Learning evolution through socioscientific issues

Xana Sá-Pinto, Anna Beniermann,
Tom Børsen, Martha Georgiou,
Alex Jeffries, Patrícia Pessoa,
Bruno Sousa, Dana L. Zeidler.

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Are we allowed to tinker with (human) DNA? Addressing socioscientific issues through philosophical dialogue - the case of genetic engineering

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Are we allowed to tinker with (human) DNA? Addressing socioscientific issues through philosophical dialogue - the case of genetic engineering

Jelle De Schrijver[1,2], **Stefaan Blancke**[3], **Eef Cornelissen**[2], **Jan Sermeus**[4], **Lynda Dunlop**[5]

[1]University of Antwerp, Belgium
[2]Odisee University of Applied Sciences, Belgium
[3]Tilburg University, the Netherlands
[4]KULeuven & Royal Observatory of Belgium
[5]University of York, United Kingdom

Abstract:

Education about socioscientific issues (SSIs) can be challenging as underlying tensions can surface. When discussing the topic of genetic engineering, these tensions can be related to (1) the molecular biology of genetics and genetic engineering, (2) the evolutionary aspects of genetic engineering, (3) the nature of science and (4) the ethical understanding of this SSI. Such tensions may lead to confrontation, either between students or between students and teachers. The practice of 'philosophical inquiry' provides a pedagogical approach to help explore these tensions and engage in dialogues. Philosophical inquiry entails a dialogic approach in which a facilitator helps a group of students uncover hidden presuppositions and elicit an argumentative conversation. Stimuli such as pictures, cases or quotes provide a context to help students engage in dialogues about philosophical questions. Thus, students can reflect upon the relationship between science and evolution, the nature of science and the tensions between genetic engineering and society. In this chapter, we first explore different sensitivities related to genetic engineering. Then, we showcase learning material for secondary school students to cope with these issues. We focus on an approach to using big questions and stimulating dialogue to explore sensitivities. Ultimately, we provide tips to consider when addressing SSIs through philosophical dialogue.

KEYWORDS

philosophical inquiry, nature of science, questions, ethics

1. QUESTIONS ABOUT GENETIC ENGINEERING

For decades, the practice of genetic engineering (GE), which is the manipulation or modification of the genetic makeup of an organism, has resulted in new crops and therapies for people. In the medical field, millions of people with diabetes are treated with insulin produced by genetically modified bacteria. Genetic engineering sparks our imagination, but it can also lead to questionable practices.

For example, Schwarzenegger mice were genetically engineered to have increased muscle growth and researchers aim to protect us from HIV by genetically modifying human embryos. These and many other examples demonstrate how scientists might be tempted to genetically engineer humans to possess certain desired traits. However, is this what we want? Is this morally acceptable? Discussions about GE easily elicit hundreds of ethical questions.

The impact of GE cannot be understood without taking an evolutionary perspective. In this regard, GE can be considered an instrument to artificially select organisms that fit human needs; thus, it can be viewed as an instrument to 'steer' evolution. The introduction of new technologies to alter genetic codes and repair genes with deficiencies (CRISPR-Cas) makes such discussions ever more urgent. This raises the following questions: Are people allowed to fiddle with the gene pools? Are we allowed to tinker with human DNA and redirect the course of evolution?

GE is an archetypical socioscientific issue (SSI) in science education. This means it is a (potentially) controversial social issue related to science that is open-ended and has multiple solutions (Sadler 2004; Zeidler & Keefer, 2003). Addressing socially acute questions is one of the many ways to equip students to take part in discussions on SSIs. These kinds of questions are open-ended and involve poorly structured problems that integrate knowledge in the humanities and sciences (Morin et al., 2017).

GE allows the exploration of (socially acute) questions related to food production, identity, the direction of evolution, the interchange of science and technology, the ethics of research and the relationship between science and society. Furthermore, the topic of GE provides a myriad of opportunities to promote scientific literacy. Scientific literacy is relevant to questions that students may encounter as citizens and to the socio-ethical implications of scientific knowledge (i.e., literacy about the implications of science for society).

Thus, it provides an opportunity to not only help students understand the issues at stake and stimulate students' socioscientific reasoning skills but also contribute to citizenship education since it helps students make informed decisions and empowers them to participate in debates (Sadler et al., 2007; Simonneaux & Simonneaux, 2008).

Notably, GE can stir up emotions in a classroom. The number of (big) questions that might surface when discussing genetic modification seems endless: Are we allowed to genetically engineer humans? Are humans playing God when they do so? Can we improve nature? Do some people need to be 'fixed'? Does genetic modification only favour rich people? If we allow genetic modification, then what is next? Can we improve nature? Is it right to tinker with DNA? Are we sure that our cells function as we think they do? Do big pharma companies know what is best? Can we prohibit a technology even if it has a lot of potential? The broad variety of big questions that can be raised in the context of GE can be categorised into different domains (see Table 1).

Table 1
Types of big questions in the field of genetic engineering.

Scientific concepts	Evolution	Nature of science	Ethics
What is a gene?	Can evolution exist without genetic modification?	Are we sure that our cells function as we think they do?	Should we genetically engineer humans?
How does CRISPR-Cas function to change the genetic makeup of organisms?	Is it unnatural to tinker with DNA?	Do science and religion exclude each other?	Are humans playing God when they genetically engineer organisms?
How can genetic malfunctions lead to illnesses?	Can evolution be improved?	Do we have to know all the potential consequences of introducing a technology before it is introduced?	Are scientists allowed to improve nature?
What is the relationship between genotype and phenotype?	What is the difference between evolution, change and engineering?	How can we know genes' functions in evolutionary processes?	May we forbid a technology even if it has a lot of potential?

Whereas some of the questions focus on the scientific knowledge involved in GE, others focus on the relationship between evolution and GE, the epistemological aspects of science and the socio-ethical aspects of GE. In each of these domains, students can experience difficulties and challenges that hinder an understanding of the issues at stake. In this chapter, we explore how the practice of philosophical inquiry allows teachers to address these different aspects. First, we will zoom in on the challenges students face within each of these domains.

1.1 The molecular biology of genetic engineering

The GE of organisms is a broad domain. It covers the production of genetically modified crops, the use of genetic modification to *'improve'* organisms and discussions on the genetic modification of humans to cure diseases or promote more desirable characteristics. In any of these applications, an understanding of genetics is relevant.

This not only entails an understanding of cell biology, heredity, and genetics but further involves an understanding of the techniques of GE (e.g., the use of CRISPR -Cas to do so). It also entails a fundamental understanding of the relationships between organisms and their genes, which is the degree to which genes are simply blueprints or essences.

A broad range of misconceptions (alternative conceptions) about the biology of GE can surface in the classroom (Aldahmash et al., 2012; Briggs et al., 2016; Wisch et al., 2018). For instance, these can relate to the meaning of words such as *'recombinant DNA',* the idea that one trait corresponds to one gene, that an allele is a subcomponent of a gene and that proteins store genetic information. Questions phrased in this domain are scientific questions that can be answered through study or research. Notably, our approach in this chapter focuses on philosophical dialogue and will not focus on these types of questions.

1.2 The evolutionary aspects of genetic engineering

Dobzhanski famously wrote, *'nothing makes sense in biology, except in the light of evolution'*. Indeed, since Darwin, the *'ever-evolving'* theory of evolution has had far-reaching implications on our understanding of biological diversity, our worldview and more specific issues such as drug resistance and pandemic outbreaks. Evolution also helps us understand sensitivities related to GE.

An important connection between evolution and GE is that we can think of GE as a new form of artificial selection. Artificial selection has been practised for centuries on both plants and animals, resulting in new varieties. Unawaringly, farmers and breeders thereby altered organisms' genetic makeup. In the case of GE, scientists are certainly aware that they are selecting genes and modifying genomes, with the process and results essentially being the same (i.e., organisms evolved by artificial selection). Darwin (1859) relied on the analogy of artificial selection to explain natural selection.

As Dawkins (2009) later clarified, this analogy makes sense because we can understand artificial selection as a special case of natural selection in which organisms adapt to an environment in which the needs and tastes of humans exert strong selective pressure. The organisms with the most desirable traits are the most reproductively successful. Hence, GE can be used to clarify the central evolutionary mechanism.

Students could still argue that the products of GE are artificial or unnatural in the sense that in contrast to natural selection, we intervene with nature to produce them. Such considerations provide the ideal opportunity to discuss two important dimensions of evolution. One is that evolution is a blind process that does not have our best interests at heart.

Therefore, what is natural is not necessarily good. Evolution produces traits that favour the reproductive success of its bearers, not our well-being. These adaptive traits often include defences or weapons targeted at other organisms, including us. For example, many plants produce toxins that are harmful and sometimes even lethal, which prevents them from being eaten.

Since nature does not provide, we must do it ourselves - which implies that we must alter our ecological surroundings. However, since species will continue to adapt to changes in the environment through natural selection in ways that favour them and not us, this is a continuous struggle. For instance, consider that insects can become resistant to pesticides.

Another dimension is that humans are not separate from, but rather part of nature. This means that, like any other organism, humans will make the most of their environment. Although humans might be exceptional in this regard, their differences from other organisms are not essential but gradual. As such, artificial selection can be regarded as a form of natural selection since our interests and tastes are part of the natural environment to which other species adapt. GE is different from traditional forms of breeding in the sense that the technology enables us to modify the genomes of organisms by introducing genes from different species.

This crossing of species barriers represents an important concern among the general public. However, this practice can help explain that horizontal gene transfer is quite common in nature and that the process plays an important role in evolution - a point that scientists are now becoming increasingly aware of. For instance, approximately 8% of human DNA is of viral origin. Furthermore, the technology of GE recruits a natural process by which bacteria introduce their genetic material into the cells of their hosts.

Certainly, horizontal gene transfer is only possible because the genetic code is universal. As such, GE also provides a context in which to discuss common descent.

1.3 The nature of science of genetic engineering

How is our current understanding of GE achieved? Is our understanding of GE biased? If so, how? What is the relationship between technology and science? These issues relate to the nature of science (NOS) and touch on metaphysics (i.e., what is real; genes, evolution, species), epistemology (i.e., how we know, including the question of what we can know about genes and evolutionary processes) and axiology (i.e., what is valued), among others. Logic and different forms of reasoning are required to answer questions of this nature.

It is important to consider philosophical (i.e., NOS) questions when it comes to GE in education for several reasons. In terms of knowledge, it is important for students to understand the basis upon which claims about GE and evolution are made. Through this, they may understand how science works and be able to approach social and ethical questions from an informed position. Since GE can be a divisive topic, there is a need to establish a good understanding of what is known, what the evidence is and what the limitations and uncertainties are. GE is a *'hot'* area of research, where governance and regulations are barely catching up at times. Thus, it is important for society to answer the question *'just because we can, does it mean we should?'*.

It is also important to open spaces where students can agree or disagree with the direction that science is taking. In dealing with questions that link science and society and creating space for dialogue, we empower students to handle science-based issues that will determine their future world. Finally, it is important to pay attention to good quality thinking about what is known and how we can help students gain a better understanding of how science works in the lab and beyond while avoiding arguments based on misinformation or logical fallacies in arguments.

Critics of school science have drawn attention to the focus on *'final form'* or *'readymade'* science, which emphasises the products rather than the processes of science. When considering science-in-the-making, such as at the frontiers of GE, it is important to understand not only what is known, but also how that knowledge has been gained and the status and certainty of scientific truths.

Teaching and learning NOS is one way of responding to this criticism because it draws attention to the knowledge creation process and science as a human practice. Clough (2020) argued that NOS should be framed and taught as questions rather than as declarative statements to (i) more accurately reflect the context, cultural embeddedness and nuance needed for understanding and (ii) foreground the investigative process. The use of questions to investigate NOS in relation to GE allows teachers and students to attend to contemporary conditions including politics, democracy, capitalism, subjectivity, agency and ethics.

For example: Are we sure that genetically modified organisms will not harm the planet? How should decisions about GE be made when there is uncertainty about its consequences? Do cells function as we think they do? What does it mean to *'own'* a gene? Can nature teach us about what is good? Should we consider the impact that the GE of crops has on the job quality of farmers? Who benefits from GE? In our description of practice below, we demonstrate how questions can be used in this way.

1.4 The ethics of genetic engineering

GE is a challenge in our contemporary society. It opens a sea of possibilities and just as many discussions. It has raised many concerns, especially in the domain of agriculture. Medical applications such as insulin tend to be less contentious amongst the public. Concerns related to GE include worries about the safety of the technology, its threats to the environment and its socio-economic consequences.

Since the matter is highly complex, when assessing environmental and socio-economic impacts, it is important to consider not only the safety of the technology itself but also how it is used and regulated, as well as the impact on different groups of stakeholders in society. GE is a popular tool used to develop crops that are more tolerant to extreme conditions, resistant to pesticides and viruses or able to fight malnutrition (e.g., the case of golden rice). However, such technology also often evokes questions about the involvement of multinationals, patents and the agro-industry.

However, in the future, GE might have other applications. The possibility of human enhancement raises different types of concerns. For example: Is GE safe? Is it good for everybody or just a selected group? Should GE be used to enhance humans? What is the difference between therapy and enhancement in the use of GE? What responsibility do people have towards future generations? Is GE different from other therapies and enhancements? Is human GE *'market-based eugenics'*? A broad range of ethical frameworks resonates in discussions on GE.

In a way, what is considered *'good'* and why it is considered so depends on the ethical framework that is embraced. Consequentialism provides a costs and benefits approach to the impact of GE. A deontological approach rather focuses on the principles underpinning the act of GE and what ought to be done.

Thinking about human enhancement also invokes questions about human nature, personal identity, autonomy, values and social inequality. Philosophers and ethicists bring various perspectives to these issues. Transhumanists argue that modes of human enhancement, including GE, should be seriously considered as a means to improve the quality of human life (e.g., Bostrom, 2003).

Others, such as the influential ethicist Hans Jonas, argue that in dealing with such technologies, one should 'act so that the effects of your action are compatible with the permanence of genuine human life' (Jonas, 1984, p. 11). Feminist bioethicists focus on power relationships and the impact of human enhancement on women and other marginalised groups (e.g., Simonstein, 2019).

2. PHILOSOPHICAL INQUIRY ABOUT QUESTIONS CONCERNING GENETIC ENGINEERING

The key idea of this educational practice is to help students reflect on the NOS as well as the ethics and evolutionary aspects of GE. Here, philosophical inquiry (and philosophical dialogues) are the means to realise this goal.

2.1 Materials

- Stimuli to start the dialogue (see below).
- Philosophical questions (see below).
- A classroom in which students sit in a circle.

2.2 Time

The philosophical inquiries can last from 10 to 30 minutes (or even longer if the students are well acquainted with this teaching method).

2.3 Target audience

The activities focus on 12- to 18-year-old students in the context of both formal science education (i.e., schools) and informal contexts (i.e., science museums, science centres, etc.).

2.4 Learning objectives

2.4.1 *Learning objectives related to awareness of the SSI*

1. The social, ethical and moral issues emerging from the context of GE and sensitive SSIs.

2.4.2 *Learning objectives related to evolution*

2. Evolution does not consist of progress in any particular direction.

2.4.3 *Learning objectives related to scientific practices*

3. Asking questions.

2.4.4 *Learning objectives related to the nature of science*

5. Scientific ideas can change over time.
6. Science is a human endeavour.

2.4.5 *Learning objectives related to transversal skills*

7. Analyse issues from multiple perspectives.
8. Explore how science can contribute to the issues and the limitations of science.

2.5 Description of the educational practice

In a philosophical inquiry, participants search for answers to challenging (philosophical) questions under the supervision of a facilitator. The facilitator structures the dialogue and stimulates a logical investigation without providing any answers. This helps create a space for students to inquire about the epistemological underpinnings of science and the relationship between science and human values.

The use of philosophical dialogues is inspired by the philosopher John Dewey. He argued for a form of education in which the emphasis is placed on the learners, with the latter taking responsibility for their own learning process (Dewey, 1997). It is on this track that the American philosopher Matthew Lipman developed the methodology of *'philosophy for children'* in the 1960s (Lipman, 1988).

Lipman regarded philosophy not only as an academic discipline for specialists but as a form of dialogical thinking (Lipman, 2003). Central to philosophical inquiries is the ambition to induce *'critical and creative thinking'* in students. Logic plays a central role in this process (e.g., by exploring how to distinguish arguments from fallacies). This process occurs in a social context (e.g., a class), which is called the *'community of inquiry'*. In this community of inquiry, a group of students can search for answers to philosophical questions under the guidance of a facilitator.

Students are questioned about the coherence and relevance of arguments and the (hidden) premises or consequences of statements. In recent decades, the impact of philosophical conversations on young people's behaviour has been investigated more systematically (Reznitskaya, 2005).

Philosophical dialogues not only stimulate young people's curiosity and capacity for analysis but also sharpen their social and discussion skills and reasoning ability (Lafortunate, 2003; Lipman, 2003). Philosophical dialogues allow students to explore the meanings of (philosophical) concepts and distinct perspectives in order to understand them.

The use of philosophical dialogues may be promising to help students critically reflect and develop an ecologically valid understanding of knowledge - especially because this process of developing knowledge is re-enacted during the dialogue itself. Thus, students can come to an understanding of ideas, the relationships between these ideas and reality, and the ways such understandings can differ for different people (Worley, 2016).

Studies on the implementation of philosophical inquiries in the context of science education show how these inquiries can be used to help students reflect on scientific concepts, ethical issues or NOS (De Schrijver et al., 2018; Dunlop & De Schrijver, 2020).

2.4.1 *Learning objectives related to awareness of the SSI*

During a philosophical inquiry, students sit in a circle and are guided by the questions of the teacher (facilitator) to explore different answers.

A philosophical inquiry entails different phases (figure 1): (i) stimulus; (ii) raising philosophical questions; (iii) dialogue; (iv) meta-reflection. Depending on your approach as a teacher, different phases will allow you to work on different learning objectives (e.g., whereas the stimulus phase provides excellent opportunities to create an awareness of the issue, the dialogue phase provides opportunities to analyse an issue from multiple perspectives).

Figure 1
Phases in a philosophical inquiry.

Stimulus → Philosohphical questions → Dialogue → Meta reflection

(i) Stimulus

A philosophical dialogue often begins after a philosophical problem is introduced with a stimulus that provokes reflection. Stimuli may include short videos, songs, cartoons, texts, strange experiments, cases, images or stories.

Typically, the stimulus material is shared with the group, with students being asked to reflect on what they have seen, read, heard or shared. This might include identifying troublesome concepts, responding to the stimulus using a limited number of words or asking students to identify ideas that they agreed or disagreed with. Also, a short case study or picture can function as a stimulus to start the dialogue. A picture (figure 2) can serve as a stimulus to begin a dialogue, as shown in the following dialogue:

Facilitator	**What do you think of when you see this image?**
Student 1	A finger, DNA.
Student 2	A person who thinks he is God.
Student 3	How dangerous it is to change DNA.
Facilitator	Is this what you think or what you see?
Student 1	It is what I think, I think
Facilitator	What are the themes of this image?
Student 2	Genetic modification, God, science.
Student 5	Danger, because I see dark clouds
Student 6	Opportunities… to make what we want.
Facilitator	What do the others think?

Figure 2
Example of a stimulus for a philosophical inquiry.

(ii) Philosophical questions

What is a philosophical question?

Philosophical questions can be described as those that are 'open to informed, rational and honest disagreement...' (Floridi, 2013 —i.e., to be open and to lend themselves to authentic exploration through reasoning. Using philosophical questions (e.g., Can scientific knowledge ever be proven?) as the focus for inquiry allows students to explore, discuss and develop their own ideas about NOS. These philosophical questions can originate from the students or the teacher. Interactions between the participants and facilitation by teachers enable students to reflect upon NOS and develop their own arguments.

As a teacher, you may describe these big philosophical questions as questions that are interesting to explore together, questions that are difficult to give a final answer to and/or questions that Google does not know the answer to.

How do you raise philosophical questions?

In creating the environment for philosophical dialogue, a range of approaches to generate questions exists. This includes (i) the development and/or selection of the question by the teacher/facilitator and (ii) the creation and/or selection of the question by the students.

The creation and/or selection of the question by the teacher/facilitator might be important when there is a specific question or issue that the teacher would like the class to explore; for example, what is the difference between science and technology? Are scientists playing God? What is the difference between science and religion? This may yield a philosophical dialogue that focuses tightly on what teachers want their students to learn.

However, students may lack ownership of and investment in questions that have been selected for them. The creation and/or selection of questions by students might be important when the teacher wants to engage students by making connections between science, themselves and the world. It can further give students ownership of the inquiry and ensure that the philosophical inquiry is relevant to them. Also, it can help them develop their ability to ask (philosophical) questions. Furthermore, it gives the teacher an idea of the (pre) concepts living within the students' minds.

As discussed above, a stimulus can be useful for raising a philosophical question. For example, after a short dialogue regarding an image, the teacher can ask students to phrase philosophical questions. It may be helpful to ask students to write all the questions that come to mind and then look for the most interesting ones. It could also be helpful to stress that philosophical questions are open, easy to understand and elicit a cognitive conflict.

Table 2
Examples of philosophical questions that (do not) work in a philosophical dialogue.

Examples of big questions	Is this a useful question for a philosophical dialogue?
Why is it good to genetically modify organisms?	This question is not open. It is manipulative since it already suggests that genetic modification is good. Thus, it does not allow students to explore all of the options.
What is genetic modification?	This is a factual question. However, it is not very useful as a philosophical question since there is only one clear answer (or scientific consensus).
Can nature improve itself?	This question is a useful philosophical question since it allows us to explore the meaning of 'improvement/progress' and 'nature'. It does not lead to one scientific explanation but invites one to explore different points of view.
Is genetically modifying a plant better than genetically modifying an ant?	This question makes students smile and stimulates wonder. It invites them to look for differences between the engineering of ants and plants. Using specific organisms helps students to be concrete.
Can evolution be improved?	This is a useful philosophical question. It focuses on the meaning of 'improvement' in the context of evolution. It elicits a cognitive conflict by mixing two kinds of thinking: scientific thinking (evolution) and ethical thinking (improving).
Are we allowed to tinker with the blueprints of human beings?	This is a useful philosophical (ethical) question that invites students to argue whether they agree or disagree and why. Having a yes-or-no question is helpful since it makes it easy for participants to react. After their initial reaction, students will have to elaborate on it.

(iii) Dialogue

Whilst facilitating a philosophical dialogue, the following rules usually apply (Rondhuis, 2005):

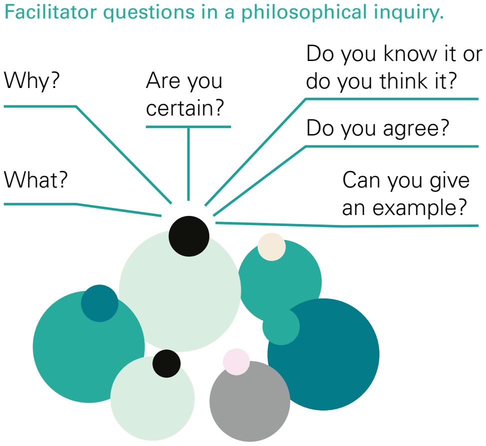
- Opinions are only allowed if they are supported by arguments.
- Participants may respond to each other's arguments, but not each other's opinions.
- Statements and arguments must be understandable and accessible to everyone.
- Dogmas, irrational certainties and arguments based on external authorities are not allowed.
- Reasoning must be structured consistently and systematically.
- Thus, the facilitator helps the learners structure and clarify their views, assumptions and concepts.

Philosophical questions can give rise to new (follow-up) questions that help to deepen the inquiry. In the table below, we show that one big question can give rise to extra questions that a facilitator may ask.

Table 3
Philosophical questions and follow-up questions.

Philosophical questions	Philosophical follow-up questions
Is genetically modifying a plant better than genetically modifying an ant?	• Who decides what is good and what is bad? • Are animals more important than plants? • May we modify everything? • Should we follow (ethical) rules for genetic modification? • Is modifying a sheep better than modifying a human
Can evolution be improved?	• Is a human better adapted to its environment than a bacterium? • Does evolution lead to progress? • Is improvement always the best option? • How do you know that something is better? • Can progress go backward? • Does evolution have end goals?
Is GE a form of evolution?	• Is life possible without change? • Is life possible without evolution? • Is GE possible without an engineer? • Is nature an engineer? • Can GE occur by coincidence?
Can you have evolution without genetically engineering organisms?	• Is there a difference between engineering, modification and change? • Which elements are necessary to be able to speak of evolution? • Can you have evolution without change?
Would the world be a better place if GE did not exist?	• Is GE a good technology? If yes, why? • Does GE have more advantages than disadvantages? • Is GE the same as playing God? • Can we interfere in nature?

Figure 3
Facilitator questions in a philosophical inquiry.



The role of the facilitator

The facilitator does not provide any answers but instead asks questions. These questions encourage students to explore various points of view.

The emphasis lies not on finding one final answer, but on collectively exploring a topic. The types of questions a facilitator may ask are presented as follows.

1. Facilitator questions asking for clarity

These questions stimulate participants to understand the words and concepts that are used.

- What do you mean with…?
- Can you give an example?
- Can you summarise what … is talking about?
- What is the main question in this discussion?
- Can you rephrase your/her/his answer?

2. Facilitator questions asking for arguments

We all make judgements all the time. However, we rarely stop to think about where these judgements come from and whether they are based on valid grounds. In a philosophical conversation, we look for the basis of our judgements and examine the hypotheses and assumptions upon which they are built.

- Why do you think so?
- Why is it so?
- How do we know this is true?
- What is it based on?
- What do we know for sure about this?
- How can we prove it?
- Is it a fact or an opinion?

3. Facilitator questions asking for alternative perspectives

These questions invite us to look at and question our own familiar perspectives. Our everyday experiences and views are usually self-evident. However, you can also experience and understand the same things differently if you look at them from a different angle. Questions about changing perspectives are also suitable for exposing unfounded arguments or opinions without explicitly acting as a content ‘corrector’ of the conversation.

- Can you imagine the opposite?
- Are there other options that could also be true?
- Can the opposite be true?
- Does anyone think otherwise?

4. Facilitator questions about implications and consequences

You can also test an assertion by making its consequences and implications explicit. For example, this type of question can be used to expose contradictions in a line of reasoning.

- What can we deduce from this?
- Is there a general rule for this?
- How does that fit in with what you just said?

(iv) Meta-reflection

The focus of philosophising is on learning to think critically together rather than on finding one correct answer. It rarely or never happens that a group comes to a consensus. The characteristic of this activity is that it raises more questions than answers. The main goal is to increase one's understanding of the complexity of the matter. You do not have to wait for an answer that everyone agrees with before you can conclude the discussion. However, it is useful to have a short meta-reflection after the research in which you discuss the conversation itself.

During a meta-reflection, the conversation is summarised, the most important insights are listed and a joint decision is made as to whether there should be a follow-up conversation. You can also conclude with a round of questions if there is sufficient time. The questions that remain after the discussion can be noted in a philosophy notebook and dealt with in a subsequent session.

It is also useful to determine how the students experienced this activity, what went well and what did not. Based on this feedback, you may want to revise the process of the discussion.

Facilitator questions for the meta-reflection

- What can we conclude?
- What insights remain?
- Do we understand the issue better?
- Was the conversation useful?
- Does everyone agree with the way
- the conversation went?
- What questions were not addressed?
- Is a follow-up discussion desirable?

2.5.2 *Dialogue examples*

Example 1: May we improve nature?

Stimulus

Students are asked to categorise objects into two groups: 'natural' and 'unnatural'. The facilitator asks students to explain why they made a choice. Other students can also respond.

Dialogue

Facilitator **May we improve nature?**

Student 1 No, we aren't God.

Facilitator **What do the others think? Do you agree?**

Student 2 No, we do it all the time—and that doesn't make us God.

Facilitator **Can you give an example?**

Student 2 My aunt has a new hip. She can walk again.

Facilitator **Student 1, what do you think about this example?**

Student 1 Yes, I agree with Student 2. But this is not what I wanted to say. I mean like cloning.

Facilitator **Can you try to put your argumentation into a rule?**

Student 1 If you don't play with our genetic material, it is OK.

Student 3 So a plastic hip is OK, but a cloned hip is wrong. Why?

Student 1 Because it will never stay with a hip. Once we have the technology, we will want more and more.

Facilitator **What do you mean by more and more?**

Student 4 Like perfect people?

Student 1 Yes.

Facilitator **Who disagrees?**

Student 5 I don't know if that is true. If we can improve hips, it does not mean that we 'will want more'.

Facilitator **What do the others think?**

Student 6 Maybe we need rules, like a boundary.

Example 2: May you doubt everything in a science lesson?

Stimulus

Quote: 'To doubt everything and to believe everything are two equally convenient solutions; each saves us from thinking' (Poincaré, 1902).

Students are asked to say what they think this quote means. Then, the students should answer why it means what they think it means. Based on their ideas, new philosophical questions can be phrased.

Dialogue

Facilitator **May you doubt everything in a science lesson?**

Student 1 Yes, because sometimes you find out something new and you have to change your original idea.

Facilitator **Does everyone agree?**

Student 2 Yes, a theory is never really finished. It is like a tree—it keeps growing.

Facilitator **Aren't there theories that never change?**

Student 3 The theory of evolution. That's a theory that cannot change.

Student 4 I disagree. Imagine that we discover a planet where all the organisms are identical to the organisms on Earth. That would show that evolution is different from what we understand… or imagine that we would find a skeleton of a human in an earth layer from the dinosaur age… Then we might have to adapt the theory of evolution, don't we? The theory of evolution can change. But thus far, we haven't needed to change it.

Student 5 Perhaps only facts can change.

Facilitator **Can you give an example of a fact that never changes?**

Student 3 The Earth is round.

Facilitator **What do the others think? Is 'the Earth is round' a fact that never changes?**

Student 3 We used to think that the earth was flat, so that has already changed.

Student 5 But then it wasn't a fact if it could change.

Facilitator **Let's go back to the beginning. Can you doubt everything in the science class?**

Student 4 Yes and no. In a way, you should doubt, because if you think something is true, it is much more like dogma—and science is no dogma.

Student 3 But if you doubt everything, you will never be able to know everything. Maybe you should doubt everything, but not the fact that science can give us knowledge.

Student 7 Ay, my head aches—but I'm inspired as well.

Example 3: Can you believe in science?

Stimulus: Case study

Students read a case study. Afterwards, they answer the questions below in small groups.

Case study. During the lesson on genetic modification, Paulo gets angry and walks out of the classroom, saying, 'We must not tamper with what God has given us! Scientists work for the devil!'

- What do you think of this statement?
- (How) Do religion and science differ?
- Can you talk about faith in science class?
- Can you believe in science?
- Can a scientist believe in God?
- Can scientists learn from religion?

Dialogue

Facilitator **Can you believe in science?**

Student 1 No, you can only believe in God. Science is not something you believe in, it is something you know.

Facilitator **Does everyone agree?**

Student 2 No, I think you can believe in science. You can believe that science gives you a better understanding of the world.

Student 3 You can believe that science is a good approach to knowing something.

Facilitator **What is the difference between knowing and believing?**

Student 4 If you know something, it is true. But if you believe it, you think it is true.

Student 2 I disagree. sometimes I say I know something. For example, I know that my brother is at home—but in the end, he is not.

Student 1 Sometimes a scientist says he knows something when he actually doesn't. He only believed that he knew it. You can never be absolutely sure.

Facilitator **Is it possible to be absolutely sure of something?**

Student 3 Hmm, perhaps not. But that makes it difficult because if we are not sure, how can we make choices?

Facilitator **Can you give an example?**

Student 3 Well, if we don't really know whether genetic engineering is dangerous, then what should we do? Should we wait with it or should we start nevertheless?

Student 4 I agree. If we cannot be really sure of anything, that's what makes science science. But at least I believe that science is one of the best instruments used to know what is true.

TIP 1: Take the Socratic stance

What teachers find most difficult is not to answer the questions themselves or to correct the students. However, most of the time, students will investigate each other's ideas on their own. As soon as you start correcting students, the dialogue evaporates and students mainly listen to your answers. Then, the thinking process has come to an end. If you start the dialogue, make it clear to the students that in a philosophical inquiry, you do not know the answers. Afterwards, in a different teaching phase, you can come back to ideas or misconceptions that surfaced in the dialogue.

TIP 2: Science education is more than dialogue alone

These philosophical dialogues should be part of a larger teaching approach. Of course, a science lesson is more than simply having dialogues and exploring student ideas. It also involves acquiring an understanding of biology and science. However, these dialogues can be useful instruments for stimulating active reflection about science and ethics.

TIP 3: Timing can vary

The dialogic exercises can vary over time. Sometimes it suffices to only ask the question for a whole dialogue to be sparked. Other times, it is more difficult. Sometimes it may suffice to simply ask a question and go on with the regular science activity. For example, the question 'Do you think this, or do you know it?' can be a useful question to elicit a brief moment of philosophical reflection.

TIP 4: Participation is not compulsory

Not everyone feels eager to participate in the dialogic process. For some students, it may be frightening that certainties are questioned. We often give students the chance to participate by actively addressing them as a facilitator. Yet, if they do not wish to respond, that is OK. Giving students time to discuss a certain question in a pair helps to involve the ideas of those who are shyer to participate.

2.6 Further perspectives on how to use the activity in other contexts or with participants of other ages

In this chapter we provided example questions, stimuli and dialogues to start a philosophical dialogue about GE in your classroom. The dialogic approach can function in many different contexts. The challenge is to find stimulating philosophical questions. Taking the Socratic stance and questioning the students' responses will create a community of inquiry that enhances a sense of wonder and motivates students to think and provide arguments.

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