Can a rabbit be a scientist? Stimulating philosophical dialogue in science classes

Lynda Dunlop and Jelle de Schrijver

ABSTRACT Philosophical dialogue requires an approach to teaching and learning in science that is focused on problem posing and provides space for meaning making, finding new ways of thinking and understanding and for linking science with broader human experiences. This article explores the role that philosophical dialogue can play in science lessons and the contribution it can make to breaking down barriers between disciplines (*why* to use philosophical dialogue). It then provides some examples of questions to stimulate philosophical dialogue and suggests some moves that teachers can make to facilitate discussion in whole-class situations (*how* science teachers can use philosophical dialogue). It is argued that facilitated discussion of philosophical questions can help students to build connections between science, philosophy and their own interests and experiences in science, other disciplines, and their lives.

Teaching science for scientific literacy requires that students acquire an understanding of the nature of science and will be able to discuss and make decisions about science. It is therefore important that teachers give students the opportunity to examine philosophical issues associated with science such as these epistemological and ethical issues: questions about how scientists know and about the implications of science for individuals and society. In this article, we explore the role that philosophical dialogue can play in the science classroom and the contribution it can make to breaking down barriers between disciplines (*why* to use philosophical dialogue). Then we provide some examples of stimuli for philosophical dialogue and suggest some moves that teachers can make to facilitate such dialogue in whole-class situations (*how* science teachers can use philosophical dialogue). While philosophical dialogue often takes on an epistemological focus, it is not limited to this: the emphasis is on authentic enquiry in response to a question. We argue that facilitated discussion of philosophical questions can help students build connections between science, philosophy and their own interests and experiences in science, other disciplines and their lives.

What is philosophical dialogue?

Dialogic or 'problem-posing' education can be distinguished from 'banking education', with the former requiring active participation and meaning making by all members of the group, in contrast with teacher-centred approaches that focus on delivering content presented as '*motionless, static, compartmentalised and predictable*' (Freire, 1993: 71). Approaches to dialogic teaching in science have focused on work on knowledge (by both students *and* teachers), a shift from immediate evaluation of students' ideas towards exploration through talk, teacher use of communicative approaches and active participation by students (Mercer, 2007). This differs from the conversation more common in lessons, in which students speak and are asked their opinion on matters raised by the teacher, and which focus on one-off exchanges of information, thoughts or feelings, mainly between individuals and the teacher (Mohr Lone and Burroughs, 2016). Dialogue is distinct: it is concerned with genuine problem solving, meaning making and finding new ways of thinking and understanding; it takes these exchanges of information, thoughts or feelings as a starting point for exploring concepts, ideas and questions and rigorously seeking the truth.

Philosophical dialogue occurs in response to a philosophical question. Although there is no consensus on the characteristics of philosophical questions, they can usefully be described as those that cannot be answered empirically, which require mental activity to answer and which are '*open to informed, rational and honest disagreement*' (Floridi, 2013: 195). Such questions are unlikely to lead to incontestable or absolute answers, but they may have better or worse answers (Mohr Lone and Burroughs, 2016). For example, in the context of chemistry, the potential for medicines to be used to remove the emotional response to traumatic events raises philosophical questions about drug development and discovery, off-label use and regulation, memory, identity, personhood and politics (who decides?), as well as more scientific questions associated with the effectiveness of such treatments and the mechanisms for their action. It is important for students to be able to distinguish scientific questions from philosophical questions and to select appropriate methods to examine issues from different perspectives. Indeed, this type of discussion has a place in science classrooms, but also beyond science in the teaching of other subjects where science can inform students' responses to questions that require approaches from different disciplinary perspectives. Examples of philosophical questions with epistemological bearings on the chemistry context above include:

- How can people be sure that medicines work?
- How can we know whether it is right to use medicines to control emotions?
- If someone takes these medicines, do they know that they will remain the same person?
- What is the difference between knowing that a medicine makes you better and believing that it makes you better?

These questions may take discussion in directions that are not epistemological: they are also concerned with ethics and metaphysics but they serve to illustrate the epistemological dimensions of an issue that can be explored using philosophical dialogue. Philosophy, more broadly, is concerned with the search for truth and meaning and with stimulating young people to think and argue for themselves. It requires good thinking, for example, analysis, examination, reflection and argument (Nussbaum, 2016), as well as defining and distinguishing – qualities that are important to the practice of science as well. Philosophical dialogue rejects compliance with tradition or authority and recognises others as responsible agents and as people with equal rights (Nussbaum, 2016). It therefore presents teachers with an opportunity to let the voices of their students be heard, and through this for students and the teacher to listen to each other, learn from and respond to the ideas of others, and to experience new insights, including those of an epistemological nature. There are a range of ways in which young people might make progress through philosophical dialogue. These might include greater clarity about a concept, awareness of connections to other concepts, awareness of different perspectives or assumptions, tentatively accepting some answers, ruling out others lacking in support, or changing minds when presented with compelling evidence or reasons. Philosophical dialogue rarely concludes with a resolution or solution, and this uncertainty and open-endedness can present a challenge to teachers unfamiliar with facilitating such dialogue.

The teacher's role as facilitator of philosophical dialogue is central: teachers are needed to select appropriate stimuli and to encourage students to think better, for example by asking them to give reasons, make connections and evaluate claims, and to ensure that the discussion is not conversational. Central to this is the teacher's awareness of, and sensitivity towards, abstract, general questions that permeate human existence, and authentic engagement with young people, taking their ideas seriously. In the next section, we outline the arguments for including philosophical dialogue in science. We then provide examples of ways in which philosophical dialogue has been incorporated into science lessons before suggesting some strategies that teachers can use to facilitate philosophical dialogue.

Why use philosophical dialogue in science lessons?

Introducing philosophical dialogue into science lessons requires a consideration of the aims of science education. Although there are many possible aims for science education, including individual benefit, democracy, social justice or socio-political action and criticality (Reiss, 2007), the supply of future scientists and improvement of scientific literacy have dominated curriculum design. Philosophical dialogue must support these aims if it is to be used in classrooms. There are three main ways in which it can do so:

- It can engage young people in science (and specifically in making links between science, philosophy and their own lives and experiences).
- It can help young people think and reason better.
- It can improve the performance of young people in core subjects.

In terms of engagement, the majority of the around 250 students aged 11–14 who participated in a series of six to eight 1-hour-long lessons involving philosophical dialogue reported that they enjoyed the approach, found it interesting and useful to help them learn in a different way, and talked about the topics after class with friends or parents (Dunlop *et al*., 2011). They reported learning new and different things, particularly in relation to how science works, and commented that these classes were more active than their usual science classes.

In terms of reasoning, philosophical dialogue requires that students analyse concepts, examine assumptions, evaluate positions and offer new perceptions and insights. Sprod (1998) found improvements in the scientific reasoning of an experimental group compared with a control group following a year-long experience of philosophical dialogue. Similarly, Bartley (2004) found that, by doing philosophy, students better understood how genetically modified (GM) crops were produced and could discuss the benefits and concerns with others.

Although we are not aware of research on the impact of philosophical dialogue on secondary science attainment, recent research (Gorard, Siddiqui and See, 2015) has found that primary-aged children who did philosophy over an extended period performed better on standardised tests in English and mathematics. A parallel study found non-cognitive gains for students in areas such as relationships, confidence, wellbeing and self-esteem, voice and engagement with different opinions, and, for teachers, attitudes towards pupils' learning (Siddiqui, Gorard and See, 2017).

Aside from these instrumental arguments for including philosophical dialogue in science, there are more democratic and humanising arguments. Philosophical dialogue puts fundamental questions of human life at the centre of young people's learning of science. It gives them voice to ask questions and to explore issues of concern to them and it creates a climate where asking questions and giving these serious consideration as a community is valued.

In the following section, we provide examples of philosophical questions across a range of scientific topics covering different branches of philosophy. These serve to illustrate the starting point for philosophical dialogue in science. Many of these have their origins in the Philozoo project based at Odisee University College, Belgium, in which science classrooms are converted into philosophical laboratories to explore philosophical question in relation to science (De Schrijver *et al*., 2016), and the Forward Thinking project in Northern Ireland, where students explored philosophical questions in relation to advances in contemporary science (Dunlop *et al*., 2011).

What might philosophical dialogue in science look like?

In discussing the intersection between disciplines, Mohr Lone and Burroughs (2016) identify hybrid questions, with no clear distinction between philosophy and science, such as: *What is the mind?* and *What does it mean to be alive?* These questions often require reference to empirical facts in order to have a meaningful philosophical discussion, but also require approaches that place young people's interpretations and judgements at the centre of what happens in the classroom. Philosophical dialogue does not necessarily require teaching of philosophy (although it may include this), but rather *doing* philosophy. This demands 'epistemological modesty' (acknowledging that anyone can be mistaken) on the part of the teacher and the students (Mohr Lone and Burroughs, 2016), as well as willingness to experience and embrace uncertainty and creativity.

Philosophical questions can be created by students or by the teacher, usually in response to a stimulus. In Box 1, we present examples of philosophical questions, themes that are likely to emerge in such a dialogue, and aspects of philosophy of science or science concepts that are likely to arise. It is important to note, however, that in a philosophical dialogue, the imperative is to go where the question leads. Each dialogue on a given topic or question will be unique and, as such, the facilitator needs to be comfortable in dealing with the unknown and with making connections across disciplinary boundaries. In the section that follows, we describe how the teacher might facilitate dialogue that begins with one of these questions.

BOX 1 Philosophical questions and where they potentially lead

Is an apple alive? '*Of course an apple is alive, it still changes colour*' one student may reply. '*But change is not enough to be alive; a dead body may change colour as well and it is not alive*', another may respond. The question about the apple elicits a search for the criteria of being alive. It is interesting to ask students to do an experiment on the apple that may help them to answer this question. Some students may cut the apple and see whether there is juice, or focus on how fast the flesh changes colour. Though the dialogue can inspire these hands-on inquiries, because of the philosophical nature of the question, it will never be definitely answered.	**Can a CO_2 molecule be bad?** Any discussion about sustainability and greenhouse gases sooner or later tackles the role of key molecules such as CO_2 or NO_X. In itself, a molecule seems neither good nor bad; it just is. Nevertheless, greenhouse gases can have a big influence on rising temperature or sea levels, thereby influencing and possibly jeopardising (human) life on Earth. To disentangle these issues and help students distinguish normative claims (this is good or bad) from descriptive ones, a discussion about the question '*Can a molecule be bad?*' elicits interesting dialogues.
Is it wrong to kill all mosquitos? Although many students at first may agree with this question, the dialogue allows them to discuss themes such as the importance of biodiversity, food chains and ecology. Thus, students are prompted to delve deeper into the meaning of the biological concepts they already know to provide a normative answer to this difficult philosophical question.	**Can a rabbit be a scientist?** Bizarre questions can provoke interesting dialogues. Although many students agree at first that rabbits cannot be scientists, exploring why this would be so makes students develop a whole range of criteria about science. These criteria can be discussed to help students gain understanding about the nature of science.
When does a person's life begin? In response to a couple's dilemma about what to do with embryos remaining following successful in vitro fertilisation (IVF), this question provokes discussion about when a human life begins, and the difference between being alive and being a person. This dialogue can help students think about the different stages in prenatal development, what constitutes a person and the implications of responses to these questions on embryonic stem cell research.	**Should you make yourself better than your original self?** This question arises in response to a stimulus about performance-enhancing drugs, treatments or prosthetics in athletics. Students are made to investigate a grey area and to make sense of why some enhancements (e.g. use of caffeine to remain alert) are permissible and others are not. It requires students to articulate the difference between therapy and enhancement and to justify their views to others.
Can you hear silence? '*Of course you can't*' a student may answer to this question. '*Why not?*' a facilitator may respond. '*Because silence is the absence of sound*' the student replies. '*But what is a sound?*' a facilitator may respond, plunging the students into a conceptual discussion about silence, sound, hearing and waves. This dialogue enables the group to focus on fundamental concepts in physics and biology, allowing students to think of and do experiments to help them to explore the topics involved.	**Are 'lab chops' suitable for vegetarians?** Developments in stem cell technology have made synthetic meat a reality. Rather than farming animals for slaughter, this involves culturing meat in a laboratory. Although the immediate response from students might be '*No, it contains cells from an animal so is still meat*', stem cells can be harvested from an animal's body and grown in a lab without the need to slaughter an animal, particularly if algae-based growth media are successful. A dialogue on whether these artificial meats are suitable for vegetarians requires students to create definitions, examine different arguments for vegetarianism (including animal cruelty and environmental arguments), and assess whether lab chops can be considered 'vegetarian' like milk or eggs.

How can we facilitate philosophical dialogue in school science?

One of the challenges associated with philosophical dialogue is in the facilitation of the dialogue. Few teachers in the UK have experience of philosophy, either at school or university level. Likewise, science teachers often find it difficult to discuss values and to deal with uncertainty (Ratcliffe, 2007). In philosophical dialogue, as outlined by Lipman (2003), who developed an extensive Philosophy for Children programme, the role of the teacher is to create a community of inquiry in which they facilitate rigorous discussion in response to a philosophical question. Different approaches to facilitating this are offered by SAPERE (the Society for the Advancement of Philosophical Enquiry and Reflection in Education) and the Philosophy Foundation. Although time consuming, philosophical dialogue provides an opportunity for active listening, real-time evaluation and feedback for students and teachers. It develops the peer culture in the classroom, often makes prior learning explicit and gives students some ownership over what is learnt and how.

We offer a focus on three aspects of facilitation:

- generating and selecting the question for discussion;
- encouraging argumentation;
- managing turn-taking between students.

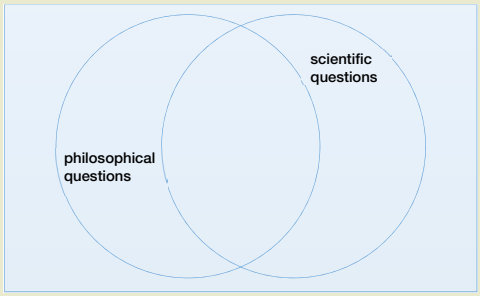
Generating and selecting questions

As the focus for philosophical dialogue, the question has a special status. It is the link between the students' lives and interests, the science topic the teacher wants them to learn about, and philosophical concepts, that is, those that are 'central, common and contestable' (Fisher, 2008). These questions can be created by the teacher or by the students, often in response to a stimulus that can take different forms, including a demonstration, puzzle or a text. In response to this stimulus, students are asked to identify key scientific and philosophical concepts and then to create a philosophical question for the class to discuss. This is discussed in more detail by McCall (2009). It is useful when starting out with philosophical dialogue to do some exercises to help students distinguish between scientific and philosophical questions and to identify key characteristics of each. An example of such an activity is provided in Box 2.

BOX 2 Question qualities

Give students the following questions and ask them to read (but not answer) the questions, and then to (a) place the numbers on the Venn diagram below to identify whether they think they are scientific questions, philosophical questions, both scientific and philosophical, or neither scientific nor philosophical, and (b) give reasons for their decisions.

1 What is a molecule?
2 Can we know what is inside an atom?
3 What is the relationship between current and resistance?
4 What is a species?
5 Is it right to allow human cloning?
6 Is there life on other planets?
7 Is a virus alive?
8 What is Newton's third law?
9 How does the eye work?
10 Why do helium balloons float?



This activity is best used before using philosophical dialogue in order to help students explore the difference between philosophical and scientific questions and to identify the types of questions that lend themselves to exploration through dialogue. In doing this activity, students also have to create criteria to distinguish between different types of questions and think about how scientists know and make claims about the world. The key outcome of an activity like this is for students to become familiar with nuance and with grey areas (many cannot easily be characterised as one or the other), and for them to value reasoning rather than 'the correct answer' (where there often is not a single correct answer, although there may be better and worse answers).

Following the creation of questions by each individual student, a single question or an agenda of questions (decided by the group as the most appropriate order in which to handle the questions) is selected in order to structure the discussion. This is usually done by means of a voting method such as multivote (every student is allowed to vote for three questions), omnivote (students are allowed to vote for as many questions as they want), or single vote (students are allowed to vote for one question, often either 'blind' or 'voting with their feet'). This process typically involves making judgements about the questions, such as are they philosophical, are they interesting and, in science lesson, do they link to scientific concepts or processes? It is also useful for students to identify what the question is asking, to distinguish between key concepts associated with the question and to identify what needs to be known before the question can be answered. Giving students the chance to create questions and make decisions about which question is discussed can be powerful in terms of converting a classroom into a community and giving students ownership of, and investment in, what they learn, but it can also bring challenges. Sometimes, albeit rarely, students 'test' whether the teacher really will go with their questions, so it is important to share and agree the criteria for the philosophical question in advance.

Encouraging argumentation

Philosophical dialogue provides an opportunity to develop and critique arguments in real time and for teachers to encourage competencies in argumentation among their students, although it is important to note that philosophical dialogue does not lend itself well to one singular particular approach to answering a philosophical question. In terms of facilitation, the teacher's role is to encourage the students to discuss the issue, and this happens primarily by asking questions to encourage students to think better.

A useful reference for teachers facilitating philosophical dialogue is Osborne *et al.*'s (2016) learning progression to assess argumentation in school science, based on identifying increasingly sophisticated facets of argumentation. Although this has been developed for science, with a particular focus on assessment, it also offers potential as an instructional support for teachers. We suggest some facilitation questions that teachers can use that map approximately on to each of the levels of argumentation in Osborne *et al.*'s (2016) learning progression (Table 1). These questions are intended to be suggestive, and not exhaustive.

Philosophical dialogue is not, however, only about enabling students to develop valid and sound arguments, but also about opening up new existential possibilities, generating new insights and valuing creative perspectives, so it is important not to stick rigidly to these when facilitating philosophical dialogue. For example, it is also important to:

- check for relevance, for example by asking students how their response relates to the question;
- check for meaning, for example by asking what students understand or mean by key terms.

Furthermore, it is unlikely that students will develop and critique arguments linearly during philosophical dialogue, particularly when it is new to them. This is something that may require practice and vocabulary (provided via teachers' questions) to develop.

We have discussed how to spark the philosophical dialogue (with a stimulus and question), and suggested some examples of questions teacher might ask to encourage students to think about the issues at hand and to ensure that arguments are developed and subject to critique during the dialogue. The final feature of facilitation we discuss below is the behavioural dimension, particularly in terms of managing turn-taking.

Managing turn-taking

In philosophical dialogue it is important that the dialogue develops between students, and is not dominated by the teacher. Students need to practise developing arguments and holding each other to account. The teacher's role is to create the environment in which this can happen and to ensure dialogue is philosophical by asking questions. This supports students to learn by allowing them to share their prior knowledge of science with others, in their own language, and by developing a classroom culture that values questioning and dialogue.

An important way of managing turn-taking is to ask students to sit in a circle. Although inconvenient in many science-teaching spaces,

Table 1 Facilitating argument during philosophical dialogue, based on Osborne *et al*. (2016)

Element of constructing or critiquing an argument	Facilitation move
Constructing a claim	What do you think? Can anyone suggest an answer to get us started?
Identifying a claim	Can you put X in your own words? Who agrees/disagrees?
Providing evidence	Why do you think X? What might explain X? Can you give a reason or example for X?
Identifying evidence	What evidence did A give in their answer? Why do you think other people might think X?
Constructing a warrant	How does this connect to why you think X? What are you assuming to be true? Why does that make X true?
Identifying a warrant	What is A assuming to be true – and do you agree? Are those assumptions true (i.e. is the argument valid)?
Constructing a complete argument	Can you give an answer with reasons to link evidence to your claim? Can you explain why (and how) the evidence leads you to believe X?
Providing an alternative argument	What alternative ideas might explain X? Why might X not be true? Are there other conclusions you could draw from that evidence?
Providing a counter critique	What would someone who disagreed with that say/argue? Are there any flaws in the argument that …? What are they?
Constructing a one-sided comparative argument	Which of the arguments you have heard is stronger? Why do you think this? What is the difference between these arguments?
Providing a two-sided comparative argument	Can you identify which idea you agree with? What are the strengths and weaknesses of the different arguments you have heard?
Constructing a counter-claim with justification	Can you bring together these different ideas and suggest an argument that is stronger? Why is it stronger?

it is rarely impossible to organise students in an approximate circle. This allows everyone to see each other, not just the teacher, and so encourages students to talk to each other by removing barriers to talking (e.g. books on desks) and spaces to hide. This makes students visibly accountable to each other and creates an environment for authentic dialogue. It also allows stimuli and questions to be placed in the centre, visible to everyone and easy to move around as connections are made or questions are classified.

Formal ways to manage turn-taking include inviting the class to decide how it should be managed, passing a toy (science-themed if possible), allowing students to select who speaks next or asking the teacher to decide on the order of talking. Speaking aloud to the whole class is challenging for some students, so as well as requiring all students to either speak or pass at key points (e.g. first words or last words), time in small groups can help make sure that everyone contributes at some point. Appropriate points for small-group discussion include:

- to create a question;
- to generate 'first thoughts' in response to a question;
- when the group appear to reach a consensus, to ask them to think what someone who disagrees might say.

Non-verbal contributions are also important. It is important to provide individual thinking time throughout the session, and also to encourage non-verbal responses, for example asking those who agree or disagree at key points to raise their hand.

Conclusion: when to facilitate philosophical dialogue in school science

We have offered some justification for the use of philosophical dialogue in science and provided some examples of ways in which this can be

initiated and facilitated. Teachers we have worked with have used philosophical dialogue in different ways: to introduce a new topic, to review a topic at the end of a unit, and during a topic to find out what students are thinking and how they are relating to science beyond the curriculum. It can also support cross-curricular work and the teaching of the more philosophical dimensions of science in the curriculum, most notably ethics and nature of science.

Teachers have also reported that philosophical dialogue is a good way to reflect on the issues and to have open and honest debates that wrestle with difficult issues. They have said that it encourages students to get a handle on what they, and others, think about key issues and to broaden their perspectives and outlook, giving voice to different views and raising the possibility that they change their mind. They have also said that it helps students understand that science does not exist in vacuum, but applies to the real world.

There are some challenges of which teachers need to be aware. The discussion rarely reaches a conclusion: a useful 'last words' activity involves students identifying what they still need to know in order to answer the question or identifying a new question that has arisen as a result of the dialogue. Some topics might result in students being unwilling to share or in over-sharing: it is important that the discussion remains philosophical, so any individual anecdotes must be linked back to the question or claim. Philosophical dialogue can also be mentally exhausting.

Going further

For teachers in the UK interested in further training, different models are available through the Society for the Advancement of Philosophical Enquiry and Reflection in Education (SAPERE, www.sapere.org.uk) or through the Philosophy Foundation (www.philosophy-foundation.org).

In a scientific context, *Philosophy for Children through the Secondary Curriculum* (Lewis and Chandley, 2012) suggests further examples for philosophical dialogue in science, and *Think Again* (Taylor, 2012) proposes ways in which philosophy can be integrated into the teaching of different disciplines in a range of ways. *Pocket P4C* (Buckley, 2011) contains examples of games for thinking that can be applied to philosophical dialogue in science.

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Lynda Dunlop is a lecturer in science education at the University of York. She has a background in teaching science and theory of knowledge. Email: lynda.dunlop@york.ac.uk
Jelle de Schrijver is a lecturer and researcher in science education at Odisee University College, Belgium. He has a background in biology and philosophy. Email: jelle.deschrijver@odisee.be