Science Beyond the Boundaries

**Geoengineering**

**Teacher notes**

**Intended learning outcome**

In this unit, students will appreciate that scientific research takes place in a social, political and cultural context, that the interaction of science with society creates new questions that need to be answered by science and other disciplines and that applications of science prompt us to consider implications such as risks and costs, questions about their use, and make decisions on what is the best or right thing to do at individual and societal level. Science can only take us so far in exploring answers to these questions and making these decisions – it is useful and necessary to consider ideas from other disciplines.

**Commentary**

As the impacts of the climate emergency become more severe and the timeline for action more restricted, more radical solutions - large-scale intervention in Earth's climate - are being proposed. These proposals are known as geoengineering (sometimes called climate engineering or climate intervention). Geoengineering generally takes one of two approaches: the removal of carbon dioxide from the atmosphere (carbon geoengineering), or reflection of solar radiation away from the Earth (solar geoengineering). In a recent Nature communication, researchers noted that “if climate geoengineering techniques were actively pursued on global scales, they would very unlikely be implementable prior to the second half of the century…” (Lawrence et al., 2018). Therefore, decisions about geoengineering research and deployment are set against a background of climate mitigation (minimising greenhouse gas emissions) and adaptation (minimising the effects of climate change).

Research on geoengineering is inherently problematic because it is an umbrella term used to describe a range of technologies from low-risk less-controversial methods to high-risk more controversial methods of intervening in the Earth’s climate, and there is little public understanding about these different methods and how they work. Furthermore, introducing geoengineering as a potential response to climate change is risky, because there exists a risk of influencing attitudes towards climate action.

Geoengineering is an example of a socio-scientific issue (i.e. a complex societal issue with conceptual, procedural, and/or technological associations with science), which requires knowledge and methods from chemistry, geography, physics, philosophy, politics and psychology.

Common approaches to teaching socio-scientific issues found in the research literature include investigation and problem-solving and tasks to promote reasoning and argumentation. Given that the social and ethical implications are central to understanding geoengineering and how public opinion is shaped and how science is communicated, there is a need to understand the social science and ethics of geoengineering, as well as the science.

**Outline of teaching unit**

In this unit, students will use science and philosophy to investigate geoengineering. Students will learn some ways of spotting bad arguments and will develop their own argumentation skills by doing a thought experiment. They will conclude by identifying unanswered questions and discussing the role of different disciplines in answering these questions.

**Bold sections are classroom-based activities,** those not in bold can be completed either in or out of the classroom.

**Phase 1. Engage.**

**Watch the short video introducing the idea of geoengineering and the resource students will use in this unit. Introduce the fallacy spotting activity.**

**Fallacy spotting. A fallacy is an invalid argument caused by faulty reasoning. Being able to spot fallacies in everyday life can students from being fooled into believing something that isn’t true. Being able to spot bad arguments might help them to create better arguments as well.**

**Introduce tasks for phase 2 Explore.**

Phase 2. Explore

Students explore geoengineering as a homework, keeping in mind logical fallacies as they investigate.

Ask students to read three sources (see reference list for suggested reading - to include [the youth guide](https://www.york.ac.uk/media/policyengine/documents/Geoengineering.pdf), videos and newspaper articles).

Students should 1) identify any logical fallacies in these resources and 2) create questions that they think need to be answered or discussed in relation to different approaches to climate engineering.

**Phase 3. Explain**

**Students share the questions they created during the homework task. This could be done on a shared slide deck or using post it notes.**

**The teacher asks students to arrange questions in a question quadrant to a) think about the role of different disciplines in understanding geoengineering and b) to identify a question for whole class discussion.**

**The class discusses a philosophical or political question (i.e. one that does not require empirical evidence and can be answered using reasoning) and then reflects on the discussion.**

**Phase 4. Elaborate.**

**In this phase, students elaborate on their thinking using a philosophical thought experiment to explore the consequences of different geoengineering proposals. The thought experiment is an adaptation of the ‘**[**veil of ignorance’**](https://www.youtube.com/watch?v=A8GDEaJtbq4) **used by John Rawls in his theory of justice.**

* **Introduce the veil of ignorance and give students the opportunity to ask questions for clarification (10 minutes).**
* **In small groups, students should come up with 3 policies for responding to the climate crisis (10 minutes).**
* **Each group shares their policies with the class followed by a brief open discussion, where students question other groups on their policies. (10 minutes)**
* **Students vote on the fairest policies for all. (5 minutes)**
* **Finally, students examine the consequences of their policies by finding out who they are when the veil of ignorance is removed. The class then discusses the impact of the new policies, who benefits and who is harmed, and whether or not the policies are fair.**

**Phase 5. Evaluate.**

**Students reflect on their knowledge about geoengineering and identify what they need to know next.**

**First, they compare their policies with the Oxford Principles for governing geoengineering.**

**Secondly, they discuss what was positive, negative and interesting about the unit, and identify remaining questions.**

***Activities for each of the five phases of learning***

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| --- | --- | --- | --- | --- |
| **Phase** | **Activity** | **Reason for it** | **Activity summary** | **Estimated time** |
| **Engage** | **1 Introduction** | **To introduce key terms and questions associated with geoengineering and build interest in the topic.** | **Students watch video and discuss challenges associated with talking about geoengineering.** | **10 minutes in class** |
| **2 Fallacy spotting** | **To prime students to identify bad reasoning used in the discussion of geoengineering and other environmental issues in media and social media.** | **Students identify logical fallacies in arguments about geoengineering, and explain why these arguments are bad.** | **10 minutes in class** |
| Explore | 3 Researching geoengineering (fallacy hunting and question creation) | To find out more about different methods of geoengineering, the stage research is at, and the social, ethical and political questions that need to be considered. | Students conduct research into geoengineering, reading the youth guide and news articles. | 1-2 hours outside of class  (research) |
| **Explain** | **4 Philosophical dialogue** | **To identify important scientific, philosophical, psychological and political questions about geoengineering, and identify ways in which these questions can be answered.** | **Students create, classify and discuss their own questions about geoengineering proposals and discuss a philosophical question.** | **30-60 minutes in class**  **(discussion)** |
| **Elaborate** | **5 Philosophical thought experiment** | **To use a philosophical thought experiment to consider the ethics of different responses to climate change, including geoengineering.** | **Students create a series of policies of principles for action, and analyse these in terms of fairness using the veil of ignorance thought experiment.** | **1 hour in class** |
| **Evaluate** | **6 Comparing with expert principles** | **To evaluate how students’ policies compare with established principles, and to assess the unit.** | **Students create further questions for discussion and exploration.** | **20 - 30 minutes in class.** |
| **7 How was the unit?** | **To evaluate the strengths and weaknesses of the unit and identify remaining questions.** | **Students do a ‘PMIQ’ quadrant to provide feedback to teacher** | **10 minutes in class** |

**Guidance notes: pedagogical approaches**

This unit involves students participating in philosophical dialogue. Doing philosophy with children in schools can raise attainment (Gorard et al., 2015) and improve pupils’ scientific reasoning skills (Sprod, 1998), and there are indications that philosophical inquiry can also improve non-cognitive outcomes such as social and communication skills, teamwork, resilience and empathy (Siddiqui, Gorard & See, 2017). In the specific context of science, philosophical dialogue has an important role to play in exploring nature of science, science ethics and in scientific reasoning.

One of the key distinctions between science and philosophy education, according to philosopher Matthew Lipman (2003), is the way in which knowledge is presented, with science education often presenting scientific knowledge as settled whereas in philosophy, knowledge is treated as intrinsically problematic, so students are encouraged to look for new problems of interpretation or conceptualisation rather than apply standard methods of problem solving to new problems (Donnelly 2004). This is particularly important when considering new science, where there are higher levels of uncertainty in knowledge.

The three main strategies we focus on are creating philosophical questions, participating in philosophical dialogue and conducting a thought experiment. Philosophical dialogue is by its nature open and informed by the participants, their knowledge and experiences, so the focus for the teacher is in creating the philosophical space and facilitating the dialogue such that arguments are present and critiqued, concepts and positions are clarified and the group gains insight into the issue. Whilst there may be more than one good answer to a philosophical question, it is important to draw students’ attention to the place for argumentation based on evidence.

SAPERE (<https://www.sapere.org.uk/>) and the Philosophy Foundation (<https://www.philosophy-foundation.org/>) offer professional development and curriculum resources for doing philosophical inquiry in educational settings.

**Further reading**

*C2G: Carnegie Climate Governance Initiative*. (2021). Retrieved March 22, 2021, from <https://www.c2g2.net/>.

Heinrich Böll Stiftung. The Green Political Foundation. Geoengineering. <https://www.boell.de/en/tags/geoengineering>

IPCC. (2018). *Global Warming of 1.5 oC: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. IPCC. https://www.ipcc.ch/sr15/

Rayner, S., Heyward, C., Kruger, T. *et al.* The Oxford Principles. *Climatic Change* 121, 499–512 (2013). https://doi.org/10.1007/s10584-012-0675-2

The Committee Office, House of Commons. (2010). *The Regulation of Geoengineering*. House of Commons Science and Technology Committee. https://publications.parliament.uk/pa/cm200910/cmselect/cmsctech/221/221.pdf

The Royal Society. (2009). *Geoengineering the climate: science, governance and uncertainty* (No. 10/09 RS1636). The Royal Society. <https://royalsociety.org/~/media/royal_society_content/policy/publications/2009/8693.pdf>

**AS/A level specification links**

### AQA sciences

***AQA Environmental science***

3.2.1.2 Global climate change: how interconnected natural systems cause environmental change

### AQA geography

3.2.1.2 Global systems

Form and nature of economic, political, social and environmental interdependence in the contemporary world.

Issues associated with interdependence including how:

* unequal flows of people, money, ideas and technology within global systems can sometimes act to promote stability, growth and development but can also cause inequalities, conflicts and injustices for people and places
* unequal power relations enable some states to drive global systems to their own advantage and to directly influence geopolitical events, while others are only able to respond or resist in a more constrained way.

3.2.1.4 Global governance

The emergence and developing role of norms, laws and institutions in regulating and reproducing global systems.

Issues associated with attempts at global governance, including how:

* agencies, including the UN in the post-1945 era, can work to promote growth and stability but may also exacerbate inequalities and injustices
* interactions between the local, regional, national, international and global scales are fundamental to understanding global governance.

3.2.1.5 The 'global commons'

The concept of the ‘global commons’. The rights of all to the benefits of the global commons. Acknowledgement that the rights of all people to sustainable development must also acknowledge the need to protect the global commons.

3.2.1.5.1 Antarctica as a global common

An outline of the contemporary geography, including climate, of Antarctica (including the Southern Ocean as far north as the Antarctic Convergence) to demonstrate its role as a global common and illustrate its vulnerability to global economic pressures and environmental change.

Threats to Antarctica arising from:

* climate change
* tourism and scientific research.

Critical appraisal of the developing governance of Antarctica. International government organisations to include United Nations (UN) agencies such as United Nations Environment Programme (UNEP) and the International Whaling Commission. The Antarctic Treaty (1959), the Protocol on Environmental Protection to the Antarctic Treaty (1991); IWC Whaling Moratorium (1982) – their purpose, scope and systems for inspection and enforcement.

The role of NGOs in monitoring threats and enhancing protection of Antarctica.

Analysis and assessment of the geographical consequences of global governance for citizens and places in Antarctica and elsewhere to specifically consider how global governance underlies and impacts on students’ and other people's lives across the globe.

3.2.1.6 Globalisation critique

The impacts of globalisation to consider the benefits of growth, development, integration, stability against the costs in terms of inequalities, injustice, conflict and environmental impact.