily or wholly in English, 17 in Greenlandic, and 11 in Danish. Eighty percent of participants identified as female ($n = 36$), 20% as male ($n = 9$). The ratio of female to male participants is roughly reflective of the demographics in the teacher education programs in both countries. In Greenland, there is only one teacher education program, at the University of Greenland. The female/male ratio was obtained from the student office. In Canada, about 74% of K-12 teachers are female (Statistics Canada, 2014).

Participants' teaching subjects

In both Greenland and Canada, teacher education programs offer a variety of teaching subjects. Participating PSTs by teaching subject are illustrated in Figure 1.

The teaching subject data provide a means to explore whether subject background is related to PSTs' knowledge of climate change, and attitudes toward climate change teaching and education. It reveals a wide variety of teaching subjects among the participating PSTs and the overrepresentation of certain groups of subjects—the languages, physical education, and mathematics. It is particularly interesting that the majority of PSTs from Greenland (82%) declared non-science teaching subjects (henceforth called "non-science PSTs") whereas 58% of PSTs from Canada declared one or more sciences as a teaching subject (henceforth called "science-PSTs") (see Table 1). We speculate that the Canadian PSTs with science backgrounds may have felt more confident in their climate change knowledge, leading to a higher participation rate.

Data analysis

Descriptive statistics were generated from the quantitative data (Creswell, 2014), giving a broad picture of participants' knowledge and thoughts on questions in different categories. NVivo 12 was used for coding qualitative data from the open-ended questions and comments fields that were meant to deepen our understanding of the quantitative results. Statements from each participant were coded individually, leading to several different codes from each category of climate change-related questions. These enabled the exploration of patterns of participants' responses. Demographic variables were used to examine differences in response, typically by location (Greenland or Canada), or by preparation to teach science or non-science subjects.

As an exploratory study using a convenience sample that was, in the case of the Canadian participants, likely biased toward people with greater than average understanding of climate change, the findings cannot be taken to represent the knowledge and views of all Canadian and Greenlandic PSTs. Nevertheless, we believe faculties of education should

Table 1. Number and percentage of PSTs who have indicated science *vs.* no-science as teaching subject.

	No science	Some science	All science	No teaching subject	Total
Canada	9% ($n = 4$)	11% ($n = 5$)	13% ($n = 6$)	4% ($n = 2$)	100%
Greenland	51% ($n = 23$)	9% ($n = 4$)	2% ($n = 1$)		($n = 45$)

Table 2. PSTs' certainty that climate change is human-caused.

	Very certain	Certain	Somewhat certain	Not certain	Neutral—not sure	Total
Canada	22.2% ($n = 10$)	13.3% ($n = 6$)	2.2% ($n = 1$)	0%	0%	100% ($n = 45$)
Greenland	13.3% ($n = 6$)	24.4% (n = 11)	15.6% ($n = 7$)	4.4% ($n = 2$)	4.4% ($n = 2$)	
Total	35.5% ($n = 16$)	37.7% (17)	17.8% ($n = 8$)	4.4% ($n = 2$)	4.4% ($n = 2$)	

consider the results carefully in thinking about climate change education in their programs.

Limitations

As described above, the sample size was small and the findings not generalizable. A second limitation is accuracy in translation. While Danish and Greenlandic have equal status as teaching languages in the public school in Greenland (Inatsisartut [Parliament of Greenland], 2012, §4), translation does present a challenge for interpreting qualitative responses; nuance may be lost (Kapborg & Berterö, 2002). While a qualified translator translated all Greenlandic responses to Danish and English and then translations were validated by re-translating responses back to Greenlandic, strong dialects in Greenland and limited specialized scientific vocabulary make precision impossible. Still, where uncertainty was suspected, an employee from the Language Department validated translations.

Though the small sample size limits generalizability, the findings contribute to the discourse on how prepared new teachers will be to teach climate change across subjects, and how teacher education in the north, in particular, is, or is not, helping prepare new teachers.

Findings and discussion

Findings are presented in three themes: *PSTs' understanding of the causes of climate change*, *PSTs' views on climate change in K-12 schooling*, and *PSTs' perspectives on preparation to teach climate change.*

Theme 1: PSTs' understanding of the causes of climate change

In the first questions related to climate change, we provided participants with information from NASA (2017) that the average global temperature has increased by 1 °C since the 1880s. Participants indicated the cause of this increase in temperature. Seventy-one percent ($n = 32$) indicated emission of CO_2 and other greenhouse gases, 24% ($n = 11$) indicated ozone depletion, 2% ($n = 1$) a change in Earth's orbit, and 2% ($n = 1$) a change in solar activity.

To explore whether science PSTs have more accurate knowledge of the main cause of climate change, we looked at the 43 participants who indicated a teaching subject and either CO_2 ($n = 32$) or ozone depletion ($n = 11$). Ninety-four percent ($n = 15$) of the science PSTs correctly identified CO_2 while 63% ($n = 17$) of the non-science PSTs did so. Only one science PST incorrectly identified ozone, while 37% ($n = 10$) of the non-science PSTs did so. This suggests science PSTs are more likely to know the most basic science of climate change and that many non-science PSTs need education in this area.

Information about how PSTs think about this came from 12 PSTs who made comments, all but one related to climate change as an anthropogenic issue. For example, one Greenlandic PST wrote: "*In my answers I have chosen emission of CO_2 and CH_4, which are also natural—e.g., methane from permafrost or carbon dioxide from volcanoes, but we are emitting more than the 'natural'—this is also affecting the climate*" (translated from Danish). A Canadian PST wrote, "*Carbon dioxide makes up 76% of the anthropogenic gases contributing to greenhouse gas effect and increasing the temperature.*" Comments ranged from indicating an anthropogenic cause to showing nuanced understanding, including chemical formulas and natural contributions.

Most (71%, $n = 32$) PSTs correctly identified the scientifically accepted main cause of climate change, somewhat better than recent work in Canada that found only about half of Canadians, including teachers, correctly identified carbon dioxide and other greenhouse gasses as the main cause (Field et al., 2019). Clearly, though, more work is needed in teacher education to ensure that all PSTs know the basic science.

Anthropogenic climate change

The next question asked participants to what degree they were certain that the current change in climate was caused by human activity. The majority of PSTs (74%, $n = 33$) were "certain" or "very certain" (see Table 2).

For comparison, recent work in Canada showed 60% of a representative sample of educators and 78% of a convenience sample of educators believed climate change to be caused "mostly by human activities" (Field et al., 2019). Canadian PSTs were more certain than Greenlandic PSTs that the rise in global temperature is anthropogenic, as were science PSTs, none of whom indicated "not certain" or "neutral/not sure." This again suggests that, at least for non-science PSTs, teacher education needs to include basic climate science knowledge.

Table 3. PSTs' knowledge of the scientific consensus.

Percentage of climate scientists who acknowledge climate change is caused by humans		25%	50%	75%	98%	100%
Distribution of percentage of PSTs by country who identify climate change scientists acknowledgement of anthropogenic climate change:	Canada	0%	0%	13.3 % ($n = 6$)	22.2% ($n = 10$)	2.2% ($n = 1$)
	Greenland	8.9% ($n = 4$)	15.6% ($n = 7$)	20% ($n = 9$)	20%(n = 9)	0%
Total		8.9% ($n = 4$)	15.6% ($n = 7$)	33.3% ($n = 15$)	42.2% ($n = 19$)	2.2% ($n = 1$)

Anthropogenic warming and the scientific consensus

Among climate scientists, about 98% agree that climate change is anthropogenic (Cook et al., 2016). We were interested in PSTs' knowledge of that scientific consensus (see Table 3).

Fewer than half of the PSTs correctly identified the 98% consensus, with a noticeable difference by country. More Canadian PSTs answered correctly. We believe this, and Canadian PSTs' greater certainly in the human responsibility for climate change, may be related to the probable Canadian sample bias toward people who are more knowledgeable than average about climate change.

In the US, Plutzer et al. (2016) found similar results with middle school and high school science teachers. It is important to know that the scientific consensus is over 90%; not knowing this can impact other beliefs about climate change and the level of one's support for strong climate policy (Cook et al., 2016). Both science and non-science PSTs were weak on this question.

Possible future consequences of climate change

Next, we asked what climate scientists suggest is likely to occur if we do not tackle climate change (Figure 2). The PSTs were asked to tick all consequences they believed applied. We interpret the indication of more than one of the listed consequences as understanding climate change as a serious threat, since they described far reaching and interrelated consequences. Most 93% ($n = 42$) of the participants ticked two or more, indicating that most participants view climate change as a serious threat.

One participant chose only "more extreme weather events," one only "coral bleaching." In seven cases, participants chose only impacts that do not explicitly involve humans, but all of them included dire impacts such as the collapse of the Greenland ice sheet or mass extinctions of animals and plants.

Seven participants added comments after this question. Five related to ice and two to severe consequences. From the latter: "*Although extreme, civilization collapse is a real possibility if nothing is done, or if too little is done too late,*" and, "*the consequences will be far-reaching; I am, though, most afraid that there won't be enough food for everyone*" (translated from Greenlandic). At various times in the past, localized changes in climate have made hunting in Greenland difficult (Kintisch, 2016) and many Greenlanders still depend on subsistence hunting (Poppel, 2015).

The five "ice" comments all concerned the loss of ice, either from the Greenland Ice Sheet or from Antarctica. For example: "*The inland ice in Greenland is melting considerably*" (translated from Greenlandic), and, "*Some icesheets in Antarctica are collapsing as well.*" It is clear that most PSTs believe that climate change will have serious consequences.

When will we experience serious impacts from climate change

Lastly, in this group of questions, we asked when "serious impacts" of climate change would occur. While open to interpretation, we expected the forest fires, heatwaves, droughts, floods, storms, food insecurity, spread of vector-borne diseases, species extinction, and human casualties that have already occurred to qualify as "serious impacts." While more than one-third answered "already occurring"—the data reveal a difference by country (see Table 4).

While this discrepancy could be related to bias in the sample, it may also be an indication of how climate change has affected the two regions differently. Canada has experienced well-publicized major forest fires—including one that devastated a small city (Derworiz, 2019)—along with ice storms, tornadoes, tick infestations, and significant flooding; climate change in Greenland has had a direct impact on the population in the far north of the country, where it has led to new job opportunities as it has opened the sea to more intense fishing (Government of Greenland, 2012). In the southeast of Greenland where sea-ice has decreased and is now almost entirely absent, climate change has led to a change in means of transport from dogsled to boat, and in some communities, it has meant easier access to fishing grounds (Poort, 2007). These changes, and an increase in melting of the Greenland ice cap, may be widely known but not seen as "serious impacts," in that they may appear to be neutral or positive. This may explain the differences between Canadian and Greenlandic participants' responses, since humans tend to focus on local rather than distant events (Marshall, 2014).

Data from these five questions suggest that most of the participating PSTs possess knowledge about climate change science, though many are not completely certain of the human cause, are unaware of the strength of the scientific consensus, and may underestimate impacts. Almost all see the impacts as serious, if, for some, occurring in the future rather than the present. An opportunity exists for teacher education programs to help PSTs, and especially non-science PSTs, to increase their climate change knowledge.

Personal action on, and concern about, climate change

As part of investigating PSTs' understanding of climate change, we asked about whether they had made personal lifestyle changes or taken part in collective political action to mitigate climate change, and whether they were worried about climate change. 42% ($n = 19$) reported having taken some action. This included 59% ($n = 10$) of the Canadian and 25% ($n = 7$) of the Greenlandic participants. It should be noted that per capita CO_2 emissions in Greenland in

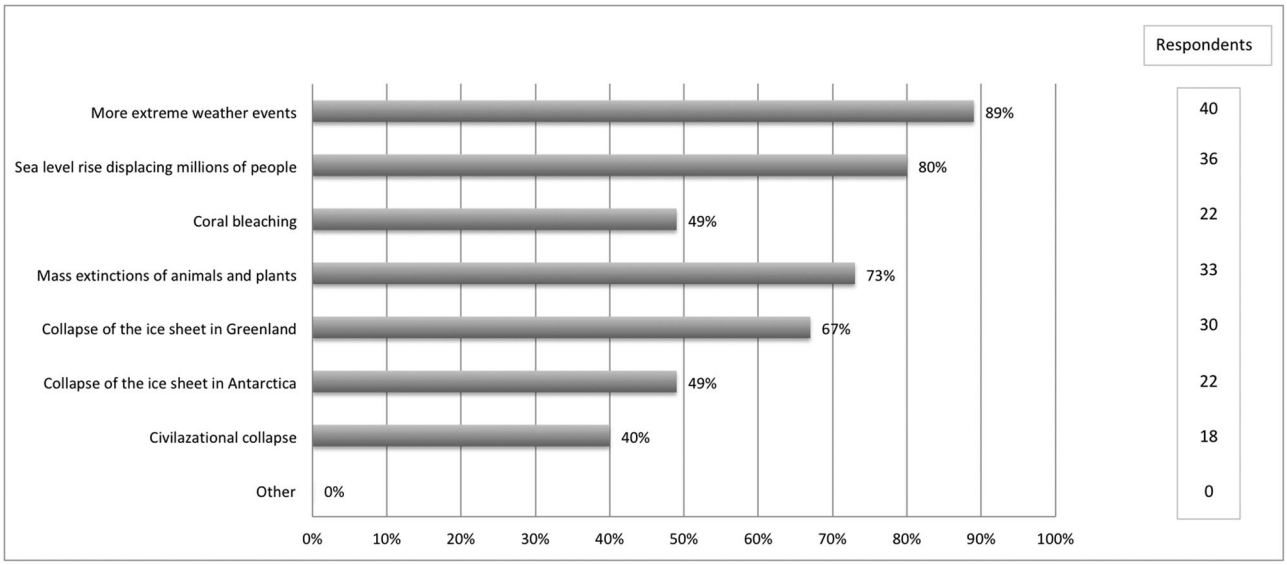

Figure 2. Pre-service Teachers' responses to questions on what, according to science may happen, if climate change in not tackled. Respondents had the opportunity to check all items.

Table 4. PSTs' thoughts on the timing of serious climate change impacts.

	Already occurring	Before 2050	Around 2050	Around 2100	Later centuries	Never	Total
Canada	31.1% ($n = 14$)	2.2% ($n = 1$)	2.2% ($n = 1$)	2.2% ($n = 1$)	0%	0%	
Greenland	8.9% ($n = 4$)	13.3% ($n = 6$)	13.3% ($n = 6$)	11.1% ($n = 5$)	15.6% ($n = 7$)	0%	
Total	40% ($n = 18$)	15.5% ($n = 7$)	15.5% ($n = 7$)	13.3% ($n = 6$)	15.6% ($n = 7$)	0%	100%($n = 45$)

2015 were 9.97 tonnes (Statistics Greenland, 2015) and 19.40 tonnes in Canada in 2016 (Canadian Government, 2018).

Sixteen PSTs (10 from Canada and 6 from Greenland) chose to explain the kind of changes they had made, providing insight into varied understandings of climate science. Personal actions that reduce emission of greenhouse gases such as CO_2 were coded as "emission reduction" ($n = 8$) and personal actions that did not clearly resonate with personal reduction of greenhouse gases coded "non-emission reduction."

Seven emission reduction actions were from Canada; the one Greenlandic voice stated: "*Personally, I think about my consumption of electricity and water; apart from that, I am not politically active on climate change*" (translated from Danish). In Canada, statements were linked to a change in transport behavior. One said, "*I drive as efficiently as possible, and drive a small car. Plan on investing in a plug-in hybrid as soon as is financially possible.*" Another said, "*Walking and taking public transit.*" All seven Canadian PSTs' primary action for reducing their climate impact were linked to driving less, though there were also comments such as "*eating local food,*" and, "*I support local agriculture as much as possible.*"

Of the eight participants whose actions were coded as "non-emission reduction," five were from Greenland and three were from Canada. These related to lifestyle changes that do not directly lead to reduction in emission of CO_2. One Greenlandic PST wrote, "*I have stopped throwing stuff in nature. It has become important [for me] that garbage ends up in the trash can*" (translated from Danish). Another wrote, "*I save water, reuse plastic, save on food, don't throw much out, don't throw electronics in the bin*" (translated from Danish). Two of the three Canadians made similar statements, such as: "*Reduce waste, primarily use of disposable plastic materials, and reusing others.*" The third Canadian made a link to a biodiversity issue: "*Yes, my Mom and I have taken up eco-beekeeping and pollinator friendly landscaping. We are also in the process of creating an educational program for visiting schools and teaching students and/or staff about the importance of honey bees and the environment and ways to make a positive impact.*"

While these actions do not directly link to a reduction in CO_2 emissions, they point to understandings of climate change that are linked to broader concepts of environmental change. For instance, the link between climate change and plastic pollution has increasingly been documented (Hamilton et al., 2019). However, these participant comments suggest understandings that may not accurately reflect the actual physics behind climate change. Misunderstanding environmental disruption as climate change does happen fairly often (Arslan et al., 2012).

We note that no participants described participating in collective political action. This may suggest that their teaching about climate change would lack the political dimension that some authors suggest is needed (e.g., Skamp et al., 2013). Engaging PSTs in discussions about possible personal and political actions would help prepare them to engage their future students in climate change actions.

Do pre-service teachers worry about climate change?

We asked to what degree PSTs worry about climate change. Ninety-one percent ($n = 41$) answered either "somewhat" or "yes, a lot" (see Table 5).

In Canada and Greenland, the general public is similarly concerned about climate change. In a recent Canadian

Table 5. PSTs' self-report on whether they are worried about climate change.

	No, not at all (%)	Not much	Neutral, not sure	Somewhat	Yes, a lot	Total
Canada	0	0%	0%	20% ($n = 9$)	17.8% ($n = 8$)	
Greenland	0	4.4% ($n = 2$)	4.4% ($n = 2$)	33.3% ($n = 15$)	20% ($n = 9$)	
Total	0	4.4% ($n = 2$)	4.4% ($n = 2$)	53.3% ($n = 24$)	37.8% ($n = 17$)	100% ($n = 45$)

survey, 83% said they are "quite," "very," or "extremely" concerned (Anderson & Coletto, 2019). In Greenland, a recent study revealed that 82% of citizens expressed that climate change is either extremely important, very important, or somewhat important (Agneman & Minor, 2018).

We asked PSTs a follow-up question about worrying: "why or why-not?" 73% chose to answer, 12 from Canada, and 21 from Greenland. Thirteen PSTs who indicated "worried a lot" elaborated on their answer. Comments from Greenland were coded as "changes to the environment" or "insecure future."

Analyzing their answers, we believe that participants from Greenland have "ice" as a defining string of consciousness. Ice, and the inland ice, was salient. One participant wrote: "*Today, the edge of the ice has retreated a lot—compared to when I was a child*" (translated from Danish). That "ice" is an important feature in the mind-set of people in Greenland is expected, as it is a historically and culturally life-defining feature in the landscape (Gearheard et al., 2013; Poort, 2007). Under the "changes to the environment" code, participants expressed concern about food security—a growing population that will meet a changing climate.

Comments from Canada were coded as "insecure future" or "too few people concerned." In a sense, they are linked. PSTs questioned whether there are people around the planet that take climate change seriously enough: "*Not enough people are taking it seriously, as there are still some who blatantly disregard climate change as a reality, despite irrefutable evidence that it is a reality.*" Comments suggested they are insecure about the future in general, but, in particular, for future generations. One wrote: "*I am very worried for the future generations. I am someone who wants kids and it scares me to think about bringing a child into this world.*"

It is not uncommon that climate change leads to thoughts of the future that are highly pessimistic (Searle & Gow, 2010). A PST's comment implicitly links an insecure future to the inaction of the general public, and the need for worldwide behavior change: "*People are putting more importance on money than the lives of everyone and every thing on our planet.*" The worry expressed here resonates with the consensus from the IPCC (1990), which has issued warnings for politicians and the general public since its first report in 1990.

Sixteen comments were recorded by people who were "somewhat worried." Eleven from PSTs from Greenland were coded "future" ($n = 8$) or "food-chain" ($n = 3$). Answers in the "future" category were similar to those reported above, while in the "food-chain" category PSTs wrote about how they foresee a future where food chains will be strongly impacted. They voiced a local perspective on how it will impact the polar bear, and, as a consequence of that, polar bears will come closer to towns: "*conditions for animal life and humans will change a lot. E.g., Ice on the sea (I assume) will be shorter, and polar bears won't have enough food. To get enough food, polar bears will more and more often come into town areas. Because of climate change, hunting animals and living conditions are changing*" (translated from Danish).

The concern expressed here is very relevant and is reflected in how decisions on safety initiatives for leisure activities are made in some areas of Greenland. One example, not from the study, is in the town of Ittoqortoormiit in northeast Greenland. Due to too many polar bear incidents when children were swimming on the beach in the nearby bay, a swimming pool was built in town (Brøns & Tobiassen, 2019).

The "somewhat worried" comments from Canadian participants ($n = 5$) were coded "action." The five PSTs were clearly looking for action—action for change at different levels of society. Their replies suggest that they have more or less given up on the current way things are going: One Canadian PST wrote, "*Only somewhat because I have little faith in consumer-capitalist society to make large-scale change (but I've got my fingers crossed).*" Another wrote: "*Tragedy of the commons makes this basically an unsolvable problem diplomatically.*" One had a very pragmatic take on it, writing: "*Worrying (like hoping) isn't really having a tangible effect. Coordinated action (regionally, nationally, globally) will. So why worry?*"

The majority of the PSTs who chose to answer this question expressed concern about both present and future changes. Knowing why PSTs worry about climate change may help us understand how they believe education should respond to climate change. While worry alone can stop people from acting, connecting things to local issues can inspire engagement (Stoknes, 2015). A Greenlandic PST connected worry to possible action: "*If nothing more is done our future generations will [have to] clean up after the mistakes made by humans—if you continue it that way, some animal species will disappear. It is important to teach the young, also, how you can be a conscious consumer who thinks about nature and society*" (translated from Danish).

Canadian and Greenlandic PSTs share concern about how climate change will have an impact on society and nature. Many presented ideas for how education and educational systems could respond.

Theme 2: Preservice teachers' views on climate change in K-12 schooling

Climate change, when it is taught at all in K-12 schooling, is most often taught in science classes from the perspective of students learning the physical properties of the greenhouse effect (Hestness et al., 2011); rarely is it taught from a social science perspective, or from a history or language

perspective, though this is occurring more and more in post-secondary schooling (Siperstein et al., 2017). We asked the PSTs two open-ended questions to explore their views on how climate change should be integrated into schooling.

Asked, "*If you will teach in an elementary school, what subjects should include curriculum topics related to climate change?*," 91% ($n = 41$) replied. Of those, 78% ($n = 35$) indicated that climate change should be taught in all subjects, or named a number of subjects including at least one subject outside of the physical sciences. Six PSTs also stated in comments that the topic of climate change should be, or could be, taught in a cross-curricular setting, involving the humanities, the sciences, and the arts. Eleven percent ($n = 5$) named only one or more of the physical sciences: geography, biology, chemistry, or physics.

Asked, "*If you will teach in secondary education, what subjects should include topics related to climate change?*," 71% ($n = 32$) replied. Of those, 75% ($n = 24$) indicated that climate change should be taught in all subjects in secondary school, or by naming a number of subjects, including at least one subject outside of the physical sciences. The other 25% ($n = 8$) named only one or more physical science.

A strong majority across both countries and teaching subjects indicated that climate change should be taught in all subjects in elementary and secondary schools, or named subjects outside of the sciences in which to incorporate climate change. The "all–subjects" agenda was very visible in their comments. We illustrate with the following two quotes:

> Any and all subjects can relate to climate change. It is a cross-curricular subject that can be used in solving math problems, as reading texts, as a basis for artistic response (music, drama, vis. arts), social studies ties directly to it, and of course, so does science. I would tend to provide emphasis upon the arts, however, and as a science major, that is an odd thing to say. I have witnessed, however, that music in particular can convey a message that words simply cannot. For this reason, I believe the arts are a great tool we can use to engage people in thinking about and responding to the reality of climate change.

> The subjects can be: Science, History, English and Biology. They can all have some connection to climate change. In Science, you can learn more about it. In History, you can see changes (from the past until now). In English, you can read different texts and perhaps write an essay or something along those lines, and perform it for the whole school. In Biology, you can see which animals have been impacted by climate change, which animals will be, or have already gone extinct because of climate change. (translated from Danish)

Others offered logic as to why cross-curricular teaching is important. A participant from Greenland wrote: "*Students have to be made aware about the problems that they will have to address. That's why it is topic for all subjects*" (translated from Danish), and another that in Social Studies you could "*talk about the risks that might affect society*" (translated from Danish). A Canadian participant wrote that it should be taught in all subjects in high school, "*to prepare students with the reality of climate change from various angles and advise them of how it would affect various aspects of their lives.*"

These PSTs' thoughts on addressing climate change across subjects other than science resonate with work in Canada (Berger et al., 2015) and Australia (Vongalis-Macrow, 2010), and with the growing desire of all stakeholders to see cross-curricular climate change education in schools (Field et al., 2019). For this to happen, teachers of many subjects need to be knowledgeable enough about climate change to facilitate teaching about it, including the science, politics, economics, sociology, ethics, and philosophy related to it. This suggests the need for PSTs to be supported in learning about climate change in teacher education programs.

Climate change in teacher education programs

We asked participants whether climate change should be a curriculum topic in teacher education; 80% ($n = 37$) answered yes. Reasons varied for the 20% ($n = 9$) who said it should not be, including an already packed curriculum, climate change already being covered in a class, a lack of interest in the topic, the desire for autonomy in choosing one's courses, and being certain already that climate change is happening (and therefore not needing to be convinced). In three cases, it appeared that the question might have been misunderstood.

There were many reasons given for why climate change should be included in teacher education. They ranged from very brief—for example, "*It is important to the whole world*," "*We should look after the world we live in*" (translated from Danish), and, "*so we can use it in the future*" (translated from Greenlandic)—to more detailed. For example:

> It's an important global topic. By not teaching teachers about it, which may lead to a lack of informed students, we are creating a future generation who may not even have the knowledge base necessary to try and solve an issue that will become more and more dire for future generations.

> Yes, because many of us will teach children. Children are our future, it's they who will raise the next generation, and I believe it is a good idea to have as many teachers as possible who have enough knowledge about climate *change. Having more teachers who have knowledge of climate change, you can more easily teach cross-curricularly or by theme in the public schools.* (translated from Danish)

One participant wrote that it would be exciting and useful to study the topic, another that it would help her to teach by increasing her understanding. Whether included as a module, a stand-alone course, or integrated into existing courses—all suggestions made by participants—there was very strong support for including climate change in teacher education; PSTs feel the need for help in preparing to teach about climate change. This resonated with earlier work with Canadian PSTs (Berger et al., 2015) and more recent work with Canadian teachers (Field et al., 2019).

Theme 3: PSTs' perspectives on preparation to teach climate change

Boon and James Cook University (2016) argued that it is of the upmost importance that PSTs be prepared to teach climate change. However, in a study of how Australian PSTs' knowledge evolved, she found that knowledge on climate change deteriorated during the course of their teacher

Table 6. PSTs' estimates of their preparedness to teach about climate change.

	Very unprepared	Unprepared	Somewhat prepared	Prepared	Very prepared	Total
Canada	0%	2.2% ($n = 1$)	20% ($n = 9$)	6.7% ($n = 3$)	8.9% ($n = 4$)	
Greenland	4.4% ($n = 2$)	22.2% ($n = 10$)	26.7% ($n = 12$)	6.7% ($n = 3$)	2.2% ($n = 1$)	
Total	4.4% ($n = 2$)	24.4% ($n = 11$)	46.7% ($n = 21$)	13.4% ($n = 6$)	11.1% ($n = 5$)	100% ($n = 45$)

education program. In this study, we explored PST perspectives on their preparation to teach climate change. We asked how they had been taught and how they would have liked to be taught. This may suggest ways initial teacher education programs could address their responsibility in incorporating climate change education.

We also asked, "*How prepared do you feel to teach about climate change?*" (see Table 6).

Seven, or 53% of those who stated that they felt "very prepared" or "prepared," had indicated that climate change was caused by ozone depletion, a serious misconception. Boon and James Cook University (2016) and Papadimitriou (2004) reported similar findings. A self-report of "feeling prepared" to teach climate change may not mean readiness to teach it; these findings suggest a huge opportunity to better prepare new teachers.

A Canadian participant commented on not feeling prepared to teach climate change: "*It's not something that has been discussed during my years as a student and it isn't covered in most education courses or curriculum.*" A Greenlandic participant wrote: "*I'm not ready to teach it, since my knowledge about the topic is inadequate*" (translated from Greenlandic). Another wrote, "*I know too little right now. I don't even know if there are materials one can use for a class, and if they exist, I don't know how to use them*" (translated from Danish). Many noted the need to learn more before teaching climate change, including some of those who felt "somewhat prepared."

Preparation for climate change teaching

When asked, "*How did you become prepared, or how do you wish you had been prepared, to teach about climate change?*", 31 PSTs chose to answer. They were coded into "curriculum" ($n = 20$) and "myself" ($n = 11$). Curriculum answers focused on being prepared through a specific course or through its inclusion in the general curriculum.

One Greenlandic PST wrote: "*If the entire institute had more focus on climate change, you could have more preservice teachers who would be worried, would do something about it—pass on the message*" (translated from Danish). A PST from Canada wrote that he had become prepared through a specific course: "*Through the 'Climate Change Pedagogy' class at Lakehead University, I was given plenty of information, lots of good thinking points, and numerous teaching resources/examples that helped me to prepare for including climate change content in my future classroom.*" A second PST from Canada learned through studying eco-criticism in an English undergraduate degree and by taking "Indigenous-centred" courses.

The other 11 PSTs who wrote about their wishes had an almost entirely different approach to being prepared for teaching climate change. They were focused on themselves as future teachers and their own responsibility. This included putting effort into searching for knowledge on climate change—either through books or through a course. For example, one Canadian PST wrote: "*As a person, I would go into every aspect to find out about what climate change really is before teaching.*"

Despite many people feeling unprepared, or only somewhat prepared, to teach climate change, over half of the PSTs said they were "likely" (35%, $n = 16$) or "very likely" (20%, $n = 9$) to teach about some aspect of climate change in their first years of teaching. In the comments field, one participant wrote, "*I have already taught about climate change in my first of four practicums*," and another, "*I will always teach it*" (translated from Danish). A third wrote, "*I expect to implement it in all subjects. I expect it will be implemented during activities*" (translated from Greenlandic).

There were, however, many who were less certain, who acknowledged their lack of knowledge on the basic science and how to teach climate change. Confidence is a major factor in deciding to teach climate change (McNeal et al., 2017). Since most PSTs who expressed confidence in their readiness to teach climate change did so based on preparation in a specific course or program, these findings suggest the need for climate change knowledge to be incorporated in many disciplines across universities, and for initial teacher education programs to incorporate mandatory courses in teaching about climate change. This resonates with the expressed desire of a large majority of PSTs in the current study, to have climate change teaching a part of the initial teacher education program.

Implications

The study sample is small and the findings not generalizable. From a local perspective in Greenland, however, the implications from the study are more substantial as there is only one teacher education program—at the University of Greenland, and the University itself is small, with relatively few students ($n \approx 700$). The findings on what PSTs know about climate change and how prepared they felt to teach it had an immediate impact on the curriculum for PSTs in their first year in the program: all first-year PSTs ($n = 49$) now attend a special course on climate change aimed at designing a teaching program for pupils in public schools.

Furthermore, the University of Greenland Board has acknowledged the need for local responsibility on climate change, and has established a working group to address the issue. Their first action will be to conduct a complete survey on climate change knowledge amongst all students, faculty, and staff, to be carried out in the fall of 2020. The goal is raised awareness and a smaller carbon footprint.

At Lakehead University in Canada, the 18-h climate change education elective at the Thunder Bay campus was increased to 36 h by structural changes unrelated to the study. As a result of the same structural changes, all PSTs must now take a 36-h course called *Environmental Education*, a course designed explicitly to include climate change education. As a direct result of the study and of the growing global awareness of the urgency of tackling climate change, colleagues have been encouraged to consider how climate change fits in the subjects they teach, so knowledge of climate change and how to teach it is not isolated in a single course.

We believe the findings are robust enough to spark discussions on dimensions of climate change education that have not previously been described in detail: a cross-curricular approach to climate change teaching, and the responsibility for teaching climate change in all subjects. The findings suggest the need for comprehensive circumpolar research on how PSTs understand both climate change and their experience of preparedness to teach it. They also point to the need for research on how climate change is being taught in circumpolar K-12 schooling.

To fundamentally change climate change education, policy change is needed. Teaching how to teach about climate change in initial teacher education is crucial. Teacher education could play a defining role for future generations, leading to a much more climate-literate citizenry.

Though research shows that climate change teaching sometimes finds its way into subjects such as psychology and social studies (e.g., Brownlee et al., 2013), the profound implications for civilizations and ecosystems on a global scale demand an intentional and focused effort to move climate change and its implications into all subjects.

Most PSTs appear ready to embrace this integration. A risk, though, is poorly-informed discussions as the foundation for curriculum and policy changes, especially if the decision-makers and stakeholders themselves understand climate change poorly (McCaffrey & Buhr, 2008).

If cross-curricular integration is to be realized, it is necessary that teacher educators across all disciplines acknowledge climate change and systems thinking, to ensure that knowledge-for-action is occurring as a goal in climate change education. This is addressed in the *Action for Climate Empowerment* guidelines from the United Nations (2016). All subjects in teacher education programs can be based on a pedagogy and curriculum that acknowledges climate change, with everyone preparing future teachers to teach climate change.

Conclusion

Most PSTs in this study believe that climate change should be taught in, or across, multiple subjects in K-12 schooling, but many do not yet have the background knowledge or pedagogy to be ready to teach it. Participants in this study, PSTs from Greenland and from Canada, experience changes in climate differently. Their concern for the future is very likely based on experience in their local regions. While many have common conceptual misunderstandings on climate science, they show a strong overall concern about climate change and believe that education should play a role in preparing future generations.

An "all subjects-approach" to climate change teaching throughout K-12 schooling and teacher education makes sense because the consequences of climate change are not only scientific. Climate change has implications on all levels of society—but somehow in both K-12 schooling and in teacher education it often only appears in the sciences. Our research suggests that PSTs are ready to disrupt that logic, with most supporting climate change teaching across many grades and subjects.

Most want to learn and teach about climate change, resonating with previous work (Berger et al., 2015) and suggesting that incorporating teaching about climate change in initial teacher education would be well received and very useful. To prepare PSTs to teach climate change across subjects in K-12 schooling suggests that initial teacher education needs also to teach climate change education across curricular borders.

Though a small survey, participants' thoughts on climate change as a cross-curricular topic are important in how we think teacher education may help prepare teachers in the north. Climate change education should have universal attention across disciplines—both in K-12 schooling as well as initial teacher education.

References

Anderson, B., & Coletto, D. (2017). Canadians: Paris Accord a good idea, Trump wrong to exit. https://abacusdata.ca/tag/climate-change/page/3/

Anderson, B., & Coletto, D. (2019, March 27). Will climate change be a ballot box question in 2019? Abacus data. https://abacusdata.ca/will-climate-change-be-a-ballot-box-question-in-2019/

Agneman, G., & Minor, K. R. (2018). Greenlandic perspectives survey GPS: Initial results. https://samf.ku.dk/nyheder/i-groenland-maerker-de-klimaforandringerne-paa-egen-krop/GP_press_release_dansk.pdf

Arslan, H. O., Cigdemoglu, C., & Moseley, C. (2012). A three-tier diagnostic test to assess pre-service teachers' misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. *International Journal of Science Education*, *34*(11), 1667–1686. https://doi.org/10.1080/09500693.2012.680618

Bangay, C., & Blum, N. (2010). Education responses to climate change and quality: Two parts of the same agenda? *International Journal of Educational Development*, *30*(4), 359–450. https://doi.org/10.1016/j.ijedudev.2009.11.011

Berger, P., Gerum, N., & Moon, M. (2015). Roll-up your sleeves and get at it!" Climate change education in teacher education. *Canadian Journal of Environmental Education*, *20*, 154–172. https://cjee.lakeheadu.ca/article/view/1370/850

Boon, H. (2010). Climate Change? Who knows? A comparison of secondary students and pre-service teachers. *Australian Journal of Teacher Education*, *35*(1), 1. https://doi.org/10.14221/ajte.2010v35n1.9

Boon, H. (2015). Climate change ignorance: An unacceptable legacy. *The Australian Educational Researcher*, *42*(4), 405–427. https://doi.org/10.1007/s13384-014-0156-x

Boon, H, James Cook University. (2016). Pre-service teachers and climate change: A stalemate? *Australian Journal of Teacher Education*, *41*(4), 39–63. https://doi.org/10.14221/ajte.2016v41n4.3

Brownlee, M. T. J., Powell, R. B., & Hallo, J. C. (2013). A review of the foundational processes that influence beliefs in climate change: Opportunities for environmental education research, environmental education research. *Environmental Education Research*, *19*(1), 1, 1–20. https://doi.org/10.1080/13504622.2012.683389

Brøns, M., & Tobiassen, N. (2019). Fare for isbjørne på stranden: Ittoqqortoormiit får svømmebassin. https://knr.gl/da/nyheder/fare-isbjørne-på-stranden-ittoqqortoormiit-får-svømmebassin

Bryman, A. (2016). *Social research methods*, 5th ed. Oxford University Press.

Canada's Changing Climate Report. (2019). Canada's changing climate report: Executive summary. *Environment and Climate Change Canada*. https://changingclimate.ca/CCCR2019/chapter/executive-summary/

Connolly, A. (2019). Canadians want to stop climate change — but half don't want to pay an extra cent: Ipsos poll. *Global News*. Retrieved on September 30th, 2019 from https://globalnews.ca/news/5948758/canadians-climate-change-ipsos-poll/

Cook, J., Oreskes, N., Doran, P. T., Anderegg, W. R. L., Verheggen, B., Maibach, E. W., Carlton, J. S., Lewandowsky, S., Skuce, A. G., Green, S. A., Nuccitelli, D., Jacobs, P., Richardson, M., Winkler, B., Painting, R., & Rice, K. (2016). Consensus on consensus: A synthesis on consensus estimates on human-caused global warming. *Environmental Research Letters*, *11*(4), 048002–048007. https://iopscience.iop.org/article/10.1088/1748-9326/11/4/048002/pdf https://doi.org/10.1088/1748-9326/11/4/048002

Creswell, J. W. (2014). *Research design – qualitative, quantitative and mixed methods approaches*. SAGE Publications.

Demant-Poort, L. (2016). *Science education in the Greenlandic public school: A multiple case study of nature, teaching and language*. PhD diss. (Danish version only). https://da.uni.gl/find-personale/institut-for-laering/lars-demant-poort/publikationer.aspx

Derworiz, C. (2019, *June). Alberta wildfires linked to climate change, scientist says. CBC News*. https://www.cbc.ca/news/canada/edmonton/alberta-wildfires-climate-change-1.5168355

Evans, J. R., & Mathur, A. (2005). The value of online surveys. *Internet Research*, *15*(2), 195–219. https://doi.org/10.1108/10662240510590360

Field, E., Schwartzberg, P., & Berger, P. (2019). Canada, climate change and education. http://www.LSF-LST.ca/cc-survey

Gearheard, S. F., Kielsen Holm, L., Huntington, H. P., Leavitt, J. M., Mahoney, A. R., Opie, M., Sanguya, J. (2013). *The meaning of ice: People and sea ice in three arctic communities*. IPI Press.

Gehlbach, H., & Brinkworth, M. (2011). Measure twice, cut down error: A process for enhancing the validity of survey scales. *Review of General Psychology*, *15*(4), 380–387.

Greenland Home Rule. (2003). Hjemmestyrets bekendtgoerelse nr. 16 af 24. juni 2003 om trinformål samt fagformaal og laeringsmaal for folkeskolens fag og fagomraader [The Home Rule Executive Order no. 16 of 24 June 2003 on step objectives as well as subject objectives and learning objectives for the folkeskole's subjects and subject areas]. http://www.lovgivning.gl

Grenier, E. (2019). Canadians are worried about climate change, but many don't want to pay taxes to fight it: Poll. Retrieved on November 12, 2019 from https://www.cbc.ca/news/politics/election-poll-climate-change-1.5178514

Goverment of Greenland. (2012). Muligheder for klimatilpasning i fiskeri- og fangererhvervet - status og handlemuligheder. https://naalakkersuisut.gl/da/Publikationer/2012?pn=1

Hamilton, L. A., Feit, S., Muffett, C., Kelso, M., Rubright, S. M., Bernhardt, C., Schaeffer, E., Moon, D., Morris, J., & Labbé-Bellas R. (2019). Plastic & climate - The hidden costs of a plastic planet. https://www.ciel.org/wp-content/uploads/2019/05/Plastic-and-Climate-FINAL-2019.pdf

Hastrup, K. (2015). *Thule på tidens rand (Thule on the edge of time)*. Lindhardt & Ringhof.

Hestness, E., McGinnis, J. R., Riedinger, K., & Marbach-Ad, G. (2011). A study of teacher candidates' experiences investigating global climate change within an elementary science methods course. *Journal of Science Teacher Education*, *22*(4), 351–369. https://doi.org/10.1007/s10972-011-9234-3

Hoegh-Guldberg, O., Jacob, D., & Taylor, M. (2018). Impacts of a 1.5° C of global warming on natural and human systems. *Special report – global warming of 1.5 °C*. International Panel on Climate Change.

Hufnagel, E. (2015). Preservice elementary teachers' emotional connections and disconnections to climate change in a science course. *Journal of Research in Science Teaching*, *52*(9), 1296–1324. https://doi.org/10.1002/tea.21245

Inatsisartut. (2012). *Inatsisartutlov nr. 15 af 3. december 2012 om folkeskolen*. Located at: http://lovgivning.gl/lov?rid=%7bA9CD7C8F-DC91-4860-A7F0-B88BA752ED35%7d&sc_lang=da-DK

IPCC. (1990). Climate change: The IPCC scientific assessment. https://www.ipcc.ch/site/assets/uploads/2018/03/ipcc_far_wg_I_full_report.pdf

IPCC. (2018). Global warming of 1.5 °C. *Author*. https://www.ipcc.ch/sr15/

Kapborg, I., & Berterö, C. (2002). Using an interpreter in qualitative interviews: Does it threaten validity? *Nursing Inquiry*, *9*(1), 52–56.

KIIIP/Inerisaavik. (2004). Laereplan for naturfag [Curriculum for science]. (Danish version). https://iserasuaat.gl/emner/folkeskole/fag-og-undervisning/laereplaner?sc_lang=da

Kintisch, E. (2016). Why did Greenland's Vikings disappear? *Science. Retrieved on July 8 2019 from*, https://www.sciencemag.org/news/2016/11/why-did-greenland-s-vikings-disappear

Lambert, J., & Bleicher, R. (2013). Climate change in the preservice teacher's mind. *Journal of Science Teacher Education*, *24*(6), 999–1022. https://doi.org/10.1007/s10972-013-9344-1

Marshall, G. (2014). *Don't even think about it: Why our brains are wired to ignore climate change*. Bloomsbury.

McCaffrey, M. S., & Buhr, S. M. (2013). Clarifying climate confusion: Addressing systemic holes, cognitive gaps, and misconceptions through climate literacy. *Physical Geography*, *29*(6), 512–528. https://doi.org/10.2747/0272-3646.29.6.512

McNeal, K. S., Walker, S. L., & Rutherford, D. (2014). Assessment of 6- to 20-Grade educators' climate knowledge and perceptions: Results from the climate stewardship urvey. *Journal of Geoscience Education*, *62*(4), 645–654. https://doi.org/10.5408/13-098.1

McNeal, P., Petcovic, H., & Reeves, P. (2017). What is motivating middle-school science teachers to teach climate change? *International Journal of Science Education*, *39*(8), 1069–1088. https://doi.org/10.1080/09500693.2017.1315466

NASA. (2017). Long-term warming trend continued in 2017: NASA, NOAA. https://climate.nasa.gov/news/2671/long-term-warming-trend-continued-in-2017-nasa-noaa/

Nicholls, J. A. (2016). *Understanding how Queensland teachers' views on climate change and climate change education shape their reported practices* [Unpublished doctoral dissertation]. James Cook University.

Nunavut Climate Change Centre. (n.d.). Climate change impacts. https://www.climatechangenunavut.ca/en/understanding-climate-change/climate-change-impact.

Orsi, A. J., Kawamura, K., Masson-Delmotte, V., Fettweis, X., Box, J. E., Dahl-Jensen, D., Clow, G. D., Landais, A., & Severinghaus, J. P. (2017). The recent warming trend in North Greenland. *Geophysical Research Letters*, *44*(12), 6235–6243. 10.1002/2016GL072212. https://doi.org/10.1002/2016GL072212

Pan, B., Woodside, A. G., & Meng, F. (2014). How contextual cues impact responses and conversion rates of online surveys. *Journal of Travel Research*, *53*(1), 58–68. https://doi.org/10.1177/0047287513484195

Papadimitriou, V. (2004). Prospective primary teachers' understanding of climate change, greenhouse effect and ozone layer depletion. *Journal of Science Education and Technology*, *13*(2), 299–307.

Park, K., Park, N., Heo, W., & Gustafson, K. (2019). What prompts college students to participate in online surveys? *International Education Studies*, *12*(1), 69.https://doi.org/10.5539/ies.v12n1p69

Plutzer, E., McCaffrey, M., Hannah, A. L., Rosenau, J., Berbeco, M., & Reid, A. H. (2016). Climate confusion among U.S. teachers. *Science*, *351*(6274), 664–665. https://doi.org/10.1126/science.aab3907

Perkins, R. A. (2011). Using research-based practices to increase response rates of web-based surveys. *Educause Review Online*. https://er.educause.edu/articles/2011/6/using-researchbased-practices-to-increase-response-rates-of-webbased-surveys

Poort, L. (2007). *The impact of climate change on society and education in Greenland* [Unpublished master's thesis]. University of Greenland.

Poppel, B. (Ed.). (2015). *SLiCA: Arctic living conditions – Livin conditions and quality of life among Inuit, Sami and Indigenous peoples of Chukotka and the Kola Peninsula*.

Reja, U., Manfreda, K., Hlebec, V., & Vehovar, V. (2003). Open-ended vs. close-ended questions in Web questionnaires. *Developments in*

Applied Statistics, *19*, 159–177. http://www.websm.org/uploadi/editor/Reja_2003_open_vs._close-ended_questions.pdf

Saleh, A., & Bista, K. (2017). Examining factors impacting online survey response rates in educational research: Perceptions of graduate students. *Journal of MultiDisciplinary Evaluation*, *13*(12), 63–74. https://journals.sfu.ca/jmde/index.php/jmde_1/article/view/487

Searle, K., & Gow, K. (2010). Do concerns about climate change lead to distress? *International Journal of Climate Change Strategies and Management*, *2*(4), 362–379. https://doi.org/10.1108/17568691011089891

Siperstein, S., Hall, S., & LeMenager, S. (2017). *Teaching climate change in the humanities*. Routledge. [Database][Mismatch.]

Skamp, K., Boyes, E., & Stanisstreet, M. (2013). Beliefs and willingness to act about global warming: Where to focus science pedagogy? *Science Education*, *97*(2), 191–217. 10.1002/sce.21050 https://doi.org/10.1002/sce.21050

Statistics Canada. (2014). Back to school … by the numbers. https://www.statcan.gc.ca/eng/dai/smr08/2014/smr08_190_2014

Statistics Greenland. (2015). Data. http://www.stat.gl and https://bank.stat.gl/pxweb/da/Greenland/Greenland__EN__EN20/ENX2CO2E.px/

Stoknes, P. E. (2015). *What we think about when we try not to think about global warming: Toward a new psychology of climate action*. Chelsea Green.

UNESCO (n.d.). Global action programme on education for sustainable development. https://en.unesco.org/gap

UNESCO. (2013). *Climate change in the classroom*. http://unesdoc.unesco.org/images/0021/002197/219752e.pdf

United Nations. (1987). *Report of the world commission on environment and development: Our common future*. Oxford University Press. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

United Nations. (2015). The Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

United Nations. (2016). *Action for Climate Empowerment – Guidelines for accelerating solutions through education, training and public awareness.* https://unfccc.int/files/cooperation_and_support/education_and_outreach/application/pdf/action_for_climate_empowerment_guidelines.pdf

Van Zee, E. H., Roberts-Harris, D., & Grobart, E. (2016). Ways to include global climate change in courses for prospective teachers. *Journal of College Science Teaching*, *045*(03), 28–33. https://doi.org/10.2505/4/jcst16_045_03_28

Vernon, D. E., Marbach-Ad, G., Wolfson, J., & Ozbay, G. (2016). Assessing climate literacy content in higher education science courses: Distribution, challenges, and needs. *Journal of College Science Teaching*, *45*(6), 43–49. https://doi.org/10.2505/4/jcst16_045_06_43

Vongalis-Macrow, A. (2010). Developing pedagogies for teaching about climate change. *The International Journal of Learning*, *17*(9), 237–247. http://dro.deakin.edu.au/view/DU:30032542

Wynes, S., & Nicholas, K. A. (2019). Climate science curricula in Canadian secondary schools focus on human warming, not scientific consensus, impacts, or solutions. *PLoS One*, *141*(7), e0218305. https://doi.org/10.1371/journal.pone.0218305