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EDITORIAL

A crisis in science literacy and communication: Does reluctance to engage the public make academic scientists complicit?

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The impetus for this commentary was the news that I was chosen to receive the 2018 Canadian Association of University Teachers (CAUT) *Lee Lorch Award* (the *CAUT Distinguished Academic Award*), which recognizes contributions to the three pillars of academia: teaching, research, and service. Although delighted by the news, I admit that it felt odd to receive a reward for doing something that I love. I have always believed that it is a privilege to be a professor. I love universities. I love universities because they are keepers, interpreters, and disseminators of our collective knowledge. I love universities because they are also the place where we create new knowledge: knowledge that can be used to improve our lives.

Universities are also where we change lives. As professors, one of our jobs is to communicate our created knowledge (i.e., the products of research) to students and the broader public (i.e., teach). It is critically important for our society to have well-informed, articulate, socially active, and thoughtful citizens to meet the challenges ahead. This is part of what we try to achieve in universities. Namely, we mentor students to be prepared to tackle the problems that we have created.

On balance, I think we do a good job in research and teaching at our institutions. What we are not doing very well is translating this information effectively for politicians, policymakers, and the public.

This brings me to the content of my CAUT keynote, which I have now condensed into this invited editorial. I will focus on science, and specifically on what I see as a developing crisis in science literacy and communication and, by extension, how poorly science is being used to formulate evidence-based policy. My general concern is that science, at the very least, is being under-used by politicians, policymakers, and the public at large. At worst, science is being misinterpreted, misrepresented, and misused. I believe that we, as academics, are partly to blame for this situation. My focus will be on environmental science, using primarily Canadian examples, although I believe many of my concerns are applicable to other disciplines and regions.

To begin my discussion, I should first determine whether we have solid evidence that we have a serious science literacy problem in Canada and other countries. Multiple lines of evidence point to the fact that we do, in a big way.

Let us explore the biggest environmental problem that humanity faces today: climate change.

There are many examples that make me concerned, but a recent study left me speechless. As I was writing these notes, CBC News (Zimonjic 2018) reported that a recent Abacus Data (2018) poll concluded that about a third of Canadians are not yet convinced that recent climate change is caused by human activity.

This is a remarkable finding, considering the mountains of science-based evidence that show that recent climate change is, in fact, linked to human activity. Contrast the Abacus Data (2018) poll with, for example, the work of Dr. James Powell, who has tracked peer-reviewed publications on climate change for some time. First, Dr. Powell is not someone whose research is tainted by ideology! His (2018) biography notes he was born in Kentucky, USA, holds a PhD from the Massachusetts Institute of Technology and several honorary degrees, and served as Acting President of Oberlin College, President of Reed College, President of the Franklin Institute of Science Museum in Philadelphia, and President and Director of the Los Angeles County Museum of Natural History. US President Reagan, and later President George H. W. Bush, both Republican presidents, appointed him to the National Science Board, where he served for 12 years. He is currently Executive Director of the National Physical Science Consortium. To put it plainly, his credentials are solid.

What did Powell (2017) find in his analysis (which itself was peer-reviewed) of the peer-reviewed literature on climate change? His most recent count (1991–2015) showed that 54 164 peer-reviewed papers concluded that human-induced global warming is happening, whereas only 31 papers rejected this conclusion. This means that about 99.94% of the studies indicate a human cause for recent climate change, as opposed to 0.06% that deny the connection, with a ratio of about 1747:1. This is similar to the percentage (about 99%) that other researchers have used, including myself, as an estimate of scientific acceptance of the effects of human-generated greenhouse gases on climate change.

Let us now compare this 99.94% value in the peer-reviewed scientific literature, which affirms the connection between human activity and climate change, with what Canadians believe about the current state of climate science. Let me remind you that the recent Abacus Data (2018) poll concluded that about 1/3 of Canadians were not convinced by the overwhelming scientific data. Granted, although 27% believed there was *some evidence*, they also believed that it was not conclusive. An astounding 11% said there was little or no evidence to suggest that recent warming is real. On the plus side, about 61% thought the data were conclusive or at least "solid", but why are the numbers not higher?

Looking back at Dr. Powell's analyses, I wondered: Suppose these same people who questioned the human connections to recent climate change had a seriously ill child. Now let us imagine that as parents of a sick child they went to 1748 doctors for a consultation, and of those 1748 medical professionals, all but one said their child needed immediate medical attention. Would the parents find the 1747 doctors credible, or would they believe the one dissenting view?

How did we get to this state of poor science literacy and the poor use of quality scientific information?

Science is under attack from many fronts. A growing trend that challenges our scientific literacy is the precipitous decline in reliable science journalism. Of course, there remain some excellent science media people in Canada and elsewhere, but the number of journalists in general is declining, with especially heavy attrition among those who specialize in serious science stories. This problem has been developing for some time. Charbonneau (2009) quoted the respected (now retired) science writer Peter Calamai's 2008 opinion piece in *Re$earch Money*, in which he stated that the number of dedicated science journalists in the major media had declined dramatically. Calamai had also noted, "When the Canadian Science Writers' Association was founded in 1971, there were at least 30 staff newspaper reporters in Canada whose beat was science, sometimes combined with

medicine … Today there are about six such reporters". In the intervening decade, the situation has deteriorated further. As some excellent science journalists retire, or more often are laid off or re-assigned, they are not replaced. Moreover, as Rehman (2013) noted in *The Guardian*, the bulk of contemporary science journalism falls under the category of "infotainment", with a focus on entertainment rather than science translation. I fully support presenting scientific discoveries in an engaging and entertaining fashion—of course they should be, but they should be presented without losing sight of the foundational science on which the news story is based.

When I discuss this lack of science reporting with mainstream media representatives, I am often told that there is simply insufficient time or bandwidth to discuss science. But what do they discuss? I recall watching national newscasts on Groundhog Day a few months ago, near the time that several key climate scientific reports were released. But were these reports covered? No. Instead, much of the newscast was dedicated to reporting which groundhogs in which cities had seen their shadows…. No wonder we have a science information crisis!

In addition, we have celebrities like movie stars espousing unsubstantiated scientific claims about disease, vaccinations, and ways to improve your health. Remarkably, science dollars and efforts have to be constantly diverted to negate these often ridiculous claims.

To complicate matters even more, a recent Pew Research Center study (Mitchell et al. 2018) concluded that 42% of Canadians get news reports through social media. Beyond issues such as confirmation bias and fake news, one can only wonder how much filtering occurs before a user gets his or her "tweeted" science information. Today, anyone with an internet connection is a potential publisher (and "expert")! The checks and balances that scientific peer review offers have largely disappeared—a basement blogger receives the same credibility (and often more reads) as a professional scientist who has spent decades investigating an environmental issue.

In summary, science dissemination is not happening on an "even playing field". The lack of serious science reporting and communication allows vested interests and lobbying groups, which often possess considerable resources for public relations and large capacities for swaying public opinion, a much freer hand in delivering messages that help them achieve their agendas. Many industry spokespeople, with well-oiled campaigns, quickly fill any "information vacuum", and the arguments they provide often go unchallenged by academic scientists.

Consequently, I believe the onus falls increasingly on academic scientists to provide information transfer in effective ways. We must do a better job of communicating the results of our research and, equally importantly, we must correct misconceptions concerning "how science is done". A recent survey for the Ontario Science Centre (2017) provided a chilling example of how the public views science. Most alarming was the finding that almost half (43%) of Canadians think science is "a matter of opinion". This is very worrisome. In science, what you might "believe" is not important, rather it is what you can show with data that is important.

So, our first challenge is to make it clear that opinions (and belief!) mean nothing in science. In science, only reproducible data matter. We don't put forward a hypothesis, test it, and then ask for a show of hands of "who likes" the outcome of our experiment. Science works by falsification and repeated challenges. A hypothesis is put forward only to be tested by controlled experiments and observations.

Some examples that come from my own research area illustrate some of the misconceptions people have about how science functions, and show how we, as scientists, have done a poor job of explaining the "culture and practice of science". Examples include letters and e-mails (some of them even

published in the alumni publication of my own university) that attacked me personally for my research that has shown the human role in recent climate change. Two recurring and totally unfounded attacks repeatedly come my way, again reflecting a misunderstanding about how science functions.

One recurring misconception common in many of these attacks is that if a scientist wants to advance in her/his career, she/he has to "toe the line" and "follow the herd". Successful scientists know this to be absurd. To imagine that a scientist would make progress in her/his career simply by confirming "accepted dogma" highlights the lack of understanding of how science operates. The fuel that drives science forward is criticism, or as the Nobel laureate Max Planck (1858–1947) said "Science advances one funeral at a time". One does not gain promotion and advancement by agreeing with the status quo; one gains recognition with new and bold ideas, which can be backed up by data that challenge the status quo. Perhaps this is best captured by the motto of the Royal Society, founded in 1660, which is "*Nullius in verba*", loosely translated as "Take no one's word for it". Scientists, by their very nature, are skeptics.

The second accusation frequently hurled at me is that the reason I claim humans are causing climate change is to get more grant money. Let's examine the absurdity of this charge. Since at least the 1990s, I have said that anthropogenic climate change is the biggest environmental problem we face, and that we have to deal with it immediately by implementing bold and innovative policies. I have said repeatedly "we have enough data and good science to move forward with decisive action". This is not really the type of comment one would expect from someone who is "only in it to get more grant money to study the topic". In fact, it is those who *deny* the effects of human-caused climate change who repeatedly challenge the science and claim that more research is needed. Frankly, there are many other pressing environmental problems I would like to pursue; the time for serious action on climate change is now.

Now for some good news. There were some positive aspects revealed in the recent Abacus Data (2018) poll on perceptions of science. Importantly, the survey noted that, although 33% of Canadians consider themselves "science illiterate", 82% want to know more about science and how it affects our world.

Another piece of good news is that the Canadian public apparently trusts academic scientists! The Edelman Trust Barometer (2018) runs annual surveys to determine the public's trust and credibility. In the 2018 survey, "academic experts" had the highest trust and credibility rating (deemed to be "very/extremely credible") of the 11 groups of spokespeople used in the survey. Interestingly, the lowest credible groups were CEOs and Board of Director members.

Why, then, do so few academic scientists engage the public? The classic excuse is "I don't have time". Yes, academics are all busy; however, if history teaches us anything, we need to engage more effectively for our own self-interest as scientists, if not for the interest of society as a whole.

Second, there are potential pitfalls in science outreach. For example, what will my peers think? The first rebuttal is that you are not becoming engaged to impress your peers—you are engaging to better inform the public. The same public who, by and large, paid for the research in the first place!

Some scientists are concerned that, by engaging the public, people will think "I am just blowing my own horn". When I started doing science more than 30 years ago, I did hear such complaints. I "cut my teeth" as an academic researching the environmental effects of acid rain; in many respects, that was one of the first major environmental problems that put some scientists (like me) before the media. I would hear (invariably second hand) that: (1) "he just likes to hear his own voice on the radio"; and

(2) the science was somehow tainted because the general public was interested. Well, I don't think this excuse not to engage was valid 30 years ago, and it certainly cannot be used now. My response then was the same as it is now: the public paid for this research with their tax dollars, and we are obligated to tell them what we found. Furthermore, attitudes at universities have changed over time. Universities now typically have communication departments that are tasked with "getting the message out" concerning the research done at their institutions. Funding agencies often have sections on their grant proposals where you are asked to outline how you engaged the public in outreach, media, and similar activities. Nonetheless, I believe there is still insufficient institutional and cultural support for science communication and public engagement. We can and should do better.

Another recurring excuse is that "The science I do is too complicated and so the media and the public will never be able to understand what I do". Nonsense! If you can't explain to an interested person what you do and why it is important, then you probably don't understand what you are doing!

The fourth and final reason, and perhaps the most worrisome excuse, is that communicating controversial data can be unpleasant. True, indeed, and I know this from my experience in dealing with environmental issues. In environmental science there are three main types of scientists. Industry scientists, who are paid by private companies that typically have their own agendas. Government scientists, who may or may not be able to speak freely about their research, and may lack the freedom to independently pursue research that may reveal "inconvenient truths". And then there are academic scientists. With all the academic protections we have, one would think we would be completely unfettered to conduct research and report on the truth. Well, yes, at least in principle. But some university professors perceive real or imagined restraints. For example, some of my colleagues have admitted they did not want to "make waves" about a new finding because they were preparing a grant proposal for submission to a government agency and (or) would soon require a letter of support. Scientists working with industrial partners often have additional "complications" if they are, for example, identifying new environmental problems that will be "inconvenient" for supporting industries. This is alarming. If academic scientists start self-censoring, then who will provide unbiased information on science? Researchers are obligated to communicate their findings, even if they are "inconvenient".

In summary, although we may all invoke reasons not to engage, we have to be cognizant of the consequences of not engaging effectively. And there are many.

In universities we search for the truth. In some quarters, however, it has become acceptable to dismiss the search for evidence as the domain of "elites". We live in an era when it has become increasingly common to receive unsubstantiated pronouncements on complex issues like climate change and human rights, sometimes in 140-character (now 280-character) "tweets" (quite often at 2 am).

Scientists and other academics have to counter this attack. Facts and data *do matter*. As the late US Senator Daniel Patrick Moynihan noted, "Everyone is entitled to his own opinion, but not to his own facts".

We have to be vigilant in pursuing thoughtful studies and discussions, all of which are critical to the functioning of a democracy. If facts and information are not prized and communicated, then ideology will trump evidence. And if you don't value truth, then you don't value democracy.

And yes, at times, that means we will have "to throw stones at giants".

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Author contributions

JPS conceived and designed the study. JPS drafted or revised the manuscript.

Competing interests

JPS is currently serving as a Subject Editor for FACETS, but was not involved in review or editorial decisions regarding this manuscript. Due to a family relationship, the Editor-in-Chief, Jules Blais, was also not involved in the review process or editorial decision.

Data availability statement

All relevant data are within the paper.

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