Can a Philosopher and a Scientist Co-teach a Class on Climate Engineering?

Thomas Ackerman
Department of Atmospheric Sciences, University of Washington

Stephen Gardiner
Department of Philosophy, University of Washington

THE ANSWER to this question is 'yes' because we did it, so perhaps it is more appropriate to ask whether such a class can be taught *successfully*. Climate engineering may be defined as "deliberate, large-scale intervention in the Earth's natural systems to counteract climate change".[1] The most commonly discussed categories are 'carbon dioxide removal', which includes techniques such as direct air capture and removal of CO2 from the effluent of energy generation facilities, and 'solar radiation management', the reduction of solar radiation to cool Earth in order to counteract some level of global warming due to rises in greenhouse gas concentrations. In either case, climate engineering provides an interesting, and perhaps disturbing, case study of the nexus of science (can we do it), ethics (should we do it), and governance (how would we do it). The idea of co-teaching a class on ethics and science focused on climate engineering originated with Steve Gardiner in mid-2013, leading to a class that we co-taught at the University of Washington during Winter Quarter 2015. Our intent here is to summarize our experience and provide some lessons learned.

Our earliest discussions revolved around the level at which we wanted to teach the class. Because we and our graduate students are engaged in climate engineering research and the boundaries of our research overlap in some areas, we decided to start with a research-oriented class. In general, there is a fairly significant gap in the "toolbox" possessed by graduate students in the sciences compared to undergraduates – graduate students have a substantially better grasp of how to conduct research and how to use the necessary tools. There is less of such a gap between upper-level undergraduates and graduate students in the humanities. We decided to allow entrance into the course only with the permission of one of the instructors.

On the science side, only graduate students were allowed entrance, while on the ethics and policy side, both graduate students and seniors with a strong background in relevant areas were considered. The composition of the class was multi-disciplinary with four science students (all in a Ph. D. track), four philosophy students (three grads and one undergrad), and four policy students (2 grads and 2 undergraduates). In addition, the class was joined by two post-docs, one working in climate science and one in climate ethics. Our course goals were two-fold. We wanted to explore the emerging subject of climate engineering in an inter-disciplinary environment and to create a research community within the UW to address issues at the interface of climate science, ethics, and policy. Our initial focus was to be on climate engineering, but we said we were potentially open to extending the research community to address related issues.

Our intent was to structure the class as a reading seminar – more typical of the

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[1] Oxford Geoengineering Program. We choose to call this "climate engineering" to make it clear that we are talking about Earth's climate and to differentiate from engineering of Earth's geological formations.

humanities than the sciences. We met for an hour and 50-minute session each week of a 10-week quarter. We assigned a substantial reading list for each class, roughly split 50/50 between a science/technology issue and an ethics/policy issue. There was always a connection between the two issues but not a simple 1:1 correspondence, primarily because of the breadth of the latter issues. We divided the class in half and each week assigned one half to provide written comments on the readings. This was designed to encourage reading but, more importantly, to engage the students in providing discussion material on issues that required clarification and further probing in class. The class meetings were the core of the learning experience. They almost always stretched another 20-30 minutes beyond the scheduled close because of the lively discussions and enthusiastic participation.

For class projects, we chose to assign both a group project and an individual project. The intent was to force a multi-discipline engagement among the students, but also to allow space for individual creativity and performance. For the group project, we suggested a handful of broad research topics (e. g., stratospheric particle injection or iron fertilization) and then allowed students to express their preference for the top two or three. We then used the preferences to create four groups of 3 students, balanced across the three specialties. Each group was tasked with narrowing their broad topic to a more focused research project that spanned science, ethics and governance. After approval of the topic by the instructors, each group was assigned to create a group presentation, present that to the class, and then write a group paper. The two instructors and the two post-docs each acted as an advisor for one of the groups.

Individually, ethics and policy students were asked to write a paper on a topic of personal interest that might possibly be related to the group project. Science students were asked to write a short research proposal related to some aspect of climate engineering linked to their group project.

The class syllabus was:

- **Week 1**: Introduction to science and ethics issues
- **Week 2**: The case for and against climate engineering
- **Week 3**: Governance principles and legitimacy
- **Week 4**: Policy and Politics (Guest speaker)
- **Week 5**: Stratospheric sulfate Injection
- **Week 6**: Justice and exit strategies (Guest speaker)
- **Week 7**: Marine cloud brightening
- **Week 8**: Ocean fertilization
- **Week 9:** Presentations of group projects by student teams
- **Week 10**: CO2 storage and recapture (Guest speaker)

We were fortunate to have three guest speakers, two from off-campus. The first two were a visiting policy expert and a visiting ethics expert. We somewhat re-arranged our syllabus to accommodate the schedules of the visitors, but this was more than compensated for by having additional expertise brought to our class. The third guest speaker was a UW scientist with a much stronger background in carbon storage and capture than either of the instructors. Given the breadth of the material we were covering, the use of guest speakers provided valuable insights for the class and allowed the students to experience additional viewpoints.

Co-teaching a class always comes with compromises due, in large part, to individual teaching styles and expectations, but co-teaching across disciplines presents much greater challenges because of the need to accommodate expectations about curriculum content and disciplinary pedagogy. We were fortunate that we started with a personal and intellectual relationship built on several years of interaction about climate change, climate engineering, and climate ethics. During this period, we had come to appreciate and respect each other's perspective and disciplinary knowledge.

Even with that prior relationship, however, we found that there were issues arising with co-teaching; here we summarize three of those.

One of the first and most challenging issues is learning to speak each other's language. All academic disciplines, we think it fair to say, develop short-hand language. To a climate scientist, the phrase "El Nino Southern Oscillation" brings a host of thoughts about large-scale climate and connectivity of ocean and atmosphere. Similarly, to an ethicist, the phrase "moral hazard" invokes a web of knowledge about choices in which a more ethical choice is obscured by a less ethical but easier choice. One of our constant struggles was to make sure that our statements were clear to the "other" side and not obscured by our academic short-hand. It is interesting to note in this context that scientists and ethicists use different conversation tools, with the policy people somewhere in between.

Scientists are fluent in mathematics and analytics. They naturally gravitate to diagrams and figures with an intuitive ability to grasp graphical information. Ethicists are fluent in logic and conceptual analysis. They recognize logical structures, both good and bad, and intuitively respond with point and counter-point arguments. They are also keen to clarify central concepts, to explore their limits, and to interrogate the value assumptions that often drive them. It was interesting to watch the two groups of students engage with each over the quarter and try to master the basics of each other's skill sets. There is no easy solution to this problem, but continuous vigilance and questions of clarity certainly can help.

Given this language problem, a second issue was finding the right balance between breadth and depth in the course. Despite climate engineering being a relatively new topic, there is a broad spectrum of topics and literature.

We were forced to limit the topics that we could address but, equally importantly, we struggled to limit the depth of the dive. This is probably more difficult from the science side because of scientists' love of technical detail, but the ethicists and policy people also struggled with limiting scope. One particularly challenging aspect of this problem was finding appropriate readings – we wanted overview articles on various issues that could help bring students up to speed but they simply don't exist. As a result, we were faced with using some part of our discussion time to provide overview lectures for the students.

The third issue was one of perspective and problem solving. Ethicists are adept at using analogies to illustrate moral reasons. They have a tendency to choose hypothetical examples that present the starkest choices, often couched in terms of life and death, in order to isolate the clearest cases. But they also like to be sensitive to the social and political contexts in which decisions are actually likely to be made. By contrast, scientists typically approach complex problems by delimiting the boundaries and/or complexities to arrive at a problem that can actually be solved in some approximate form.

Not surprisingly, these two approaches produce conflict. The scientists often urge the ethicists to look at issues more narrowly to constrain the implications, whereas ethicists often find themselves urging the scientists to think more broadly about underlying issues and the social context in which they arise. The policy people, typically focused on how to manage issues in a concrete setting, tend to find themselves with differing instincts based on the topic under discussion.

It is perhaps useful to provide a simple example of this dichotomy. During the class, we had extensive discussions about the ethics of climate engineering research (as opposed to actually deployment of climate modifying techniques). In particular, we discussed whether there were ethical questions posed by a research experiment that has no *measurable* impact on the climate system because its impact is not detectable given existing, natural variability within the climate system. To the scientists, this experiment raises few ethical questions because, in their view, the lack of measurable impact is pragmatically the same as no impact. The ethicists, however, are far less sanguine about such experiments because the lack of a measurable impact does not preclude the possibility of impact. The discussion time in class allowed us to explore issues such as this and to clarify our positions, even if we did not always arrive at agreement among the class.

As one might anticipate, there were a lot of lessons learned from our experience with some clear successes and some areas where improvements are needed. On the positive side, our assessment is that we clearly met our goals. We were able to discuss climate engineering in a multi-disciplinary setting and engage all sides of the subject. The group projects were a success. They forced students to accommodate to diverse backgrounds and pool their strengths, learn how to work together, and appreciate each individual's expert knowledge. This is not a common experience in graduate school where the emphasis is typically on individual research or research within a relatively small group of individuals with similar backgrounds (a typical professorial research group). The group reports were excellent and one of them is being turned into a journal paper co-authored by three students and both of us. The group dynamics were definitely enhanced by having an advisor for each group who acted in part as a facilitator for group activities. Our goal as advisors was to help with direction but not to intrude upon the research or generate conclusions

The individual projects were also successful in many instances, but perhaps less evenly so. In any case, they were an important component of the course. They allowed each student to do individual research and writing on an issue that he/she was passionate about. There was more freedom than the group project but, in most cases, the individual project added depth to the group project.

The guest speakers were on balance a significant plus. The students definitely enjoyed interacting with them because they brought a different perspective to the class and had expertise beyond that of the instructors. Given resource limitations and schedules, we were forced to slot the speakers in on their schedule. It would likely have been an improvement to schedule them more directly in the flow of the curriculum.

There were two areas that stood out in terms of requiring improvement. The first is a need for better balance in terms of material covered and relative depth of coverage. Developing a curriculum for an emerging topic is always complicated because the instructors' knowledge of the field is somewhat uneven and new material is being produced while the course is in progress. In addition, we were hampered to some extent by insufficient class discussion time. A partial solution here may be scheduling additional class time each week so that some time can be devoted to tutorial overviews without taking away from the discussions.

In addition, there is a need for improved organization. Although the level of student preparation and engagement was generally very high, improvements in the narrative structure of the course and in providing more advance availability of required reading would have given students a chance to do some tutorial work on their own. Again, this is primarily a function of the "first time through" for the class.

It is pretty clear that education has become much more attuned to "outcomes", although not generally at the graduate level. As veterans of teaching graduate classes, we are aware of the difficulty in assessing outcomes and that is certainly true for this class. One desired outcome was the creation of a multi-disciplinary research community, which has occurred. In Fall Quarter of 2015, a core group continued to meet regularly to comment on works-in-progress from the group and discuss recent publications in the field. Several collaborative projects have also been launched. These include: a paper published by Gardiner and Augustin Fragniere, the climate ethics postdoc[2]; a recently-funded NSF grant on justice, legitimacy and geoengineering, led by Gardiner and Fragniere; a joint research project between Ackerman, Rick Russotto (a graduate student in Atmospheric Sciences), and Ben Kravitz (a research scientist at Pacific Northwest National Laboratory), from which two papers will be submitted shortly.

Another outcome, not entirely expected, was the direction and re-direction of student research. Of the 12 students in the class, one has already completed a master's thesis in the area of climate engineering policy, and two others are pursuing doctoral dissertations, one in the ethics of geoengineering and one in climate impacts. We think it fair to say that all three off these efforts are a direct outcome of the class. In addition, there are several articles in preparation that spun off discussions and group projects in the class.

Perhaps the ultimate evaluative test for an experience like this is, would you do it again? We were highly encouraged by the student evaluations and comments, which were resoundingly positive. We both thoroughly enjoyed the teaching experience and co-teaching with each other. There was a distinct sense of all of us (students, post-docs, and instructors) learning together that is rare in education and extremely rewarding when it occurs. We also need to point out, however, that there are educational and fiscal restraints on being able to do what we, the instructors, did. Each of us is committed to the educational curriculum of our respective departments and required to teach courses within that curriculum. Departments are not always keen, and not always able even if keen, to allow two senior faculty members to co-teach a class with limited enrollment in place of each teaching a distinct course that are more traditional parts of the curriculum. This is one of the conundrums of education: good education, especially innovative education on

[2] Augustin Fragniere and Stephen M. Gardiner. 2016. 'Why Geoengineering is not Plan B'. In Christopher Preston, ed. *Justice and Geoengineering*. Rowman and Littlefield.

cutting-edge topics, does not always match up well with institutional realities.

So, would we do it again? The answer is a resounding yes. Will we do it again? That answer to that question is more complicated. We plan to do so, but at some personal cost to ourselves because of the need to add this class into the existing demands of our academic life, rather than replacing some of those demands.