Integrating a Science and Public Policy Module into an Undergraduate Science Course

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Introduction

As issues of environmental science play a growing role in public policy and public discourse, it becomes increasingly essential for scientists to be able to effectively communicate their work to policy makers and the general public. While scientific communication is generally considered an important skill for scientists and communication classes are working their way into undergraduate science curriculums, there has been less emphasis on introducing public policy to science students. Effective communication as a scientist to policy makers relies on more than just oral and written presentation skills, it also requires an understanding of the complex structures under which scientific policies are made and the language which policy makers use.

Through support of the NSERC CREATE training program for Integrating Atmospheric Chemistry and Physics from Earth to Space (IACPES) and Professor Jessica D'eon, I will introduce a public policy module into an existing undergraduate science course at the University of Toronto (ENV233 – Earth System Chemistry, instructor: J. D'eon) in the winter semester (January – May) of 2017.

Through integrating a Science and Public Policy (SPP) module into ENV233, students will be provided with instruction and case-study based exercises designed to improve their understanding of science policy. The contents of the SPP module will be described in the next section. The SPP module will include question and answer panel session with environmental scientists who work in public policy and an overall report summarizing what they have learned from the module. Students will also fill out two (non-graded) surveys, before and after the module, to monitor how their understanding of the role of scientists in public policy has improved.

The choice of integrating a SPP module into ENV233 was twofold. First, the course objective for ENV233 is to teach how the chemistry of the earth system has changed over geological time including recent perturbations by humans, and the SPP module will introduce a topical aspect of modern change. Second, by incorporating public policy material into a core environmental science course, the students will be able to connect what they are learning about science policy to ENV233 course content, as well as to their other courses, thus providing them with a clear context for their new public policy knowledge.

This module will put the students into the role of science advisors. They will review evidence, assess risk, and practise communicating that evidence to policy makers. Role-playing has been used as an effective teaching method in undergraduate science classrooms in the past, and seems particularly well suited for the environmental sciences, where policy and research frequently collide (Kimbrough et al., *Journal of Chemical Education*, 1995; Stokes and Selin, *Journal of Environmental Studies and Sciences*, 2015).

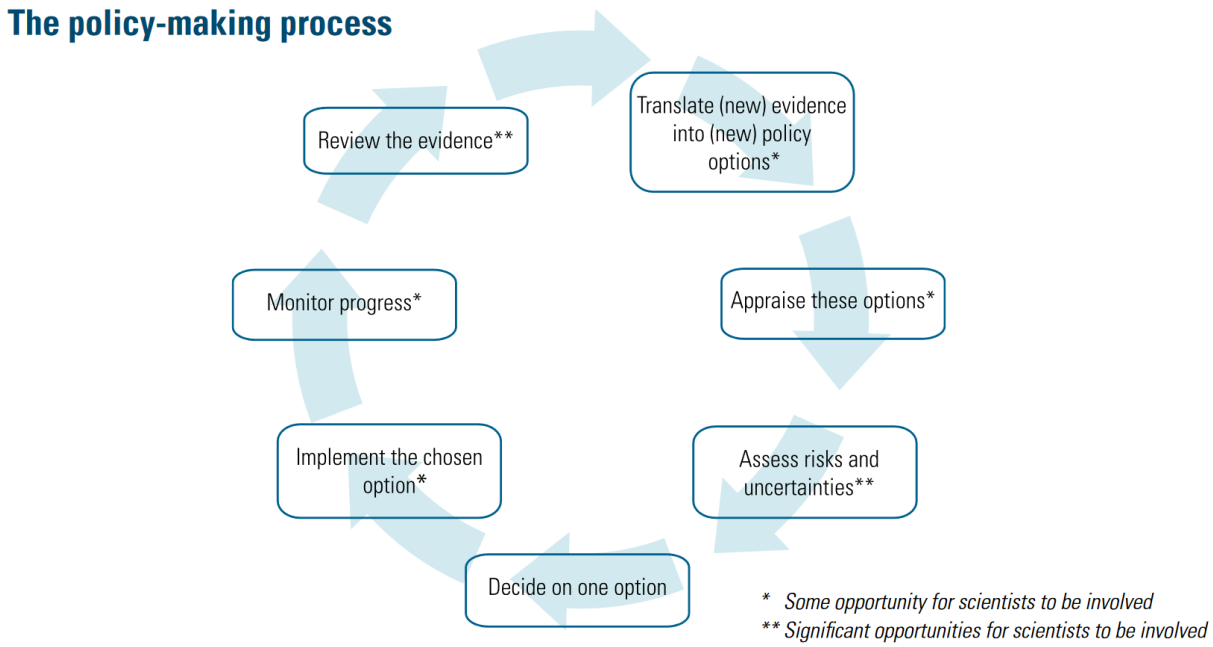

Fig 1. The science-policy interaction framework (from: Science into Policy: Taking Part in the Process, *Natural Environment Research Council, 2013*)

Students will be introduced to the policy-making process in tutorial and through the panel discussion with policy experts, and will then produce a document to inform policymakers, practising the style and language used in documents from science advisors to decision makers. We will focus on the two areas of the NERC science-policy interaction wheel (Fig 1.) where scientists have the greatest role: reviewing evidence and assessing risks and uncertainties.

Science and Public Policy Module

The public relies on governments to make decisions on environmental policies to ensure the health of citizens and the environment, even in the face of scientific uncertainties. Scientists who wish to contribute to public policy must understand not only how to effectively communicate those uncertainties but also how to reconcile policy implications with the diverse public interests relevant to the policy in question. Regulatory decisions must be based on both the perceived risk of inaction and the cost of regulation, two concepts that we will introduce students to through a series of assignments based around the Montreal Protocol.

The Montreal Protocol was signed into law in 1987 and was the first universally ratified treaty in the history of the United Nations. It is also a clear example of policy makers following the *Precautionary Principle*. Policy makers are generally unable to examine all evidence related to a given policy decision. In some cases, policy makers choose to follow the Precautionary Principle, which states that precautionary measures are justifiable when “not taking action raises the risk of harm to human health or the environment, even when the scientific evidence is not sufficiently strong to establish the certainty of a cause and effect relationship” (Barrieu and Sinclair-Desgagne, *Management Science*, 2006).

The World Meteorological Organisation Global Ozone Research and Monitoring Project was established by the Montreal Protocol to preserve the stratospheric ozone layer by regulating the production and use of compounds that may lead to ozone depletion. In the 1970s, scientists found evidence which pointed to halogenated hydrocarbons as important culprits for the degradation of stratospheric ozone. Since the ozone layer absorbs high energy ultraviolet radiation, its depletion posed a major risk to the public and the environment at large. While major scientific uncertainty existed in the relationship between halogenated hydrocarbons and ozone depletion at the time of the initial ratification of the Montreal Protocol, the treaty post ratification has proven itself to be a great success. Not only has stratospheric ozone rebounded as expected, but the Montreal Protocol has also proven to be an effective policy in regulating the emissions of potent greenhouse gases. It serves as an ideal case study to introduce students to the role of risk and uncertainty in science policy.

Assignment 1: Review The Evidence

The first assignment that students will complete will involve investigating a series of refrigerant compounds (including legacy CFCs, HCFCs, and modern halon alternatives) for their potential to deplete stratospheric ozone and their radiative forcing potential over 100 years. To do this, students will preform a series of simple box model calculations in excel (or another program of their choice) after instruction in tutorial. Students will be able to identify why the compounds already listed under the Montreal Protocol have been phased out and why some modern refrigerants are likely to be added to the list soon. The chosen compounds will be ranked by their potential for environmental harm.

Assignment 2: Assess The Risks and Uncertainties

The second assignment will focus on risk assessment and characterization of uncertainties. For the compounds from assignment 1 that have not yet been phased out, students are to return to their box model and preform a series of future emission scenario tests – where emissions are double, held constant, and cut in half over a period of 50 years. Students will be tasked with reading Roger's "The Precautionary Principle as a Provisional Instrument in Environmental Policy: The Montreal Protocol Case Study" (ES&P, 2014). Risk and uncertainties identified in the zero-dimensional simple box modelling preformed should be clearly discussed with reference to outside literature. Students should identify a few other studies that highlight additional risk and, importantly, additional uncertainties with more complex modelling approaches.

Science-Policy Panel

Tentatively scheduled for either of the last two weeks of March, students will have the opportunity to meet science advisors and policy makers in a panel discussion in which experts will briefly introduce themselves and explain their role in science policy. Students can then ask questions. The panel guest list is still to be determined as speaker availability is subject to date. This is expected to be resolved in early January, 2017.

Assignment 3: Assessment for Decision Makers

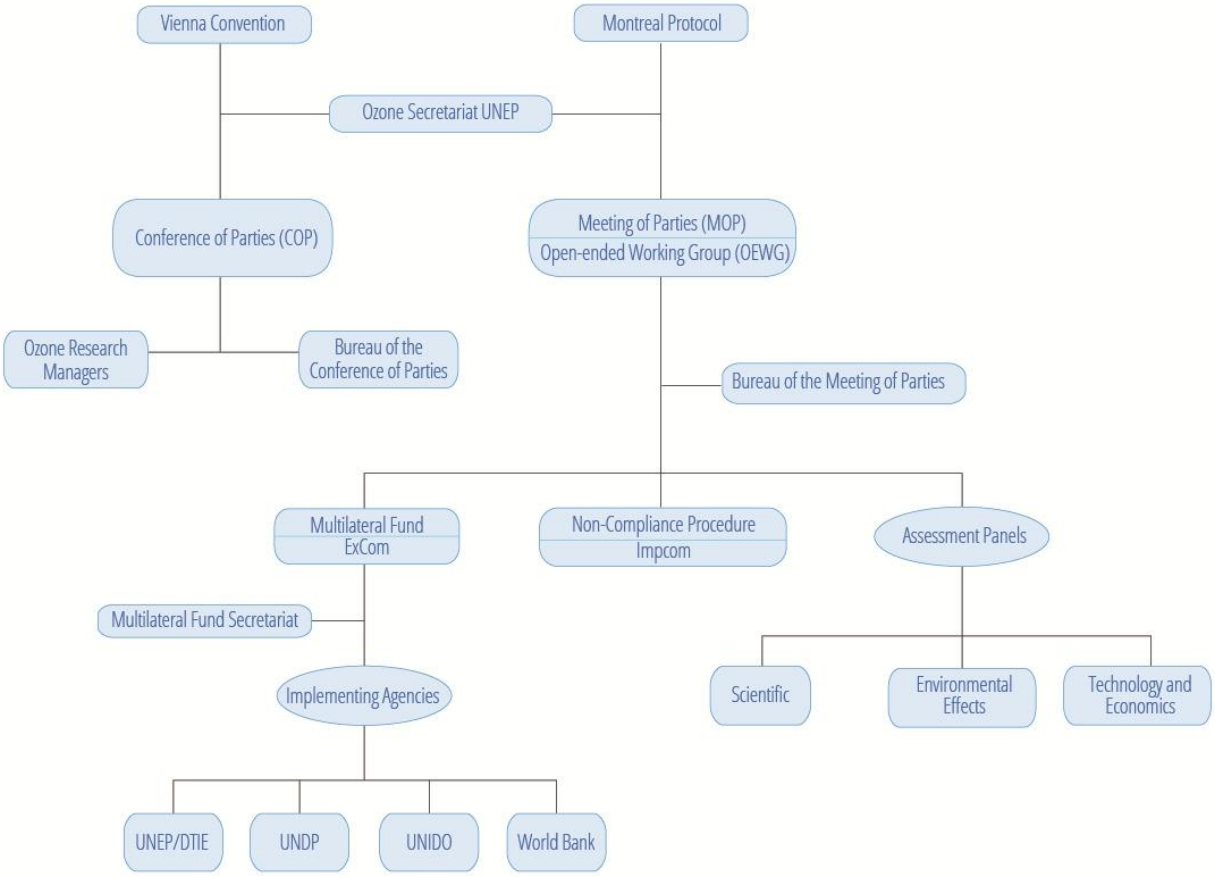

Fig 2. Institutions of the UNEP Ozone Secretariat (Ozone Secretariat, 2016)

The final assignment will be the most substantial, as it will be a synthesis of what students have learned framed as an executive summary for policy makers, as produced by the Scientific Assessment Panel (Fig. 2). This will give the students the opportunity to practice accessible science communication, while familiarizing themselves with the structure and language of scientific assessments for policy makers by taking on the role of science advisor.

An example template to follow is below:

EXECUTIVE SUMMARY

WMO/UNEP

"Scientific Assessment of Ozone Depletion: ENV233"

PREPARED BY THE
SCIENTIFIC ASSESSMENT PANEL

OF THE
MONTREAL PROTOCOL ON SUBSTANCES
THAT DEPLETE THE OZONE LAYER

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Contents

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In order to effectively produce their assessment for policy makers, students will have to read the assessments currently produced annually by the actual scientific assessment panel. Students will need to present their modelling results with clear graphs and tables, with clarity of information being emphasized. The options for policy formation will give students the opportunity of proposing options of their own choosing. What they propose will need to be supported with evidence from potentially their own box modelling work and literature review.

Required Student Reading List

J. Roger Jacobs, The Precautionary Principle as a Provisional Instrument in Environmental Policy: The Montreal Protocol Case Study, *Environmental Science & Policy*, 37 (2014) 161-174

Paul Cairney et al., To Bridge the Divide between Evidence and Policy: Reduce Ambiguity as Much as Uncertainty, *Public Administration Review*, 74 (2016) 399-402.

Chapters 12 and 17 from Komp, Kasting, and Crane, *The Earth System*, Third Edition, (Pearson, 2010).

Suggested Reading for Interested Students

J.R. Primack and Frank von Hippel, *Advice and Dissent: Scientists in the Political Arena*, Basic Books, 1974.

Sharon Roan, *Ozone Crisis: The 15-Year Evolution of a Sudden Global Emergency*, Wiley, 1990.

Roger A. Pielke, Jr., *The Honest Broker: Making Sense of Science in Policy and Politics*, Cambridge University Press, 2007.

Alice Dreger, *Galileo's Middle Finger: Heretics, Activists, and the Search for Justice in Science*, Penguin Press, 2015.

Surveys

The SPP module will be introduced in a course with an estimated enrollment of 50 students, where we hope to gain valuable information about the effectiveness of this module through the use of surveys. Anonymous, optional, surveys will be set to students at the start of the class and the end of the class, with approval from the University of Toronto's Research Ethics Board. In both surveys, students will be asked a series of non-identifying questions about what they think the role of scientists in policy are and what opportunities exist for them to inform policy. Answers from both surveys will identify what students have taken away from the SPP so it can be improved in the future.

Outcomes

2017 will be the first implementation of this activity, but it is anticipated to become a regular element of ENV233. After May 2017, we will have had our first run through and have collected survey data such that Dr. Jessica D'eon and I can prepare a manuscript for the Journal of Chemical Education detailing the SPP module and the learning outcomes.