Climate change knowledge and attitudes of pre- and in-service Nova Scotia teachers

An assessment of educator readiness and needs

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1. INTRODUCTION

Improving climate change education has the potential to have far-reaching benefits. Exposing students to climate change in the classroom can introduce students to complex systems and help prepare them for encountering and dealing with conflicts and uncertainty in other contexts[1]. Teaching young people about climate change can help alleviate anxiety related to climate change and empower students and motivate them to adopt appropriate mitigation and adaption activities[2], behaviours which may be transmitted to students' families through their influence on purchasing and other decision-making[3]. Despite these and other benefits, however, recent studies[4] suggest that students may not be receiving adequate exposure to climate change as part of their formal education.

We carried out this project in order to generate information that would help identify and explain deficiencies in the level and quality of climate change education in Nova Scotia. Specifically, we conducted a large survey of pre- and in-service Nova Scotia teachers in order to gain insight into the following: 1) climate change knowledge, attitudes, and comfort levels – with an emphasis on what teachers in Nova Scotia know and think about climate change; 2) current teaching practices - if and how they integrate climate change into their classroom teaching; and 3) opportunities for improving climate change education - any perceived or actual barriers to teaching climate change, as well as resources and other support that may increase and improve coverage of climate change in Nova Scotia classrooms. Funded by Nova Scotia Environment's Climate Change Adaptation Fund, this project is part of a provincial effort to improve climate change education.

1.1 Rationale

Much previous work has focused on student understanding of climate change. Studies from across the globe reveal that students of all ages hold misconceptions about climate change and have extensive knowledge gaps[5]. Although little work has been carried out in Canada, the few

[1] Dahlberg, S. (2001). Using climate change as a teaching tool. *Canadian Journal of Environmental Education, 6*, 9-17.
[2] Taber, F. & Taylor, N. (2009). Climate of concern - A search for effective strategies for teaching children about global warming. *International Journal of Environmental & Science Education, 3*(3), 97-116
[3] Vaughan, C., Gack, J., Solorazano, H. & Ray, R. (2003). The effect of environmental education on school children, their parents, and community members: A study of intergenerational and intercommunity learning. *The Journal of Environmental Education, 34*(3), 12-21
[4] See, for example, Sharma, A. (2012). Global climate change: What has science education got to do with it? *Science & Education, 21*(1), 33-53
[5] See, for example, Boyes, E., Skamp, K., & Stanisstreet, M. (2009). Australian secondary students' views about global warming: Beliefs about actions, and willingness to act. *Research in Science Education, 39*, 661-680 and Shepardson, D. P., Niyogib, D., Choi, S. & Charusombat, U. (2011). Students' conceptions about the greenhouse effect, global warming, and climate change. *Climatic Change, 104*, 481–507

Canadian studies that exist have produced similar findings. For example, a 2011 pilot study funded by Nova Scotia's Climate Change Adaptation Fund found that Grade 4 students in Nova Scotia hold many of the same misconceptions that have been identified in studies elsewhere[6].

Similarly, studies have also revealed that misconceptions and knowledge gaps are common amongst teachers. Surveys of teachers' understanding of climate change have been carried out in the US[7], Australia[8], the UK[9], Greece[10], the Czech Republic[11], and Turkey[12]. Although a small number of Canadian studies exist[13], this project is the first of its kind in Nova Scotia. Most of the existing research has also focused only on pre-service teachers[8-10&12-13], making it difficult to determine how practicing teachers think about or address climate change in the classroom. The few existing studies that involve in-service teachers are mostly limited by small samples sizes and/or low response rates[7].

By surveying a large sample of pre- and in-service teachers from across Nova Scotia, this project adds to the small body of Canadian research focused on teachers' climate change knowledge and preparedness for teaching climate change. Importantly, this study has generated information that can be used to directly target gaps in support that Nova Scotia teachers have identified as undermining their efforts/ability to integrate climate change into their classrooms. This was one of our main project goals. International studies identified a variety of general challenges and perceived and/or actual barriers to teaching climate change, including the fact that climate change can seem overly complex, controversial, and political[1&14]. With no specific information on Nova Scotia teachers' needs and current practices, however, until now

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[6] Baker, J., & Sherren, K. (2011). *Bringing climate change into the classroom: Introducing teaching modules for use with Nova Scotia's public school curricula.* Retrieved from http://climatechange.gov.ns.ca/files/04/24/ClimateChange_TeachingModules_NSSchools_Mar2012.pdf

[7] See, for example, Wise, S. B. (2010). Climate change in the classroom: Patterns, motivations, and barriers to instruction among Colorado science teachers. *Journal of Geoscience Education*, 58(5), 297-309

[8] See, for example, Boon, H.J. (2010). Climate change? Who knows? A comparison of secondary students and pre-service teachers. *Australian Journal of Teacher Education, 35*(1), 104-120

[9] See, for example, Holden, C., & Hicks, D. (2007). Making global connections: The knowledge, understanding and motivation of trainee teachers. *Teaching and Teacher Education, 23*, 13-23

[10] 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

[11] Milé, T., Hollan, J., Válek, J., & Sládek, P. (2012). Teachers' understanding of climate change. *Procedia - Social and Behavioral Sciences, 69*, 1437-1442

[12] See, for example, Çelikler, D., & Kara, F. (2011). Determining the misconceptions of pre-service chemistry and biology teachers about the greenhouse effect. *Procedia Social and Behavioral Sciences, 15*, 2463–2470

[13] See, for example, Hayhoe, D., Bullock, S., & Hayhoe, S. (2011). A kaleidoscope of understanding: Comparing real with random data, using binary choice items, to study preservice elementary teachers' knowledge of climate change. *Weather Climate and Society, 3*(4), 254-260

[14] See, for example, Reardon, S. (2011). Climate change sparks battles in classroom. *Science, 33,* 688-689

there has been no way to know towards which, if any, of these challenges and barriers provincial resources would be most effectively directed.

2. DELIVERABLES

We set out to produce four deliverables with this project:

1. Development and implementation of a questionnaire to a large sample of pre- and in-service teachers in Nova Scotia. The goal of the survey was to identify climate change, general science, and nature of science knowledge, current teaching practice and attitudes about climate change education, perceived and/or actual barriers to teaching climate change, and teachers' wish-lists of resources and other support specific to climate change education
2. Preliminary analysis of our large and detailed data set (on knowledge, attitudes, and needs of Nova Scotia teachers regarding climate change education), formatted in a final report delivered to Nova Scotia Environment
3. Comparison of science requirements and opportunities to learn about climate change and/or the nature of science at Nova Scotia's four English language university departments of education
4. Creation of a Nova Scotia-specific climate change teaching companion, based upon teacher needs identified through the survey (deliverables 1 and 2), i.e., knowledge gaps, misconceptions, and teacher requested support

This report and accompanying documents meet all of the deliverables identified above. Some categories will continue to be expanded and explored after the completion date of this project (as additional data become available), with results made available to Nova Scotia Environment. (See discussion in the following sections.)

2.1 Questionnaire

We created our questionnaire with the goal of generating a large volume of information that could be used to improve climate change education in Nova Scotia. The questionnaire (see Appendix A) consists of the following: 1) a series of demographic questions (years of teaching experience, institution of study for Bachelor of Education, etc.); 2) 30 short answer questions (multiple choice, T/F, etc.) on general science (including nature of science) and climate change knowledge and attitudes; and 3) eight questions on climate change teaching practices and beliefs, including prioritization of climate change, confidence in teaching climate change, current

approaches to teaching climate change, perceived/actual barriers to teaching climate change, and identification of needed resources. (See section 3.2: Survey Design for a more detailed discussion of how we selected questions and arrived at this design.)

2.2 Preliminary data analysis

We generated summary reports (Appendix D and E) of the pre-service and in-service survey data, including graphical representation of results for each question. We provide a detailed discussion of our in-service teacher results, along with contextualization, in the following sections. (See section 3.4 for a more detailed explanation of our methodology.) As data is currently limited for pre-service teachers, we only provide a brief discussion of pre-service teacher results. Raw data and graphs of our current pre-service teacher data, however, are included in Appendix E.

2.3 Comparison of teacher preparation

We have produced a brief summary of some of the preliminary results from our sample of pre-service teachers, and included this as part of a draft overview of pre-service teachers' climate change knowledge and the role of teacher education in preparing Nova Scotia teachers for exploring climate change in the classroom (Appendix B). We looked at admission requirements for four NS B.Ed programs, compared program course requirements, and looked for electives that might help prepare pre-service teachers to teach climate change. We also contacted faculty in the departments of education at Cape Breton University, Acadia University, Saint Francis Xavier University, and Mount Saint Vincent University, asking them to share additional ways that pre-service teachers are prepared for teaching complex and controversial issues like climate change at their respective schools. These outreach efforts have only returned limited results at the time of writing. We will update this document once we have access to the remainder of the survey data and to the information we requested from the departments of education. We have also included a summary of some ways that climate change is being addressed as part of teacher education in other jurisdictions.

2.4 Teaching companion

We created a climate change teaching companion for use by Nova Scotia teachers. The teaching companion (Appendix C) is meant to encourage Nova Scotia teachers to integrate climate change into their classroom teaching and to make teaching about climate change easier. In order to achieve these goals, the teaching companion includes the following: 1) a brief explanation of why teaching climate change is important, 2) suggestions for dealing with possible barriers to integrating climate change into classroom teaching, 3) an introduction to

climate change basics and the essential principles of climate science, and 4) clarification of common climate change misconceptions. We also included a final section in which we direct teachers to a variety of useful climate change resources, including backgrounders, professional development modules, and lesson plans and teaching units. All links to resources are annotated with information on grade level, subjects, contents, etc., and evaluated for quality and applicability to Nova Scotia classrooms.

The contents of the teaching companion are informed by the results of our climate change questionnaire (section 2.1, above). For example, the barriers we focused on are those most commonly identified by teachers who completed the questionnaire, and the misconceptions we addressed are those that are frequently held by our sample of teachers. Further, although we initially planned to include a brief list of recommended resources as part of the guide, we expanded this section due to the fact that increased access to educational materials and prepared teaching resources were the most common requests made by teachers in our questionnaire.

3. METHODOLOGY

The questionnaire was central to this project. The resulting data will be valuable on its own, but it has also been used to inform the shape and content of the other project deliverables. In the following section, we identify and discuss the key components of our survey methodology.

3.1 Literature Review

We performed a thorough literature review before constructing our survey. (See Appendix F for a partial bibliography of academic materials consulted.) A considerable body of research focusing on teachers' understanding of environmental issues (e.g., the greenhouse effect, pollution, and ozone depletion) has been produced in recent decades, including studies that have focused specifically on teachers' understanding of climate change and global warming. However, as little work has been carried out in Canada, and none (that we are aware of) in Nova Scotia, we felt it was important to familiarize ourselves with research from other jurisdictions in order to learn from–and ideally improve upon–their experiences.

Completing a literature review helped inform the content, format, and delivery of our survey. For example, we included questions in our survey that targeted common climate change

misconceptions revealed in previous studies[15]. The certainty scale that we included with the questions on climate change science and impacts was also modelled after the three-tier assessment used by Arslan et al. (2012)[16], and designed to help detect and eliminate the confounding effects of random guessing in binary response (true/false or yes/no) questions (see Hayhoe et al, 2011). Another issue that came up during the literature review was the fact that earlier work often suffered from small samples sizes and/or low response rates. For example, Hayhoe et al. (2011) surveyed 89 Ontario pre-service teachers and Lambert et al. (2012) surveyed 126 US pre-service teachers and just 23 US in-service teachers. Wise (2010) had a large sample, with 628 in-service teachers in Colorado who completed her online questionnaire, but had a response rate of only 26%. We settled on our method of delivery (see section 3.3 Survey Administration) after comparing methods of survey administration and response rates. Our final approach was designed to ensure broad representation (multiple school boards and schools), while still producing statistically meaningful rates of response.

The literature review will also be important when we conduct a more in-depth data analysis and detailed discussion of our results, as we will be comparing our findings to previous studies.

3.2 Survey Design

The questionnaire consists of four categories of questions: demographic information (gender, years of teaching experience, educational background, etc.), knowledge of general science and nature of science, understanding of climate change science and impacts, and attitudes about climate change and climate change education (including current teaching practice). The pre-service teachers answered a very slightly modified questionnaire: several questions were changed in the demographic information and attitudes about climate change education sections due to this group having less classroom experience. The rest of the questionnaire was the same for both pre- and in-service teachers.

The following are brief explanations of the four categories:

Demographic information:

Including some demographic information will allow us to determine if there is a relationship between knowledge/attitudes and teaching practice and a variety of factors, including years of

[15] See, for example, Hayhoe, D., Bullock, S., & Hayhoe, S. (2011). A kaleidoscope of understanding: Comparing real with random data, using binary choice items, to study preservice elementary teachers' knowledge of climate change. *Weather Climate and Society, 3*(4), 254-260

[16] 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

teaching experience, educational background, and gender. This is potentially useful and important information, as previous studies suggest that performance on similar assessments varies with gender, educational background, and geographic location[17]. Collecting demographic information from the pre-service teachers also allows us to compare performance between B.Ed programs.

General science/nature of science knowledge:

We included a selection of general science and nature of science questions in our survey in order to determine whether poor performance on the climate change questions may be at least partially explained by an overall lack of knowledge and understanding of science. We obtained written permission from the National Science Foundation (NSF) to use questions from surveys they use to assess public understanding of scientific terms, concepts, and processes. Using these questions allows comparison to be made between Nova Scotia teachers' performance on these questions and results from two decades of NSF surveys of public science knowledge.

Climate change knowledge:

We chose the climate change knowledge questions carefully after reviewing survey instruments used in previous studies. We obtained written permission from the authors of Hayhoe et al. (2011)[18] to use (with slight modification, in some cases) a number of their questions that displayed high discrimination indexes, i.e., individual questions that were predictive of respondents' success on the survey as a whole. We supplemented these with additional original questions in order to assess teachers' knowledge of the essential principles of climate science (as identified in *Climate Literacy: The Essential Principles of Climate Science*[19]) and to determine whether misconceptions identified in previous research are also held by NS teachers.

Climate change attitudes, teaching practice, and needs:

We included a variety of questions in this final section of the survey with the goal of better understanding teachers' level of concern about climate change, their views on alternative actions in response to climate change, and their attitudes and approaches to climate change

[17] See, for example, Johnson, R. (2011). Climate change education in K-12: Teacher preparation, understanding, needs and concerns. *National Earth Science Teachers' Association*. Retrieved from http://sites.nationalacademies.org/DBASSE/BOSE/DBASSE_071087#.UT30ZRzo6ao

[18] Hayhoe, D., Bullock, S., & Hayhoe, S. (2011). A kaleidoscope of understanding: Comparing real with random data, using binary choice items, to study preservice elementary teachers' knowledge of climate change. *Weather Climate and Society, 3*(4), 254-260

[19] U.S. Global Change Research Program. (2009). *Climate literacy: The essential principles of climate science.* Retrieved from http://www.climatescience.gov/Library/Literacy/

education. Questions were original, but were informed by the literature and by consultation with Nova Scotia Environment and Dr. Michael Bowen (MSVU). We designed questions to generate information that could be used to produce teaching resources and other support for teachers. For example, we included barriers to climate change education identified in other jurisdictions[20] in a question designed to determine challenges faced by Nova Scotia teachers. We also asked teachers to explicitly identify what types of resources and materials (e.g., pre-made climate change-specific lesson plans, climate change focused professional development opportunities, access to qualified guest speakers) would be most helpful in supporting their efforts at teaching climate change. Finally, we provided an open response question to allow teachers to suggest teaching supports and resources that we had not anticipated.

3.3 Survey Administration

Pre-service teachers at Acadia University, Saint Francis Xavier University, Cape Breton University, and Mount Saint Vincent University were offered the opportunity to participate in our survey. Participants were recruited from these institutions with help from our project partners (Dr. Michael Bowen, Associate Professor, Faculty of Education, Mount Saint Vincent University; Dr. Patrick Howard, Associate Professor, School of Professional Studies (Education Department), Cape Breton University; and Dr. Katarin MacLeod, Assistant Professor in Science Education at St. Francis Xavier University) and with assistance from department heads and program coordinators (Acadia and MSVU, respectively). When possible, partners verbally invited students to participate (CBU, StFX, and part of MSVU) before sending a follow-up email invitation with a link to the online questionnaire. (Note: many pre-service teachers were completing their practicum when we were administering the survey; this meant that these students had to be both notified about the survey and invited to participate via email.) All invited pre-service teachers were given a second email reminder to participate, and some also received a third reminder (CBU).

The process of recruiting in-service teachers was slightly different. We were required to obtain approval from principals before inviting teachers to respond to the questionnaire as a condition of the ethics approval for this study given by the three participating regional school boards (Halifax Regional School Board (HRSB), Cape Breton-Victoria Regional School Board (CB-VRSB), and Strait Regional School Board (SRSB)). Before contacting principals, we visited the

[20] See, for example, De Melker, S., & Jacobson, R. (2012, May 1). Climate in the classroom: Teachers share their stories. *PBS Newshour*. Retrieved from http://www.pbs.org/newshour/rundown/2012/05/teaching-climate-change.html

websites for each school within the three participating boards in order to determine whether teaches' email addresses were publicly available. This was the primary selection criteria for inclusion in this study, however, schools in the HRSB were also chosen to ensure intraregional diversity, i.e., to ensure that Halifax and Dartmouth did not dominate. Principals at all schools with publically available staff emails in the CB-VRSB (10) and SRSB (13) received an email invitation to participate in the study, along with thirteen schools in the HRSB with publically listed staff email addresses. Initial recruitment emails to principals included information about the study and the larger project, as well as a copy of the informed consent form for participating in-service teachers. Except in the few cases where principals notified us by email that they were unable to participate, we followed-up with a phone call to the principals in order to answer questions, offer more information, and to give instructions to those willing to participate. In some cases, follow-up phone calls or additional emailed information were necessary to gain participation.

The three regional boards were nearly equally represented in terms of the number of schools that participated in the project: eight schools in the CB-VRSB, seven in the HRSB, and nine in the SRSB. Teachers from each of the participating schools were first notified about the project and invited to participate by their principals, who agreed to forward an email invitation we provided with a link to the online questionnaire. In total, 128 teachers in CB-VRB, 137 in HSB, and 162 in SRSB received a link to participate in our study. We sent two personalized follow-up email reminders to all teachers[21], with participation improving after each.

To encourage completion, we invited teachers to enter a lottery for a cash prize ($500 for in-service teachers, $300 for pre-service teachers) once they had reached the end of their survey. (We offered pre-service teachers a lower monetary incentive since previous research found that university students are easier to recruit than working professionals.) Upon completion of the questionnaire, respondents were directed to a second, single-question survey in which they were asked to provide their official school email address in order to be notified if they are selected as the winner. We opted for a cash lottery instead of a small honorarium for each participant because the latter approach yielded a very poor response rate in a similar study of in-service teachers[22]. In contrast, lottery prizes have been shown to be effective at increasing

[21] Teachers at all but one school (Inverness Education Centre) received a second reminder email. Inverness Education Centre will receive a second reminder after March Break.

[22] Wise, S. B. (2010). Climate change in the classroom: Patterns, motivations, and barriers to instruction among Colorado science teachers. *Journal of Geoscience Education*, 58(5), 297-309

survey response rates[23]. To further incentivize participation, we added a small additional prize for the in-service teachers in the final reminder email: a $50 gift card to Tim Horton's. This prize was chosen because of its humourous effect, since it coincided with Tim Horton's ongoing Roll Up the Rim to Win® contest. Although prizes undoubtedly helped, we also designed our emails to maximize participation: each follow-up invitation was headed with the invitee's name (requiring over 1,000 emails to be individually sent), and contained an honest and personal request for their time (we were straightforward about our initial low response rates - 33% at time of reminder). This combination of humor, empathy, incentive, and personalization appeared to be very effective: our response rate was higher than expected (see response rate discussion in Section 4.2) and a number of teachers took the time to individually write to let us know they had to participated and/or to wish us luck.

3.4 Preliminary Data Analysis

Detailed statistical analysis of our entire dataset will be conducted in preparation for submission to an academic journal, however, examination of patterns evident from basic descriptive statistics was sufficient to meet the goals of this project, i.e., to identify common climate change misconceptions, general teaching practices, and real/perceived barriers. We generated detailed data reports for both pre- and in-service teachers using the analysis tools within the survey software (Opinio). These reports include histograms and tables of data for all survey questions, as well both raw data and adjusted frequency data (see Appendix D and E, and figures in Section 4). In-service teachers' responses to all knowledge questions were further coded for correct and incorrect answers, so that we could determine average performance and between group differences (e.g., elementary vs. secondary teachers). Average performance on the general science and knowledge of probability questions was also compared to both the detailed demographic breakdown of the National Science Foundation's 2010 Science and Engineering Indicators survey and the NSF's long-term survey performance data (1992-2010). Because our data set for pre-service teachers is still very limited (49 respondents), we did not conduct more than a cursory evaluation of responses, in addition to the Opinio data report (Appendix E).

[23] See, for example, Doerfling, P., Kopec, J.A., Liang, M.H.,& Esdaile, J.M. (2010). The effect of cash lottery on response rates to an online health survey among members of the Canadian Association of Retired Persons: a randomized experiment. *Canadian Journal of Public Health, 101*(3), *251-254*

4. RESULTS

4.1 Pre-service teachers

We encountered a number of difficulties administering the questionnaire to pre-service teachers. Of the two largest participating education departments, one (StFX) was on strike during the main data collection period and the other (Acadia) presented challenges with survey administration. Response rates were within the expected range at Cape Breton University, but the class size was relatively small. Many more students at MSVU received the survey invitation, however, most of them only received notification via email, and response rate was very poor. Our partner at StFX began administering the survey to her students after March Break, and we expect a response rate similar to CBU (where a personal entreaty was made by our partner). Our partner at MSVU has volunteered to try administering a hard copy of the survey to his students, and also to re-administer the survey to the incoming 2013/2014 class. Our partner at StFX also offered to extend the survey timeframe and to administer paper copies of the survey. Because our pre-service data is so limited at present (49 total respondents), we have restricted our initial data analysis to in-service teachers.

4.2 In-service teachers

In addition to the preliminary Opinio analysis (see Appendix D), we provide some further interpretation and commentary in the following sections.

Response rate:

As of the time of writing, 188 in-service teachers completed the entirety of the survey, out of an invited population of 427 teachers, for a response rate of 44%[24]. A higher number of teachers began the survey, but dropped out at some point before submitting: 254 teachers at least opened the survey, and 225 teachers made it out of the demographic section of the survey. In total, 74% of those who began the survey completed it, with an 84% completion rate for those who moved beyond the demographic section (beyond Question 12)[25]. Only four teachers who opened the survey answered 'No' to the informed consent.

Demographics:

Not surprisingly, given the well-known gender disparity amongst teachers (majority female),

[24] The survey will remain open until March 31st, so final numbers may change slightly.

[25] The survey software creates a new entry each time the link is accessed. Since some teachers likely clicked on the link to examine the survey, and then clicked again at a later date to complete it, they would have been counted multiple times, inflating the apparent rate of survey abandonment.

males were outnumbered 3:1. More secondary teachers (58%) completed the survey than elementary (42%). Of the elementary teachers, the majority (66%) taught Grade 3 or above, with 43% teaching Grade 3-5. Of the secondary teachers, science was the most frequently taught subject (39%), with approximately 25% of respondents teaching one or more of math, English, or social studies. A wide range of disciplines were reported, including Gaelic, Mi'kmaq, distance education, and special education. Overall, our respondents were highly experienced teachers, with 63% reporting teaching for greater than 10 years, and only 12% teaching for less than five years. Respondents were also highly educated: 51% had a graduate degree, and three respondents held PhDs. Science was the most commonly reported undergraduate major (30%).

General science/nature of science knowledge:

Despite some odd lapses (e.g., 9% of teachers answered that 'The Sun goes around the Earth'), teachers in general showed high levels of general science knowledge. Teachers scored an average of 89% on the eight general science knowledge questions. This compares very favourably to long-term US national science response data. On average, Nova Scotia teachers answered correctly every science question more frequently than either of the most educated demographic categories used in the National Science Foundation's 2010 Science and Engineering Indicators survey (the categories 'formal education: graduate/professional' and 'science/mathematics education: high'[26]) —see Figure 1. Only 8% of Nova Scotia teachers scored below the long-term average (1992-2010) of US NSF survey respondents with a baccalaureate education. Nova Scotia teachers also performed exceptionally well on the two nature of science questions (probability), scoring 95%, with only a single teacher answering both questions incorrectly.

[26] Defined as >9 science/math courses at the high school level or above.

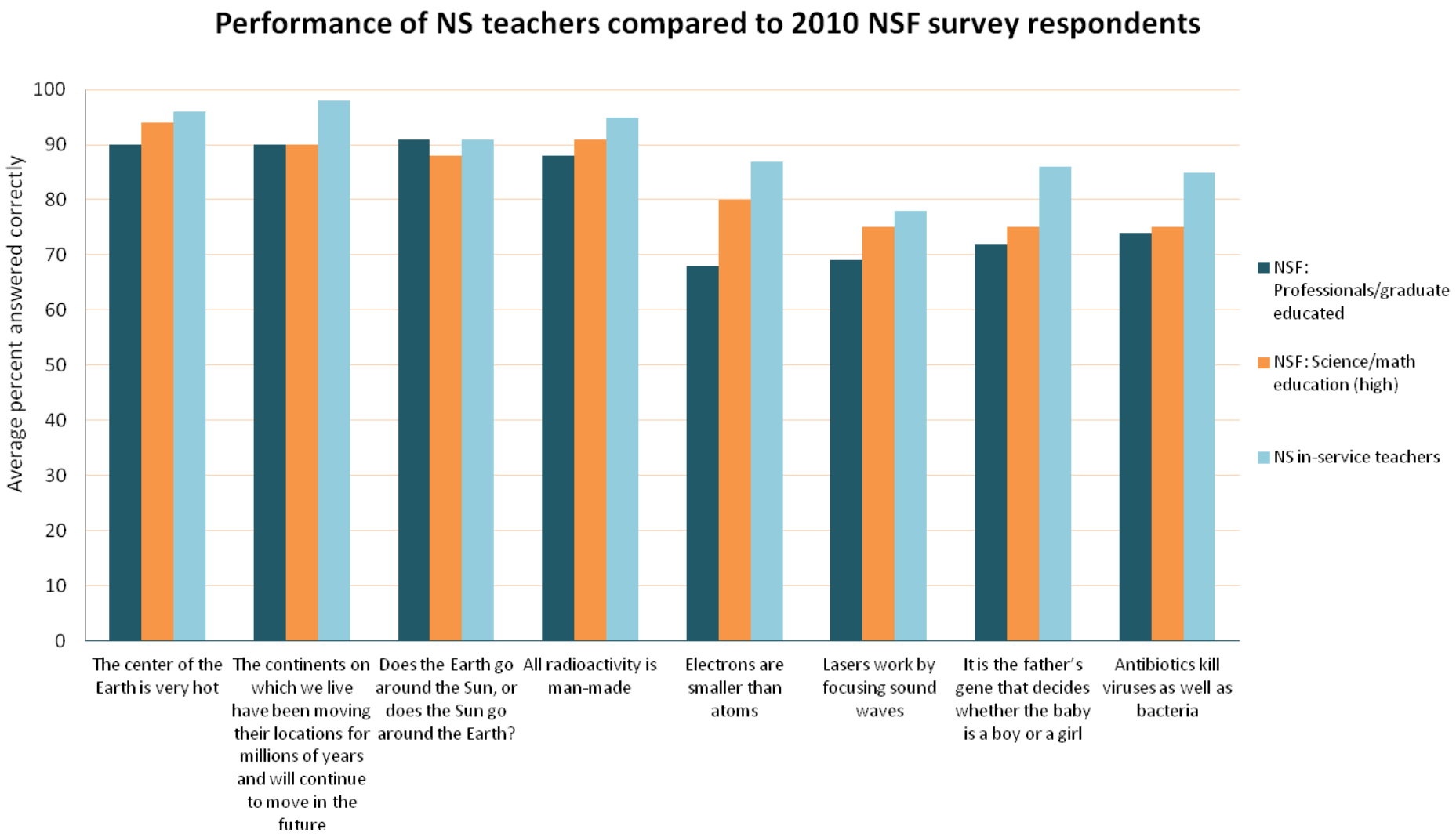

Figure 1. Average performance of Nova Scotia in-service teachers on general science knowledge questions, compared with average performance of respondents to the National Science Foundation's 2010 Science and Engineering Indicators survey ('graduate/professional' and 'science/mathematics education: high' categories only).

Climate change knowledge:

Almost all teachers viewed themselves as having an average level of knowledge about climate change (see Figure 2). Only 7% of teachers viewed themselves as having high or low levels of knowledge (1-2 or 9-10 on a ten point scale). Elementary teachers had a slightly lower average perceived knowledge (4.96/10 vs. 6.23/10). Planned follow-up statistical analysis will determine whether this and other apparent correlations are statistically significant. Teachers report that they rely most heavily on traditional media (books, newspaper, TV news, etc.) for information on climate change. Fewer teachers indicate that they gained information from government sources, NGOs, professional development, or university classes (all less than 25%). Online sources show differing levels of uptake. Websites, such as Wikipedia, are sources of information for nearly 50% of teachers, but only 9% of teachers learn from blogs.

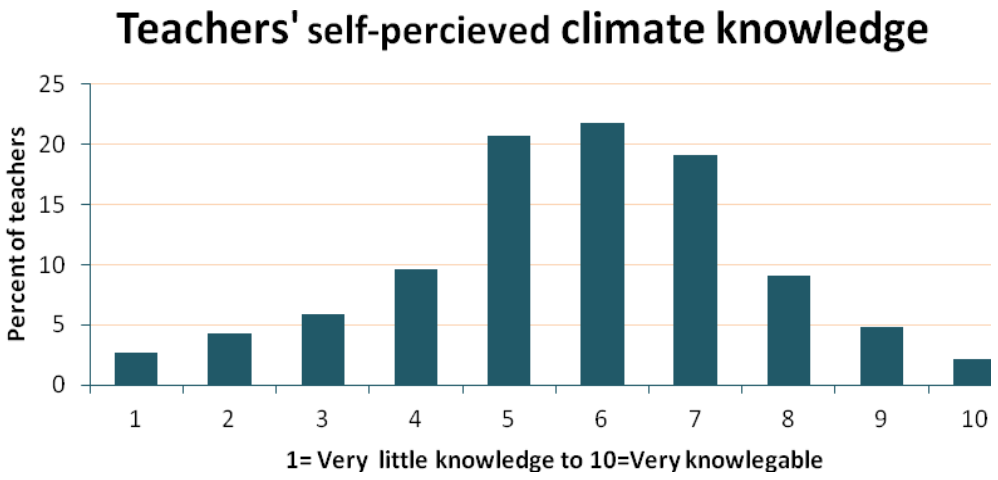

Figure 2. Nova Scotia in-service teachers' self-reported levels of climate change knowledge (teachers were asked to rank their level of climate change knowledge on a ten-point scale).

Teachers did well on average on the ten binary answer climate change knowledge questions (7.69/10), with a small apparent difference in performance between elementary and secondary teachers (7.35/10 vs. 7.95/10). Without a direct comparative population, it is difficult to determine how teachers' performance would compare to other university educated groups. Many of these questions were duplicated from Hayhoe et al. (2011), which examined Ontario teachers, and our planned in-depth analysis will compare performances where possible.

Each of our climate knowledge questions had an accompanying certainty question. This allowed us to distinguish genuine misconceptions from random guesses. Our results show that Nova Scotia teachers hold many of the same misconceptions that have been identified through

previous studies of teachers, students, and the general population. Most of the misconceptions involve confusing the causes or consequences of climate change in a manner that increases or maintains the importance of action on climate change, rather than undermining it (i.e., most NS teachers do not appear to hold anti-climate science misconceptions of the sort found in denialist literature). For example, teachers were far more likely to wrongly predict dire effects (increased skin cancer, acid rain, and earthquakes) resulting from climate change, than they were to reject actual projected effects (extreme weather events)—see Figure 3. Teachers also frequently wrongly linked other environmental issues with climate change, e.g., nuclear waste and ozone depletion as significant causes of warming – see Figure 4. In the case of both of these linkages, many teachers expressed high confidence that they were correct in their assessments. For example, 80% of teachers indicated that thinning of the ozone layer "[h]as contributed significantly to the greenhouse effect." Amongst this group, average certainty in their response to this question was 7.2/10, slightly higher than the professed confidence of teachers who correctly answered the question.

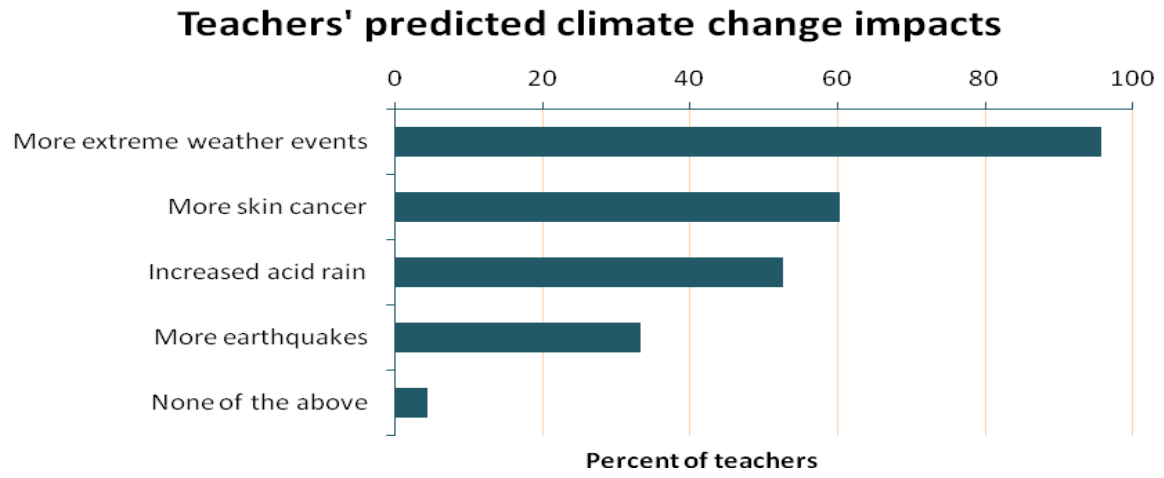

Figure 3. Percent of Nova Scotia in-service teachers who reported that the projected impacts of climate change include more extreme weather events, more skin cancer, increased acid rain, or more earthquakes.

Similarly, 66% of teachers responded that radioactive waste from nuclear power plants contributes 'considerably' or 'moderately' to climate change. (See Table 1 for additional misconceptions.) It should be noted, however, that some misconceptions that have been reported in similar studies are not widely held by Nova Scotia teachers. For example, the overwhelming majority of teachers understood that climate and weather are different things[27].

[27] See, for example, the following study, which found pre-service teachers confuse weather with climate: 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

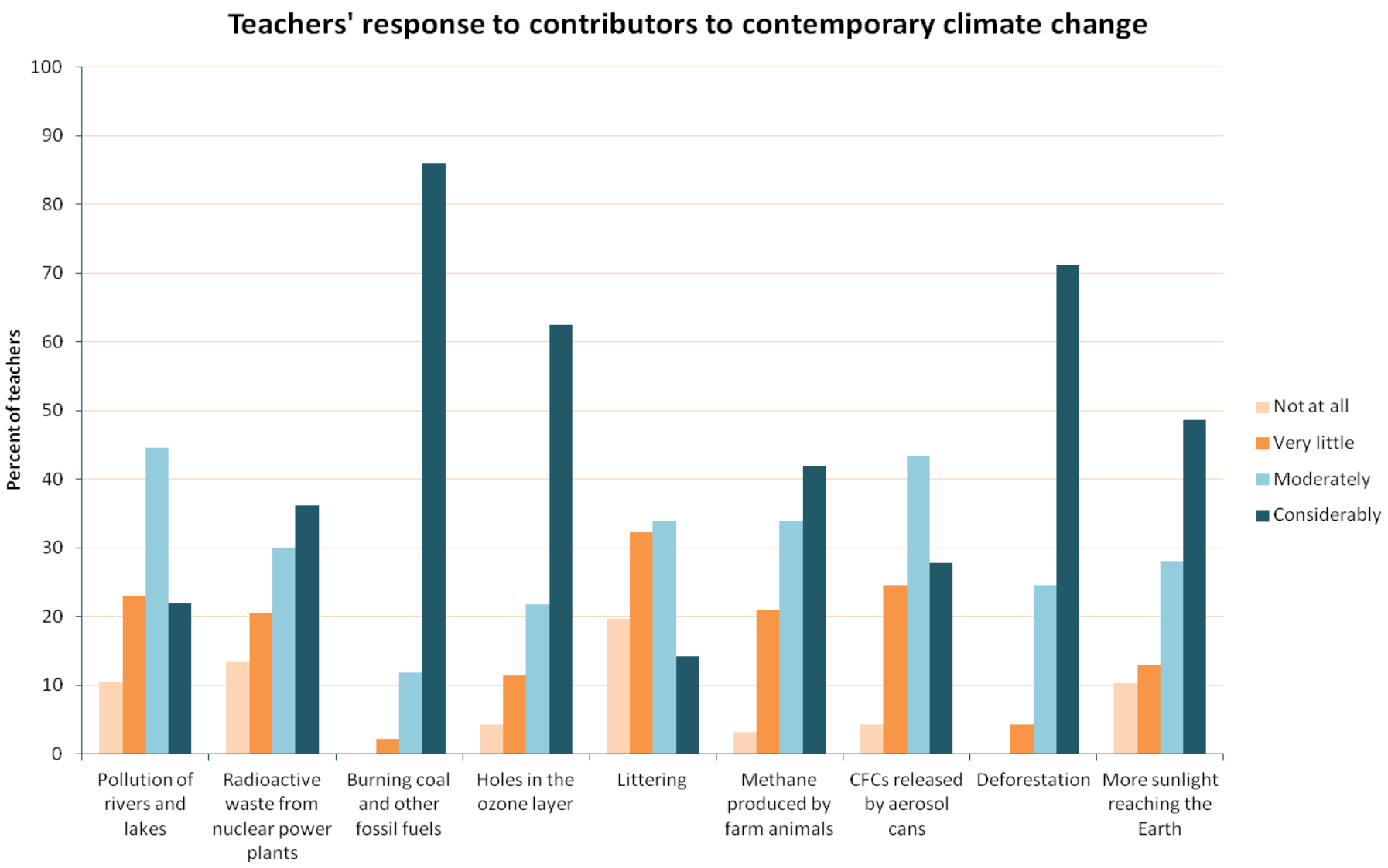

Figure 4. Nova Scotia in-service teachers' perception of the degree to which various factors contribute to present day climate change.

This held both when the terms themselves were compared and when short-term weather events were offered as climate change counter-evidence. Some important factual gaps were also identified. In particular, very few teachers understood the role thermal expansion plays in sea-level rise.

MISCONCEPTION	% OF TEACHERS
Thinning of the ozone layer contributes significantly to the greenhouse effect	80%
Radioactive waste from nuclear power plants contributes to climate change	66%
The greenhouse effect is entirely human-caused	21%
Pollution of waterways contributes to climate change	66%
Littering contributes to climate change	48%
Melting of sea-ice causes sea-level rise	68%
Methane is produced primarily by burning fossil fuels	19%
More sunlight reaching the Earth contributes significantly to present day climate change	77%
Climate change causes earthquakes	33%
Climate change causes skin cancer	60%
Climate change causes acid rain	53%
Half or less of climate scientists endorse anthropogenic climate change	33%

Table 1. Misconceptions related to climate change and the greenhouse effect that are frequently held by Nova Scotia in-service teachers.

Climate change attitudes, teaching practice, and needs:

Nova Scotia teachers' views on climate change responses are largely in line with those expected from political liberals. They strongly support government-led mitigative efforts, and are deeply skeptical about the ability of business/the free market to enact positive change on their own. They are mostly opposed to prioritizing technological investment over efforts to change human behaviours (16% 'strongly' and 33% 'somewhat' disagree, while only 4% 'strongly' and 26% 'somewhat' agree). Teachers also strongly reject prioritizing adaptation over mitigation (55% 'strongly' disagree that "money would be better spent on adapting to climate change, rather than trying to reduce greenhouse gas emissions"). However, teachers do appreciate adaptive efforts: 65% rank "creating community adaptation plans" as a 4 or 5 on a 5 point scale of importance. Regarding mitigative efforts, teachers believe that individual actions are important and can make a difference (90% believe that "individual actions...can significantly

reduce greenhouse gas emissions"). Teachers show some confusion regarding what mitigative or adaptive actions are most meaningful. A large majority strongly endorse sensible actions such as planting trees, using active transportation, and switching to energy efficient appliances, but other less vital or only weakly related actions, such as buying local products and cleaning up polluted rivers, are ranked nearly as high.

The majority of teachers professed high levels of concern about climate change (>8 on a ten point scale - see Figure 5). Only three out of 188 teachers indicated that they were not concerned about climate change (<4 on the ten point scale). Similarly, teachers strongly support including climate change in public school education, with 76% ranking climate change education as 'very important' (5 on a 5 point scale) for Nova Scotia students, and 94% selecting either 4 or 5. Nova Scotia teachers appear to recognize the interdisciplinary nature of climate change. When asked what classes they viewed as appropriate venues for climate change instruction, 97% identified science, 87% social studies, and 82% geography. Despite the quantitative nature of much of climate science, only 34% had the same view of mathematics. Interestingly, more teachers identified history (51%), language arts (46%), and visual arts (36%) as appropriate places for instruction. Write-in suggestions included disciplines as diverse as music and physical education, with three teachers explicitly stating that climate change is appropriate in all classes.

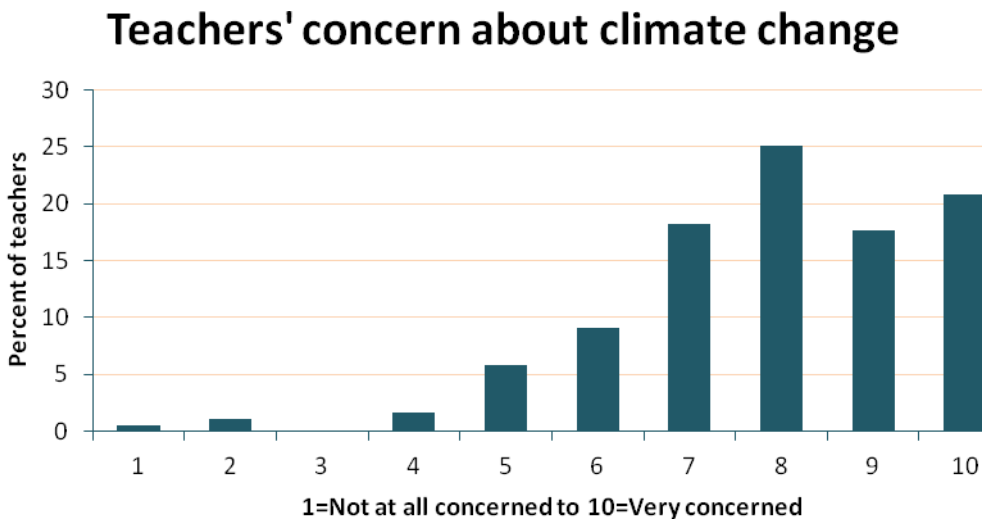

Figure 5. Nova Scotia in-service teachers' reported levels of personal concern about climate change.

Teachers' concern and open-mindedness regarding climate education appears to translate into teaching practice: only 13% of teachers indicate that they do not discuss climate change at all in their classrooms (either formal or informal lessons). Unexpectedly, given the near absence of climate change within provincial curricula, 28% of teachers report addressing climate change in formal lessons.

Amongst those who teach about climate change, the most commonly cited barriers limiting the time they devote to the topic (each at 49%) are lack of knowledge and lack of time. These two concerns are reinforced by the next two most common barriers: absence from the required curriculum (39%) and lack of access to prepared teaching materials (37%). Other explanations for lessened uptake, which were noted elsewhere[28], ranked very low in our survey. For example, fear of frightening children was identified by only 6% of teachers, and perceived scientific controversy and fear of negative feedback from parents, teachers, and school administrators were each identified by less than 3% of teachers. Amongst those teachers who do not presently integrate climate change into their teaching practice, the most cited explanation (75%) was absence from the curriculum. Forty-five percent of those who do not teach climate change report that the topic is not relevant to their classes, and 29% each report lack of time and materials as barriers. (See Figure 6 for additional information.)

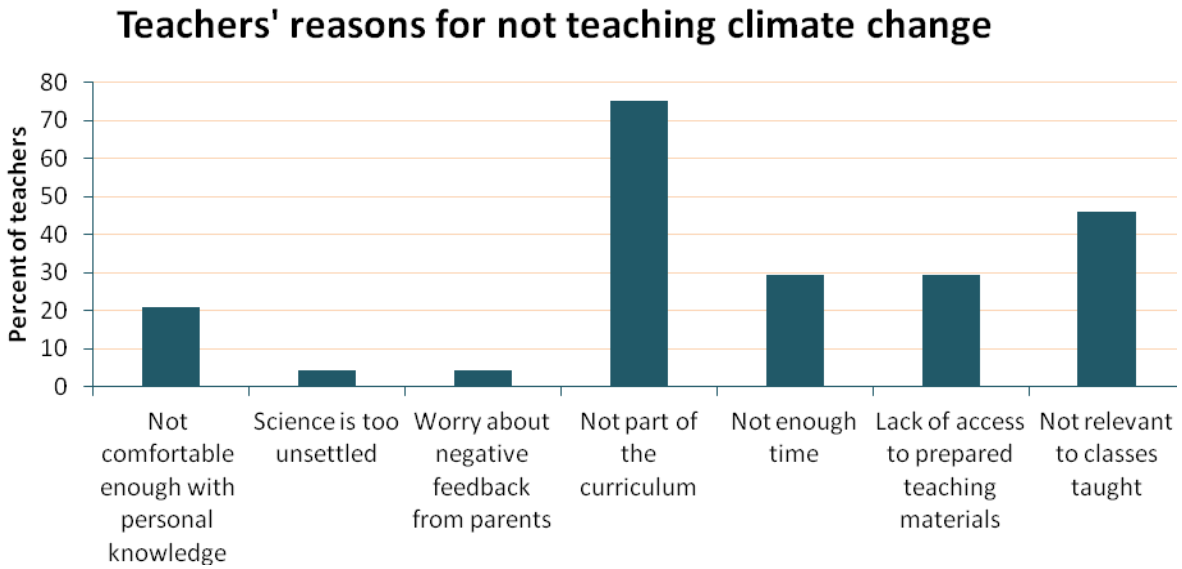

Figure 6. Nova Scotia in-service teachers' reasons for not teaching about climate change (either in informal discussions or formal lessons) with their students.

[28] See, for example, De Melker, S., & Jacobson, R. (2012, May 1). Climate in the classroom: Teachers share their stories. *PBS Newshour*. Retrieved from http://www.pbs.org/newshour/rundown/2012/05/teaching-climate-change.html

Although most teachers did not report that controversies within climate science acted as a barrier to engagement with the topic, nearly a third (31%) of teachers answered that they would include the views of contrarian scientists/climate skeptics because "[t]heir views are valid and their arguments should be heard." This option was chosen less frequently than the option of including contrarian views "only as an exercise in critical thinking" (65%), but much more frequently than the option of teaching only consensus science (4%). The significance of these results is unclear. Our use of the term 'valid', rather than 'correct', creates the possibility that teachers were simply stating their commitment to freedom of expression and intellectual exchange. A nearly identical number of teachers agreed that climate change was endorsed by 50% or less of climate scientists, which would appear to support a more alarming explanation: that contrarian and mainstream views have equal standing. However, these same teachers do not seem to be more likely to have indicated that contrarian views are valid (30% of those teachers who agreed that almost all climate scientists endorsed anthropogenic climate change also agreed that contrarian views are valid).

Teachers indicated that a wide variety of resources would be useful for supporting their efforts at teaching climate change. Teachers nearly unanimously endorsed all of the options they were given, however, slightly more teachers responded that pre-made lesson plans would be 'very helpful' (75% vs. 60-69% for the other options – see Figure 7). Teachers were given the opportunity to indentify additional resources not included in our list. Requests included bilingual materials, materials suitable for younger students, and critical thinking and media literacy tools.

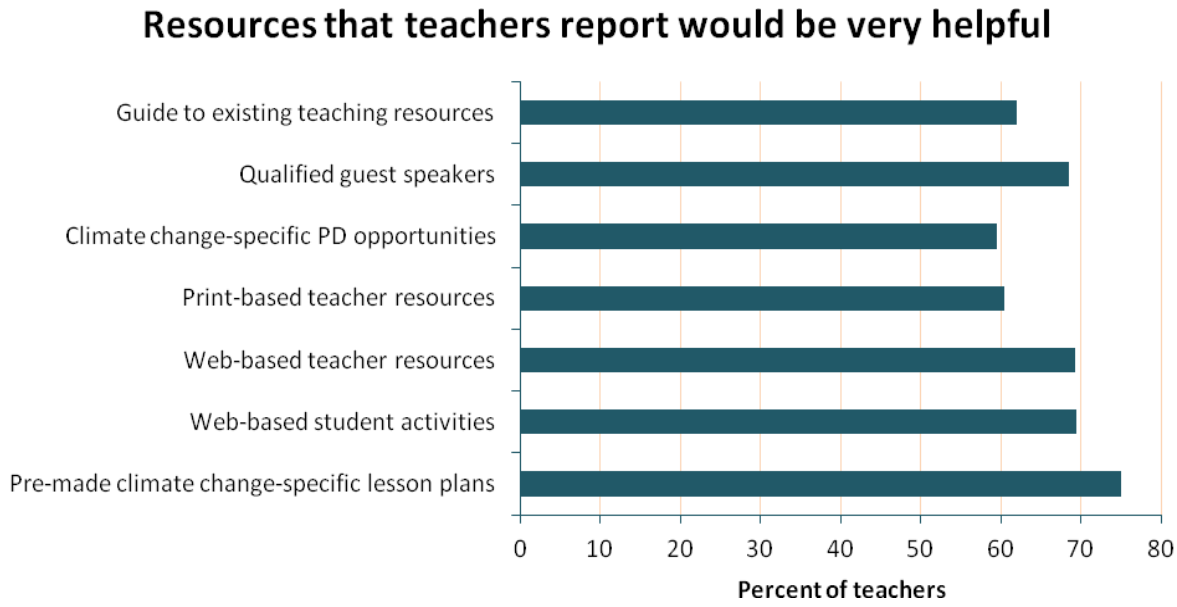

Figure 7. Resources that Nova Scotia in-service teachers reported would be very helpful in supporting their efforts to teach climate change in their classrooms.

5. CONCLUSIONS

Principals, education faculty, and in-service teachers were highly supportive, and were instrumental in helping us meet our research goals. In-service teachers responded well to our web-based survey, even though we administered the survey during a period when teachers were particularly busy (due to upcoming report cards, March Break, and a high number of weather cancelations). Pre-service teachers, despite their high reliance on the Internet and electronic communication, appeared less receptive. However, as we did not have access to pre-service teacher emails (for privacy reasons), and had to rely on partners and partners' faculty contacts to recruit participants, we did not have the same opportunities to personalize invitations and send reminder emails. Where faculty took a strong lead in promoting participation, survey response rates were higher (CBU). Our planned follow-up of pre-service teachers will rely more heavily on targeting specific classes where instructors are project partners/have expressed strong interest in assisting, rather than attempting to survey entire student populations through mass email. The use of hard copy questionnaires, completed during class time, would also increase response rates; however, this would create additional ethics and logistical issues.

Overall, it appears that Nova Scotia teachers have some base of climate change knowledge that can be built upon in future educational efforts (although teachers also showed considerable variation). Teachers voiced high levels of concern about the impacts of climate change and reported relatively low levels of self-perceived climate change knowledge. Despite relatively strong performance on general science and climate specific questions, teachers held a number of climate change misconceptions and showed other knowledge gaps or misunderstandings (results from our NS survey largely mirror previous research conducted elsewhere). At the same time, they showed strong support for additional learning opportunities, and reported that they presently receive little climate change information from professional development opportunities, formal university courses, or government sources. This indicates an opportunity for Nova Scotia Environment or other organizations to support the development of new professional development opportunities and other education materials.

Teachers generally support strong action on climate change, including government-led, individual, and community-based action. They support both mitigation and adaptation, but showed some confusion regarding action priorities. They tended to overestimate causes and impacts, skewing more towards an 'alarmist' rather than 'skeptic' position. In terms of remedial efforts, this is a positive finding, as it indicates that most teachers do not hold world views

antagonistic to climate science or climate change adaptation/mitigation, which should make correcting misconceptions easier.

Teachers overwhelming support exposing Nova Scotia students to climate change and many, despite the near absence of climate change within the province's curricula, report that they are currently integrating climate change into their teaching through either informal discussion or formal lesson plans. They see climate change as an interdisciplinary topic, and support its inclusion in class work outside of science and social studies. Both those currently teaching climate change and those who are not teaching climate change flagged lack of knowledge, lack of teaching materials, and lack of time/curriculum outcomes as major barriers to increasing climate change instruction. In comparison, all other potential barriers were insignificant (although a number of others were identified as affecting at least some teachers—see Figure 6 and individual responses in Appendix D). Our teaching companion (Appendix C) is designed to address concerns about lack of materials and lack of knowledge, however, producing additional Nova Scotia-specific learning opportunities and educational support should be a priority for future climate change funding.

The above identified interventions should prove effective in increasing Nova Scotia students' access to climate change instruction; however, revising the province's curricula to explicitly include climate change should be a long-term goal. Although climate science has a logical place within upper-level science courses, given that many Nova Scotia students, especially non-university streamed students, will not take these courses, efforts should be made to include climate change at lower grade levels and/or within other disciplines. Other provinces provide examples of successful curriculum integration. For example, Ontario, at the Grades 9-12 level, explicitly mentions climate change in the outcomes for Geography of Canada, Science (applied and academic), Chemistry, Environmental Science, Physical Geography, and The Environment and Resource Management[29].

Future work could develop and test pilot professional development opportunities and teaching materials based upon the survey results included here. Detailed examination of teacher classroom practice and knowledge levels/misconceptions of Nova Scotia students (at various grade levels) would also help improve and streamline climate change education in Nova Scotia.

[29] The Pembina Foundation. (2010). *Climate change curriculum connections*. Retrieved from http://ecards.greenlearning.ca/docs/curriculum-connections-cc.pdf

6. APPENDICES (see attached)

Appendix A In-service teacher questionnaire

Appendix B Comparison of teacher preparation in NS

Appendix C Climate change teaching companion

Appendix D Summary report of response data (in-service)

Appendix E Summary report of response data (pre-service)

Appendix F Partial bibliography of academic sources consulted