

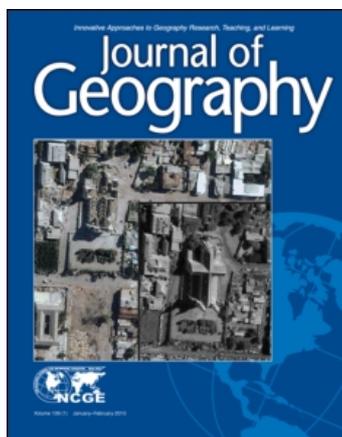
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Agnotology as a Teaching Tool: Learning Climate Science by Studying Misinformation

Daniel Bedford

ABSTRACT

Despite the existence of a clear scientific consensus about global warming, opinion surveys find confusion among the American public, regarding both scientific issues and the strength of the scientific consensus. Evidence increasingly points to misinformation as a contributing factor. This situation is both a challenge and an opportunity for science educators, including geographers. The direct study of misinformation—termed agnotology (Proctor 2008)—can potentially sharpen student critical thinking skills, raise awareness of the processes of science such as peer review, and improve understanding of the basic science. This potential is illustrated with examples from a small, upper-division collegiate weather and climate class.

Key Words: *global warming, agnotology, misinformation, active learning*

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INTRODUCTION

Agnotology is a term recently coined by science historian Robert Proctor and linguist Iain Boal to refer to the study of ignorance and its cultural production (Proctor 2008). While epistemology is the study of knowledge, how and why we know things, agnotology is the study of how and why we do not know things. As such, it presents a potentially useful tool for students to explore topics where knowledge is or has been contested by different interest groups, such as evolution by natural selection versus intelligent design, or the scientific and legal struggle to identify cigarette smoke as a significant health hazard. Directly relevant for the geography classroom is the debate between global warming proponents and skeptics. This article focuses on the use of agnotology—the study of how and why ignorance or misunderstanding exists—as a teaching tool to explore the science of global warming. First, the misconceptions about global warming that opinion polls have found among the general public (and, by extension, among students) are outlined. Second, the role of misleading or inaccurate statements in the popular media (referred to in this article as “misinformation”) in creating this public confusion are considered. Finally, ways for students to learn the science of global warming through direct study of this misinformation are examined.

PUBLIC MISUNDERSTANDING OF GLOBAL WARMING

Before proceeding, it is important to clarify some key terms. It is easy to use phrases such as “climate change,” “global warming,” or “anthropogenic global warming” interchangeably, but there are important, if subtle, differences in meaning between them (Akasofu 2008). The term “climate change” can refer to any change in climate over time, such as warming or cooling, or getting wetter or drier (Intergovernmental Panel on Climate Change [IPCC] 2007b, 2). There is no reference to any particular spatial scale, so “climate change” could refer to events that are global, regional, or local in extent. By contrast, “global warming” refers explicitly to the global scale, and explicitly to increasing temperatures as distinct from other climate changes, but does not identify a particular cause. The term “global warming” could refer to natural changes in temperature, such as those that occurred at the end of the last glacial period. “Anthropogenic global warming” refers explicitly to a global-scale increase in temperature that is human in origin. Global-scale climatic changes, either anthropogenic or natural, involve changes at the global average scale, and significant variations from the global average may be encountered at regional or local scales. Thus, anthropogenic global warming refers to a human-driven increase in temperature for the Earth as a whole, but individual locations on Earth might not experience the same changes as the global average (indeed, some locations may even become cooler). For this reason, some may feel that the term “climate change” is more accurate. Popular usage often invokes the terms “climate change” and “global warming” to refer specifically to anthropogenic changes. For the sake of brevity, this article uses the term “global warming” interchangeably with “anthropogenic global warming.”

Within the scientific community, the reality of anthropogenic global warming is not seriously contested. On the contrary, there is strong agreement on several basic points: that warming is occurring, is due in large part to anthropogenic emissions of greenhouse gases such as carbon dioxide and methane, and major sources of these greenhouse gases include burning of fossil fuels and land-cover changes such as forest clearance for agriculture. This consensus is

based on the overwhelmingly clear and strong message emanating from the peer-reviewed literature (Oreskes 2004) and is summarized in statements from major scientific bodies such as the Intergovernmental Panel on Climate Change (2007a), the American Geophysical Union (2007), the American Meteorological Society (2007), and numerous others. Perhaps the clearest, most succinct statement of the current scientific consensus can be found in the IPCC's Fourth Assessment Report (Intergovernmental Panel on Climate Change 2007b, 3), which states that there is "*very high confidence* that the global average net effect of human activities since 1750 has been one of warming" (italics in original), with "very high confidence" defined as at least a nine out of ten chance of being correct. A recent opinion poll of scientists themselves found that the great majority agrees with this consensus (Doran and Zimmerman 2009).

However, surveys of American public opinion reveal a disconnect between the strength of the scientific consensus on global warming, and the views of ordinary citizens. Leiserowitz (2007) found that 40 percent of those surveyed believed that there was a lot of disagreement among scientists about whether or not global warming was occurring; other opinion polls show that acceptance or rejection of the science of global warming is strongly correlated with political viewpoint, with Democrats tending to accept and Republicans tending to reject the scientific consensus (Dunlap and McCright 2008). More troubling still, one opinion poll suggests that education tends to increase skepticism among Republicans but decrease it among Democrats (Pew Research Center for the People and the Press 2007). Consequently, for many members of the public, global warming is still seen as a contested issue despite the scientific community's very strong consensus.

There are likely many reasons for this situation, including news media attempts to present "both sides of the argument" (Boykoff and Boykoff 2004), but considerable evidence has amassed that a major factor has been, and continues to be, an organized campaign intended to engender doubt and confusion in the public mind (Proctor [2008] refers to the cultivation of ignorance as *agnogenesis*). For example, McCright and Dunlap (2000) find sharp increases in the number of publications with a skeptical message coincident with significant international efforts to reduce carbon emissions, notably the United Nations Conference on Environment and Development (or Rio Summit) in 1992, and the run-up to the Kyoto Protocol in 1997. Nisbet and Myers (2007) find a sharp increase in public skepticism about global warming between 1992 and 1994, coincident with a significant increase in agnogenesis publications, suggesting that the campaign had some success. Some of the practitioners of global warming agnogenesis are veterans of the battle over the health effects of smoking (Oreskes and Conway 2008), whose infamous internal slogan was "Doubt is our product" (Proctor 2008).

Not all misleading or inaccurate information on global warming in the popular media is intended to be so, and there is therefore a difference between *misinformation*

and *disinformation*, the latter being deliberately false or misleading. However, at least some of the misinformation in the popular media has the very strong appearance of being deliberately misleading. For example, the views of Carl Wunsch, an oceanographer at the Massachusetts Institute of Technology, were so thoroughly misrepresented in the documentary film *The Great Global Warming Swindle* that Wunsch has claimed the film "comes close to fraud" (as reported in *The Economist* 2007, 61). Writers of syndicated opinion columns in leading news publications occasionally quote the scientific literature in such an egregiously selective manner that only the most charitable interpretation could see the mistake as a genuine oversight rather than a deliberate attempt to misrepresent (examples are provided by Peterson, Connolley, and Fleck 2008). Thus, although not all incorrect material in the popular media on global warming is deliberate, at least some of it has the strong appearance of being so.

The existence and effects of this agnogenesis campaign are problematic, both in the larger sense of society's response (or lack thereof) to an increasingly urgent problem, and for the scientific education community, including geographers. However, it also presents an opportunity. The study of misinformation about global warming—an agnology of global warming—can help teach critical thinking skills, the process and nature of science (as distinct from opinions), and the relevant basic scientific concepts. In the remainder of this article, some common characteristics of global warming agnogenesis that are useful for teaching purposes are outlined; then, approaches to using agnology in the classroom are illustrated with the example of a small upper-division weather and climate course.

AGNOGENESIS STRATEGIES

McCright and Dunlap (2000) conducted an extensive survey of the literature devoted to debunking the science of global warming, and found three persistent major themes: first, that the science was uncertain (that is, there was no consensus) or of poor quality; second, that even if warming was occurring, it was likely to be a good thing; and third, that any attempts to reduce carbon emissions would cause more harm than good. These themes have persisted in the global warming disinformation literature into the 2000s. The focus here is on the major features of the first theme because of its direct bearing on the content of many physical geography classes, although themes two and three could easily be explored by instructors teaching classes more related to environmental or policy issues.

The idea that the science underpinning global warming is either uncertain or of poor quality is often promoted in the agnogenesis literature via three approaches, individually or together. Significant weaknesses in the public's understanding of the nature and processes of science, in particular the importance of peer review, have been identified by the National Science Foundation (2008), and all three agnogenesis approaches exploit these weaknesses.

The first approach is to assert the absence of scientific consensus (despite the overwhelming evidence to the contrary cited earlier) by referring to the stated opinions of a relatively small number of scientists who disagree that global warming is real, or agree that global warming is occurring but disagree that it is anthropogenic. Sometimes these are scientists who have a substantial track record of research in climatology or meteorology (for example Richard Lindzen, the Alfred P. Sloan Professor of Meteorology at the Massachusetts Institute of Technology), but often they are scientists working in impressive-sounding but unrelated fields such as astrophysics (for example Sallie Baliunas, a Harvard astrophysicist). Regardless of the background of the individual being referenced, the approach is to present interviews or public statements as being on an equal footing with peer-reviewed research. This becomes problematic when the statements being made are simply personal opinions of scientists, unsupported by findings published in the peer-reviewed literature. Newspaper opinion articles (also known as op-eds) can be especially prone to misrepresenting the scientific consensus in this way, precisely because they present the writer's point of view on an issue rather than the purely fact-based, supposedly objective journalism of straight news articles; examples can be found in syndicated op-eds by Murdock (2008) and Ambrose (2009).

This approach is effective because, as noted earlier, significant weaknesses exist in the American public's understanding of the nature and processes of science. Thus, equal weight is easily given to opinion versus the overall body of peer-reviewed literature, and the impression of disagreement among scientists is fostered. This tendency fits well with findings from public opinion research and psychology, that "experts" are highly effective in moving public opinion (Page, Shapiro, and Dempsey 1987) because of the theorized existence of two routes in information gathering: central and peripheral (Petty and Cacioppo 1986). In areas where people lack expertise, the peripheral route dominates and we tend simply to "trust the experts." (See Manjoo [2008] for a highly readable discussion of the consequences of human psychology for our tendency to accept or reject information according to preconceptions.) When the experts are arguing, even though one side is doing so outside the conventional channels of the scientific process, public opinion, unsurprisingly, perceives disagreement.

A second tactic inverts the first by citing scientists in the 1970s who warned of imminent global cooling. Here, instead of claiming disagreement in the scientific community where it does not really exist, the claim is of a past scientific consensus that did not really exist, the implication being that the scientific community was wrong about global cooling then, so it may just as easily be wrong about global warming now. Again, however, many of the references to global cooling are derived from the popular, rather than peer-reviewed, literature, and Peterson, Connolley, and Fleck (2008) have shown that even though a small number of peer-reviewed articles were published on the subject of

imminent global cooling, they were greatly outnumbered by those addressing global warming (seven versus forty-four respectively, over the period 1965 to 1979). Peterson, Connolley, and Fleck's examination of the views of the scientific community as represented by the peer-reviewed literature of the time demonstrates that there was no consensus about the dangers of imminent global cooling, and that such a position, although it did exist in the scientific community, was marginal at best. By emphasizing popular sources and the small number of legitimate scientific articles on global cooling at the expense of the clear weight of scientific opinion towards warming, the agnogenesis campaign again exploits the public's general lack of understanding of the scientific process in general, and peer review in particular. Fine examples of this approach can be found in Beck (2007), Will (2009), and the sources referenced by Peterson, Connolley, and Fleck (2008).

A third approach exploits the concept that certain aspects of a multi-faceted problem become less contentious with further research, while new difficulties arise and need to be addressed. It is therefore possible, indeed common, to achieve a scientific consensus on some aspects of a problem, but not others. Thus, for example, there are certainly areas of global warming research that are legitimately contested in the peer-reviewed literature, such as the extent to which hurricanes have already strengthened due to anthropogenic climate change (see, for example, the exchange constituted by Mann and Emanuel 2006; Landsea 2007; Holland 2007; Mann *et al.* 2007). However, the basics of global warming—that greenhouse gases cause warming, and human emissions of those gases are enhancing the greenhouse effect and causing Earth to warm further—are essentially uncontested. By blurring the distinctions between the generally agreed-upon basics and the still-contested areas at the margins, the agnogenesis campaign is once again able to suggest that there is no consensus on global warming.

In addition to these three approaches intended to weaken the public's perception of scientific consensus, global warming agnogenesis literature also contains themes regarding the actual science, although again they are misleading rather than edifying. Two common and related examples are the conflation of weather with climate, and the claim that computer general circulation models (GCMs) are completely useless. Conflating weather with climate often occurs as a writer claims that recent cold weather somewhere in the world, or a recent, relatively short-term, interruption in the global warming trend, shows that global warming is not happening, as exemplified by Murdock (2008) and Crichton (2004). This conflation sometimes occurs to justify the claim that GCMs are useless, because computer models cannot predict the weather one year from now, so how can they be expected to predict the weather 100 years from now? For example, in an influential work of fiction, Crichton (2004), speaking through an authoritative scientist character, states "[N]obody tries to predict weather more than ten days in advance. Whereas computer modelers are predicting what the temperature will be one hundred years

in advance" (275). These claims exploit the public's generally weak understanding of the details of global warming (Nisbet and Myers 2007), but are easily refuted with improved knowledge. Earth's climate is subject to multiple forcings at different timescales, of which anthropogenic greenhouse gases are an important (and increasingly dominant) example, but not the only example, so interannual variability around a longer-term trend is expected. Not every year in the global climate record will be warmer than the previous year. Further, although GCMs have their weaknesses, they are certainly not completely useless, and statements to the contrary are at odds with existing published research (Reichler and Kim 2008). Finally, GCMs are intended to investigate the sensitivity of climate—not weather—to a range of forcings, including increased greenhouse gas concentrations. Thus, statements conflating weather forecasting with climate sensitivity research are misleading.

Although the agnogenesis literature on global warming seems to have been successful at increasing public confusion (McCright and Dunlap 2000; Nisbet and Myers 2007), it also provides teaching and learning opportunities. The examples presented above show how agnogenesis literature lends itself to studying the processes of science, such as peer review, as well as the details of climate science itself, including such basic points as the difference between weather and climate. In the following section, examples are provided of ways to exploit these teaching and learning opportunities, as utilized in an upper-division collegiate weather and climate course.

AGNOTOLOGY STRATEGIES

The goal of incorporating agnotology as a teaching tool in the classroom is to study how and why there is ignorance about well-established facts about global warming, such as why public opinion sees disagreement among scientists when little or none exists. This can be approached through the explicit study of influential works of agnogenesis, including op-ed articles by syndicated columnists, and the best-selling novel *State of Fear*, by Michael Crichton (2004), which includes many of the more commonly encountered arguments from the wider agnogenesis literature. Numerous additional specific works of agnogenesis exist and could be used in the classroom, including the Hollywood film *The Day After Tomorrow*, which presented a highly misleading depiction of the possible consequences of escalating greenhouse gas concentrations.

Numerous resources are available for the incorporation of agnotology into the geography classroom. Especially valuable for global warming agnotology is the Web site RealClimate (<http://www.realclimate.org>), which provides commentary and discussion of science issues and debunking of agnogenesis by highly qualified, working climate scientists. Britain's Royal Society (2008) has developed a guide to misleading arguments about global warming, available online. The documentary film *Everything's Cool* explores the agnogenesis campaign in detail (Jacques,

Dunlap, and Freeman (2008) provide a peer-reviewed examination of the political roots of this campaign). The potential for studying deliberately misleading information about important scientific issues is therefore considerable.

Specific learning outcomes addressed by using agnotology are as follows:

- *Understanding the true nature of the scientific consensus on global warming.* Assessing the veracity of agnogenesis claims about the scientific consensus requires looking at the documented evidence, and determining the value of the evidence presented (such as interviews or speeches compared with peer-reviewed research).
- *Understanding the processes of scientific inquiry*, including peer review and how it differs from opinion, and the scientific method. This learning outcome incorporates the idea that not all skeptical claims about global warming are connected to agnogenesis, but may be part of legitimate disagreement or uncertainty within the scientific community. Such debates within the scientific community are good illustrations of the scientific method, showing the repeated testing of hypotheses, as distinct from the popular media.
- *Strengthened critical thinking skills*, improved by repeated attempts to distinguish accurate portrayals of the state of global warming research from misrepresentations.
- *Strengthened understanding of the basic science of weather and climate*, which again results from repeated attempts to identify accurate versus inaccurate portrayals of scientific concepts. A classic example here is the tendency in much agnogenesis literature to conflate weather with climate. This learning outcome includes recognizing the areas in climate science where there is genuine uncertainty, such as the limits of GCMs.

These learning outcomes overlap, but all of them can be addressed by explicit study of misleading or inaccurate information about global warming.

To accomplish these learning outcomes in class, agnogenesis literature is scrutinized in a homework assignment, through in-class discussion, and a final exam question, the latter also serving to help assess the effectiveness of the approach. The final exam makes use of a short, syndicated op-ed article published recently in the local newspaper, but the main piece of agnogenesis literature considered is Michael Crichton's (2004) *State of Fear*. This book is examined towards the end of the semester, after students have been exposed to material on climate science and the peer-review process.

Crichton's book portrays global warming as the invention of a small group of eco-terrorists, who attempt to deceive the world into believing the problem is real by engineering a series of disasters that can be blamed on global warming by a gullible, overexcited news media. The book's heroes travel the world, attempting to thwart the eco-terrorists' efforts, and debunking numerous 'myths'

about global warming in the process. Crichton's style in this book follows his well-established pattern of weaving real issues or real science into his entertaining plot lines, as with paleontology in *Jurassic Park* (1991), or Japanese business culture in *Rising Sun* (1992). *State of Fear* includes an impressive references section containing real peer-reviewed science as well as more controversial work such as Bjorn Lomborg's *The Skeptical Environmentalist* (Lomborg 2001). *State of Fear* was a best seller, and is superficially persuasive, especially in the absence of more detailed knowledge. Under more careful and better-informed examination, however, the book's numerous objections to and criticisms of global warming research collapse.

To examine Crichton's claims, and by extension the similar claims made by other commentators in the news and popular media, students are asked to summarize and critique several arguments and themes, both in preparation for an in-class discussion and in a written assignment. A general argument in the book is that the scientific consensus on global warming is a media fabrication, and that serious, hard-headed scientists (personified by the character of Kenner, an MIT scientist and government secret agent) remain unpersuaded. Other themes include the failings of GCMs, the alleged weakness of evidence for a cause-and-effect relationship between carbon dioxide and global mean temperatures, and the ineffectiveness of the Kyoto Protocol. Students are asked to summarize Crichton's arguments in these areas, explain whether they agree or disagree, and provide evidence for their position. They are also asked to compare Crichton's arguments with those of Oreskes' (2004) essay summarizing the scientific consensus in the peer-reviewed literature. In doing so, students are required to reflect on material covered throughout the semester, strengthening their understanding of the relevant physical processes as well as practicing their critical thinking skills. When applied in this way, the agnotology approach is an active learning strategy, in which students engage with class material rather than passively absorbing it. Active learning tends to promote higher-order thinking and more effective learning (Hooey and Bailey 2005).

The skills and knowledge gained through this agnotological approach are tested using a question on the final exam. Here, students are presented with a recent piece of agnogenesis (a syndicated op-ed by DeRoy Murdock (2008)) and, as with their analysis of Crichton's arguments, asked if they agree or disagree and why. The article conflates weather with climate in arguing that recent cold weather in the southern hemisphere means that global warming is a fiction, and uses nonpeer-reviewed sources such as interviews to claim that there is no scientific consensus on global warming. Almost all students were able to correctly identify the flaws in the arguments, pointing out that the climate system is subject to multiple forcings over different timescales, thus leading to interannual variability that does not in itself contradict the existence of a longer-term warming trend. Many were also able to critique the sources used as not being comparable to the peer-reviewed

literature. The students' strong performance on this final exam question suggests that the agnotological approach to teaching global warming has some merit. Not enough students have been tested to allow statistical evaluation but, qualitatively, the approach seems effective and popular based on informal conversations and course evaluations. Several students have expressed considerable satisfaction in learning how to identify and counter misinformation of the sort presented in *State of Fear* and replicated in numerous venues in the popular media.

CONCLUSIONS

Agnotology can be a useful item in the educator's toolkit regarding politically controversial, albeit scientifically well-established, topics. This applies to many subject areas that geographic educators may be called upon to address, such as evolution by natural selection or the geographical origins of *Homo sapiens*, but is perhaps most directly applicable for geographers in teaching the science of global warming. By confronting and explicitly studying agnogenesis in this field, students can sharpen their critical thinking skills, solidify their knowledge and understanding of the scientific details, and improve their appreciation for the differences between peer-reviewed work and newspaper columns. Anecdotally, students have expressed satisfaction in being able to discuss these issues more substantively outside the classroom, with friends and family members.

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