perspectives on science

The History, Philosophy and Ethics of Science

Teacher Resource File

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There are links to relevant websites in this book. In order to ensure that the links are up-to-date, that the links work, and that the sites are not inadvertently linked to sites that could be considered offensive, we have made the links available on the Heinemann website at www.heinemann.co.uk/hotlinks. When you access the site, the express code is 9617T.

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ABOUT PERSPECTIVES ON SCIENCE

The course

Welcome to *Perspectives on Science*. The main aim of this course is to help students develop skills of research, analysis, communication and argument in the context of the history, philosophy and ethics of science. The eventual goal is that students should learn to develop, and defend, their own points of view on a range of scientific issues.

It is envisaged that students will spend approximately half the course developing key skills and vocabulary. In the second half of the course, they will carry out individual research projects in which they research the 'story' behind a question with a scientific dimension, explore ethical and philosophical aspects of that question, and present the outcome of their research both orally and in writing.

The emphasis throughout is on the development of skills, rather than the learning of factual content. That is not to say the content is unimportant. Students should become familiar with appropriate terminology so that when they come to do their research projects, they can, for example, note whether a particular text is a primary or secondary source of information, identify the use of a utilitarian framework in addressing an ethical issue, or refer to a dualist or materialist position in the course of a philosophical argument.

Publications

The course materials have two parallel components: the Student book and this Teacher guide. They each have the same overall structure, with materials organised into sections which are subdivided into lessons. To enable easy cross-reference, the headings and main subheadings are the same in both publications.

About the Student book

Each part of the Student book includes the following features:

Main text

This is the main reading material in the book, in which information is presented and ideas discussed. The text in each part is organised into sections, which are sub-divided into lessons – which may, or may not, coincide with the lessons you choose to teach.

Within the main text, some words are printed in bold. These are collated in the glossary for reference, and may prove useful for student research projects.

Activities

The text includes many *Activities*. Some of these are intended for individual work, while others are designed for groups. You will need to decide which of these to use, and may prefer to adapt some or substitute others of your own divising.

Questions

Most of the questions are designed to provoke thought, to get to grips with the ideas presented in the main text, and to summarise learning. Some of the questions have definite, precise answers, but in many cases the process of thinking through the question is at least as important as the answer. As a result, answers are not always given in this Teacher guide.

Further work

Some activities and questions are designated as *Further work*. You might ask students to tackle some of these in private study time.

Project links and course references

Within the first three parts of the Student book *Project links* alert students to material that has a particularly direct relevance to their research project (though in fact *all* the material is of course relevant!), and include suggestions for topic areas that might be developed

into research questions. In the fourth part of the book, *Course references* direct students back to activities, lessons, or sections that relate to specific aspects of the research project.

Resource links
The notes headed *Resource links* guide students to additional resources relating to particular topics.

Teacher resource pack

As already mentioned, this resource pack offers a commentary on the student book along with suggested time allocations and indications of the relevant topics and skills.

In addition to this, the resource pack has several features of its own.

Summary of lessons
Each part within this guide begins with an outline of how the subject matter is divided into lessons, along with a summary of the associated activities, general resources and references and key topics and skills.

References and resources
Specific resources and references for further reading are listed in their own table with number references that correspond to individual lesson commentaries.

Website hotlinks
Links to useful websites referred to in the Student book and Teacher guide are provided on a dedicated 'hotlinks' page on the Heinemann website at www.heinemann.co.uk/hotlinks. When you access the site the express code is 9617T.

Guidance on assessment
External assessment of *Perspectives on Science* is the responsibility of an awarding body, working with the *Perspectives on Science* project team. Full details of the assessment scheme and criteria are provided in the Course specification, which is available from the awarding body. The awarding body's teacher support materials provide further guidance on assessment, along with exemplars of student project work.

Planning the course

The first three parts of the course materials suggest a route through the development of skills using various case studies and examples in the history, ethics and philosophy of science. The fourth part provides lessons that can be used to support students' work on their Research projects.

The order in which the materials are presented here is not necessarily a teaching order. You might decide to start with some discussion of ethical or philosophical issues, and leave the historical research until later. Or, particularly if the teaching is shared between colleagues with different areas of expertise and interest, two or three parts could be taught in parallel.

The tables at the start of each part of this Teacher guide summarise the lessons suggested for that part of the course. Each lesson is designed to last about 40 minutes; if this does not fit with your timetable, you can of course adapt by removing activities, or by combining activities from two or more lessons. Most lessons include Further work that can be used for extension work during the lesson or set for homework, as desired.

The order in which the lessons are printed in this guide suggests a teaching order, but this order is certainly not prescribed. Given the emphasis on skills rather than on content you could decide to use only some of the materials and case studies presented here. You might substitute lessons and activities of your own devising, perhaps reflecting your own particular interests or those of your class, or relating to topical events and issues.

The role of the teacher

Particularly in Parts 2 and 3 (Ethics and Philosophy), the main aim is that students learn to think critically about their own point of view on scientific issues. Students may well begin this process from a standpoint that you believe to be mistaken. Everything turns, however, on how they are led to see this. Are they persuaded to see that they are wrong because you, the authoritative teacher, overrule them? Or are they led, by a process of critical enquiry, to realise that they do not in fact have good grounds for their opinion? If it is the latter, then not only have they been led away from error, but also they have begun to function as free, self-motivated rational enquirers. This is the greatest benefit that a training in critical thinking can bestow.

Modelling thinking skills

To a very large extent, thinking skills are caught as much as taught. The essence of a good *Perspectives* lesson lies in a jointly pursued enquiry, in which you bring your own skills as a thinker to bear on a question as much as do your students. Students will acquire the knack of expressing their point of view clearly and precisely, backing it up with reasons and attending to objections by seeing you doing this.

In many conventional lessons, teachers 'think' their way through a problem, but there is an element of

pretence, since they know what answer they will reach already. In philosophical discussions, the comfortable certainty of knowing where you will end up is not present. You may, as a result of an objection from one of your students, find that you have to change your viewpoint. There is a high degree of symmetry in philosophical discussions: just as we expect our students to change their views in response to reasoned persuasion, so we too must be open to that possibility. It takes some courage to teach in this way, but it is the most rewarding of educational experiences, since it turns lessons into genuine adventures of enquiry.

The thinking skills developed in the philosophy part are highly transferable. They will assist students in studying Parts 1 and 2 (History and Ethics) of the course, and they will prove valuable to them in any context (academic or vocational) where they need to be able to reason their way through complex questions for which there are no agreed-on answers.

Classroom management

In teaching *Perspectives on Science*, your focus as a teacher will be on providing maximum opportunity for analysis, discussion, argument and debate. Students learn best how to develop their skills by practice. In terms of classroom management, a number of issues are worth thinking through before the fun begins.

Classroom layout

How you organise the students, and where you place yourself in relation to them, will have an effect on the learning experience. If students are sitting in rows, the opportunity for discussion is limited. They will be able to interact with one or two others on either side, but group work will be restricted. If you place yourself at the front of the classroom and address them *en masse*, you thereby give yourself a privileged position in the discussion. That may not always be the best place.

Your aim for much of the time will be to facilitate the exchange of ideas. That may happen best with the group seated around a table (or subgroups around several tables), with yourself joining the group as one of the participants. From here, you will best be able to act as a 'guide at the side, not a sage on the stage', in the elegant phrase of the SAPERE director, Will Ord.

Conversational dynamics

Much of the work in this course involves discussion of students' own views. It is important to establish conventions of listening with respect to one another and not denigrating another's views. We strongly recommend introducing students to what are known as the Chatham House rules – namely that any remarks made are not to be attributed to individuals outside of the session. This allows students to continue to talk about the issues without getting into 'You will never believe what he/she said' scenarios.

Since the course also involves a good deal of debate, a further ground rule is helpful, namely that personal attacks be avoided. Students may oppose one another's point of view vigorously but the grounds for opposition should be rational and logical, not personal.

Thought also needs to be given to the balance of the discussion. How will you restrain the overly talkative and encourage the participation of non-communicative students? It is here that there is benefit in trying out various different classroom configurations. Will you opt for a single large group, subgroups or pairs of students, with or without feedback to the class as a whole? A combination of approaches, even within a single lesson, adds a dynamic feel as well as helping towards an equable distribution of 'air-time'.

The content of conversations

There is a balance to be struck between allowing students the freedom to try out new ideas, and ensuring that the group does not lose focus on the main topic under discussion. Philosophical discussion can be tremendously exciting and you will want to keep alive the sense of exploration of a new world of ideas, while simultaneously ensuring that progress is made along a single main line of enquiry.

You may choose to allow more free-flowing 'brainstorming' sessions, which are followed up with a directed discussion in which you keep bringing the group back to one particular question.

Consider too how the conversation will be closed. It can be awkward when there is no 'answer' to present, but that is often what we have to live with when we are dealing with philosophical questions. You will have to restrain yourself from the temptation always to have the last word on the topic under discussion.

An alternative end to a lesson would be a statement of what the students have learned to do during it – what skills they have been using. This has value because, after a few lessons, some students may be wondering 'What have I actually learned?'. It may not have occurred to them that they have been learning to think more skilfully. An ideal outcome to a *Perspectives* lesson would be for students to be thinking 'I'd never thought of it like that before'.

PART 1

RESEARCHING THE HISTORY OF SCIENCE

Planning and resources

This part of the course introduces students to the history of science as an academic discipline. The first three lessons are introductory, and the rest focus on four case studies: cold fusion, the structure of DNA, evolution by natural selection, and the discovery of oxygen. These case studies are drawn from different periods of history and are designed to develop students' research skills and introduce them to the variety of information sources available to a historian of science. The *Perspectives on Science* project team intends that these lessons will be used as a vehicle for developing relevant skills and illustrating the importance and interest of historical research relating to science, and hopes that you will on occasions replace them with other lessons of your own devising, particularly in relation to other topics in the history of science that are of particular interest to you and your students.

Table 1 Summary of lessons

Section 1 Introduction to researching the history of science			
Lesson	Summary of activities	Resources and references	Key topics and skills
1.1 Questions, questions	Discussion comparing historians and scientists. Summarising a report of an event.	Recent newspaper or magazine reports of a sporting, celebrity, scientific or other event. Students' own records of GCSE science investigations.	Use of the '5 W' questions to analyse and summarise information. Awareness of bias in information sources. Distinction between objective fact, subjective opinion and speculation.
1.2 Sources of evidence	Identification of types of sources available to a historian of science. Discussion of articles written for different audiences.	Scientific and/or historical articles in newspapers, magazines and/or the Internet or CD-ROMs of newspapers or magazine archives. Scientific journals.	Distinction between primary and secondary sources. Awareness of the process of peer review.
1.3 Researching information	Visit to an academic library.	References 44 and 45.	Use of library catalogues. Procedures for locating and consulting books and journals.
Section 2 Cold fusion			
2.1 Out of the blue	Comprehension exercise using extracts from *The Times* news reports of cold fusion. Summarising content of news reports.	If the news reports are to be read in full, Internet access and reference 38.	Use of '5 W' questions. Distinction between fact, opinion and speculation. Analysis of reports written for a general readership. Making summary notes.
2.2 Fusion hot and cold	Reading and comprehension exercise on the science of fusion.	Apparatus to demonstrate electrolysis of water (reference 41).	Basic understanding of nuclear fusion and the practical challenges it presents.
2.3 The scientific world responds	Reading and discussion of reports on cold fusion from *New Scientist*.	If the news reports are to be read in full, Internet access and reference 36.	Analysis of reports written for a general scientific readership. Making summary notes. Appreciation of factors influencing the reporting of scientific work. Awareness of the role of peer review and the role of experimental evidence in science.
2.4 The tide turns	Reading and discussion of technical reports of independent investigations into cold fusion.	Reference 39. Internet access.	Analysis and summary of technical information. Awareness of the importance of experimental evidence in science. Appreciation of pressures on scientists to conform to accepted principles. The role of experimental evidence in science.
2.5 The return of cold fusion	Researching the ongoing story of cold fusion.	References 8, 12 and 25. Internet access.	Making summary notes. Distinction between fact, opinion and speculation. Awareness of the role of peer review. Distinction between primary and secondary sources. Awareness of possible bias in sources.
2.6 Making history	Critical discussion of the cold fusion story and the actions of those involved.		Selection of evidence for or against a point of view. Oral presentation and discussion.

1 Introduction to researching the history of science

This section introduces some key skills needed for historical research in science.

Key topics and skills

In this section of the course, it is intended that students encounter:

- similarities and differences between the disciplines of history and science
- the history of science as an academic discipline
- sources of evidence used by historians of science
- the distinction between primary and secondary sources
- the peer review process
- the distinction between objective fact, subjective opinion and speculation
- writing a summary of information from a textual source.

1.1 Questions, questions

This lesson introduces the history of science as an investigative subject, comparing the study of history with science and considering some of the questions that historians may ask of a scientific event.

Aims

In this lesson students should:

- appreciate the similarities and differences between the sciences and history as subjects of academic study
- be introduced to the type of questions that historians of science may ask about events in scientific history and to write a commentary on an historical event
- develop skills of extracting and summarising information.

Lesson outline

Activity 1 Science and history compared (15 min)
Activity 2 Finding answers (20 min)

Resources and references

- Recent newspaper or magazine reports of a sporting, celebrity, scientific or other event.
- Students' own records of GCSE science investigations.

Student book pages 2–3

Science and history (5 min)

As this lesson is the first, there may be some administration to carry out, books to pass around, specifications to distribute and some description of what *Perspectives on Science* is all about.

Outline the aims of the lesson and emphasise that it is an introduction to researching the history of science. It may be worth establishing the background of the students. It is assumed that all will have at least a single award in GCSE science. Some but probably not all will have studied history at GCSE level.

Activity 1 Science and history compared (15 min)

The idea is to stimulate the students into exploring their experience of the study of history and of science and of what the subjects involve in the wider academic world. The pictures of a scientist and an historian in the Student book may act as stimulus. Depending on the size of the class, students may be divided into groups of three or four to discuss the two questions for 5–10 minutes before returning for a plenary session, or the discussion may take place in the whole class.

PART 2

DISCUSSING ETHICAL ISSUES IN SCIENCE

Planning and resources

This part of the course introduces students to ethics as an academic discipline, particularly as applied to science. The first four lessons are introductory and the rest are grouped into broad themes: life, animals, genetics, science and scientists. However, these themes are not isolated from one another and there are many interrelationships between them. The *Perspectives on Science* project team intends that these lessons will be used as a starting point for a treatment of ethical issues related to science, and hopes that you will on occasions replace them with other lessons of your own devising, particularly in relation to any topical issues that may arise.

Teaching the ethics of science

In this part of the course students will be introduced to some commonly used ethical frameworks and terminology. While students should not be expected to memorise this 'content', they should nevertheless become sufficiently familiar with ethical frameworks that they can refer to them in their class discussions and in their research projects.

Table 1 Summary of lessons

Lesson	Summary of activities	Resources and references	Key topics and skills
Section 1 Introduction to discussing ethical issues in science			
1.1 Right and wrong	Discussion of ethical reasons for a commonly held point of view (namely that it is wrong to steal).	Internet access for optional Further work.	Introduction to formal ethical language and critical thinking.
1.2 Introducing ethical frameworks	Discussion of factory farming using ethical frameworks of utilitarianism and divine command. Consideration of the role of religious views.	References 3, 15, 22, 26, 40 and 42.	Use of terms utilitarianism and divine command.
1.3 Further ethical frameworks	Discussion of students' personal rights. Discussion of virtues in the context of various roles, e.g. teacher, partner, carer.	References 3, 15, 22, 26, 40 and 42.	Use of terms rights, duties, virtues. Idea of absolutism and relativism.
1.4 Dealing with inequality	'Thought experiments' relating to ethical dilemmas. Use of ethical frameworks to discuss article on maternal life expectancy.	References 45 and 67.	Appreciation that some ethical issues are individual and some social. Idea of distributive justice.
Section 2 Human life			
2.1 Sperm idol reality TV show	Structured discussion of proposed reality TV show involving would-be mothers and potential sperm donors.	References 16 and 52.	Further use of ethical frameworks to determine, and justify, a point of view. Appreciation that modern biology throws up a range of ethical issues.
2.2 The beginning of human life	Consideration of when human life begins. Discussion of when, if ever, abortions are permissible.	References 5, 12, 13, 32 and 40.	Critical thinking about 'meaning of life'. Discussion of controversial issue using ethical frameworks.
2.3 The end of human life	Evaluation of the different types of euthanasia. Discussion of what makes a good death.	References 5, 6, 12, 23, 32, 40, 47 and 57. Internet access for optional Further work.	Critical thinking about 'meaning of life'. Discussion of controversial issue using ethical frameworks.
2.4 Transplantation	Identification and discussion of arguments for and against an 'opt out' system for organ donation. Discussion of the ethics of xenotransplantation.	References 2, 24, 25, 29, 35 and 46.	Distinction between wants and needs. Evaluation of arguments and counter-arguments relating to a point of view.
Section 3 Animals			
3.1 Bugged-off students down their insect nets	Structured discussion of newspaper report about biology students refusing to collect insects. Discussion of personal experience concerning ethical issues while studying science.	No additional references for this lesson.	Identification of arguments used to support a point of view. Evaluation of these arguments using ethical frameworks.
3.2 Animal rights	Discussion of whether animals have moral rights, and how their interests might be safeguarded.	References 9, 33, 34, 39, 48 and 63.	Critical thinking about the meaning of rights.
3.3 Animal experimentation	Discussion of arguments for and against the use of animals for research. Comparison of contrasting documents relating to animal experimentation.	For the Further work, access to materials such as references 1, 11, 18, 21, 31, 38, 41, 51 and 65.	Identification and evaluation of arguments and counter-arguments relating to a point of view. Awareness of different writing styles and their likely effect on readers.

1 INTRODUCTION TO DISCUSSING ETHICAL ISSUES IN SCIENCE

This section introduces some commonly used ethical frameworks.

Key topics and skills

In this section of the course, it is intended that students encounter:

- an introduction to ethics as an academic discipline
- commonly used ethical frameworks and related philosophical views (utilitarianism, rights and duties, morality deriving from divine command, virtue ethics, absolutism and relativism)
- use of formal ethical language
- development of critical thinking
- discussion of distributive justice.

1.1 Right and wrong

Aims

In this lesson students should:

- appreciate that a range of ethical reasons can be given for even a widely accepted ethical point of view (namely that it is wrong to steal)
- begin to use formal ethical language
- develop critical thinking.

Student book pages 86–88

Lesson outline

What is right and what is wrong?	(5 min)
Activity 1 What is wrong with stealing?	(5 min)
Activity 2 Exploring your reasons	(10 min)
Activity 3 Categorising reasons	(10 min)
Activity 4 What is theft?	(10 min)

Resources and references

- Internet access for optional Further work.

What is right and what is wrong? (5 min)

This lesson introduces the subject of ethics. The intention is to begin to get students to think critically without overloading them with new technical terms. The approach here starts with students' existing knowledge and views about a specific ethical issue – namely theft (here equated with stealing).

Activity 1 What is wrong with stealing? (5 min)

The intention here is for the whole class to come up with a range of answers to the question 'What is wrong with stealing?'. Be gentle with any student who simply answers that scripture (or parents or whatever) forbids it. The aim of the course is never to denigrate any student's views. All students, whether or not they have a religious faith, will be enabled through the course better to appreciate the ethical frameworks held by people who don't share their world-views.

Don't worry if you get a smart alec or genuine anarchist who believes that stealing is totally acceptable. Use their arguments as ways to get others in the class to think. More light-heartedly, you might try confiscating their watch or wallet, then subsequently refuse to hand it back. This usually encourages the adoption of conventional morality.

Activity 2 Exploring your reasons (10 min)

Here, students begin to clarify their reasons by thinking through their implications. As indicated in the Student book, the intentions are also to establish (if needed) some ground rules about respectfully listening to the views of others and to encourage students to use valid arguments as ways to advance knowledge.

Activity 3 Categorising reasons (10 min)

Here, students begin to identify different ethical frameworks. It is not important that they propose all the frameworks to be introduced in Lesson 1.2. However, three possible ones – utilitarianism, divine command and rights – are introduced here. It is extremely likely that you will need to orchestrate the discussion in this part of the lesson. One would not expect students fully to appreciate what each of these frameworks entails after such a brief introduction. However, this part of the lesson is likely to help them considerably in the rest of this section.

The hypothetical question 'Is it worse to steal from someone who has worked hard to acquire property than from someone who has won it on the lottery or inherited it from their parents?' is not necessarily meant to be answered in the affirmative or the negative. Rather, the point is to get students to think about why it might or might not be. You might want to tell them that there are reputable moral philosophers who would answer 'yes' and equally reputable ones who would answer 'no'. This doesn't mean that ethics is all about choosing for yourself what is right and what is wrong – there are things on which all moral philosophers agree – but it does indicate that ethics is often different from a subject such as mathematics where fundamental disagreements are usually extremely rare and temporary. Depending on whether you teach this ethics lesson before or after some of the material in Part 3 (Philosophy), you might want students to look at both the similarities and differences between science and ethics in this regard (e.g. certainty of knowledge).

Activity 4 What is theft? (10 min)

This activity should start to get students into the habit of thinking critically about the language they and others use when discussing ethics (or more generally). Language clarification doesn't solve all ethical dilemmas but it can be of considerable value (as we shall see in Section 2 when considering issues of human personhood). Depending on the group, the boyfriend/girlfriend question may fall flat – in which case don't force it – or provoke heated debate! You might or might not find it helpful to introduce the aphorism 'All's fair in love and war' and get students to consider what it means and why (the view that morality is just social convention and that when the chips are down – as in the ultimate concerns of love and war – it can be discarded).

It is generally held that a government has the right to require certain things from its citizens (such as taxes – and possibly conscription in war) in return for what it provides for its citizens (e.g. protection from foreign attack and civil disorder). The issue of differential tax rates is likely to be more meaningful for teachers than for students and is to do with what is known as distributive justice (in this case distributing income more equally).

Further work

1. Students may know enough about land distribution in Zimbabwe from the general news not to need to search any websites. What is important is not the specific details but the general principles. Roughly speaking – and setting aside issues to do with violence and corruption – on the one side there is the argument that land distribution is not fair to those from whom the land is taken, and on the other side there is the argument that land distribution is fair overall. Note that a utilitarian viewpoint would also consider as many as possible of the various consequences (e.g. for foreign investment in Zimbabwe) of each alternative.
2. All that is wanted here is for students to appreciate that agreement about what is right does not always, sadly, translate into action.

1.2 Introducing ethical frameworks

This lesson and the next are very closely interlinked. Depending on your group, you might want to combine them into a single session or to redistribute some of the material between the two sessions. These lessons develop from Lesson 1.1 and look at the different ethical frameworks that are commonly used as ways of examining ethical issues. The lessons contain a high proportion of factual teaching. It is important that by the start of Lesson 1.4 students can recall what is meant by each of these frameworks and use each of them, albeit to just a limited extent. This knowledge will be reinforced and extended throughout the rest of this part of the course.

The way the material is presented in the Student book suggests that you the teacher need do nothing but facilitate discussion. However, you might prefer to teach the various frameworks didactically to the students rather than expecting them to learn from the brief written accounts presented in their book.

As is evident, a large amount of material is provided in this Teacher guide for this subject. It is hoped that this will be of use even if much of it is not directly used in teaching – unless you have some particularly bright students!

PART 3

THINKING PHILOSOPHICALLY ABOUT SCIENCE

Planning and resources

This part of the course addresses the need for students to learn how to argue for a philosophical point of view regarding scientific issues. In particular, the thinking and analytical skills which this unit aims to develop in students will help them as they write the Discussion section of their Research projects.

In the first section, a common but simple-minded picture of science is introduced and challenged. As well as prompting students to think about the nature of science, the lessons here provide opportunities to begin using the thinking skills that will be further developed in Section 2, where students are introduced to a thinking skills framework. In the third and fourth sections, students further develop their thinking skills by exploring a range of philosophical issues in science. These issues have been selected to illustrate the types of questions that students might choose to discuss in their Research projects. Broadly, the lessons in Section 3 relate to science and religion, and those in Section 4 to philosophies of mind. Finally, in Section 5 students reflect on, summarise and put into practice their work in this part of the course.

The *Perspectives on Science* project team intends that these lessons will be used as a vehicle for developing relevant skills and illustrating the importance and interest of philosophical discussion and analysis relating to science, and hopes that you will on occasions replace them with other lessons of your own devising, particularly in relation to other topics in the philosophy of science that are of particular interest to you and your students.

Teaching the philosophy of science

It is important to note from the outset that the focus in this part of the course is on helping students to develop the thinking skills needed to reason clearly and logically about science. The amount of 'content' – details of particular debates and positions in the philosophy of science – has been kept to the minimum necessary.

This does not imply that this knowledge is unimportant. It is expected that students will explore particular aspects of the subject more fully when they begin research for their projects. The resources listed in Table 2 pp. 91–93 may help here.

A thinking skills framework

A great deal of work has been done in recent years on the topic of what is variously called thinking skills, critical thinking, critical reasoning or informal logic. Different models of argument analysis have been used. In the *Perspectives* course, our aim is to help students to take some first steps in the process of thinking critically about scientific issues. Therefore a very simple model for argument analysis is used.

The *Perspectives* framework relies on a basic distinction between a point of view and reasons. A point of view is a proposition such as 'machines cannot think', 'astrology is a pseudo-science', or 'science cannot explain consciousness'. Reasons are arguments or evidence to support a point of view (e.g. 'The reason machines cannot think is that they aren't conscious').

As well as reasons, students are encouraged to consider and respond to objections to points of view (especially their own!). They learn too that it is important to express ideas clearly and precisely. This means defining key terms and using central philosophical theories in explaining their viewpoint. Students do not need to learn a great many of these theories, but they should know enough to be able to describe themselves as, for example, having a 'realist' (instead of a 'relativist') philosophy of science, or adopting a 'materialist' rather than 'dualist' philosophy of mind.

References and further reading

- References 3, 4, 5, 7, 10, 18, 19, 20, 23, 30, 31, 38 43, 44, 48, 50 and 51 (see Table 2) provide general resources for this part of the course.
- By far the best site from which to begin researching philosophical ideas is Epistemelinks (reference 31). References 10 and 44 are also recommended.
- For good online philosophy encyclopedias (all of which can be accessed from Epistemelinks) see reference 30.
- Much of this part of the course is about finding and analysing arguments on scientific issues. References 5 and 43 are particularly relevant.

Table 1 Summary of lessons

Section 1 Thinking about science			
Lesson	Summary of activities	Resources and references	Key topics and skills
		For general resources for this part of the course see references 3, 4, 5, 7, 10, 18, 19, 20, 23, 30, 31, 38, 43, 44, 48, 50, 51 (Table 2).	
1.1 Processes of science	Games (Eleusis and Twenty questions) to illustrate processes of science.	Playing cards, one deck for each group of four to five students.	The nature of science and the sort of processes that scientists go through in carrying out a scientific investigation.
1.2 Science and pseudo-science	Discussion and 'sorting' activities relating to science and pseudo-science.	A3 paper, pens and rulers. Reference 10.	Characteristics of science contrasted with pseudo-science.
1.3 Homeopathy: a little of what you fancy	A mini-case study – reading and discussion.	References 35 and 36.	Application of ideas about science and pseudo-science to a contemporary debate.
1.4 The nature of science?	Reading and discussion about Popper's view of the nature of science. Analysis of the cold fusion debate according to Popper's theory.	Reference 46. Part 1, Section 2 (Cold fusion) of this course.	Popper's philosophy of science: falsificationism. The problem of induction.
1.5 Paradigms and revolutions	Reading and discussion about Kuhn's view of the nature of science. Analysis of Darwinian evolution debate according to Kuhn's theory.	Reference 37. Part 1, Section 4 (Evolution) of this course.	Kuhn's philosophy of science: paradigms and revolutions.
1.6 The truth about truth	Reading and discussion about realism and relativism in science as applied to the discoveries of a new planet and of oxygen.	References 45 and 47. Part 1 Section 5 (Oxygen) of this course.	The debate between realist and relativist interpretations of scientific theories. The concept of truth as it applies to science.
1.7 Growing your own philosophy of science	Critical thinking and discussion of a range of viewpoints on the nature of science. Articulation of a personal point of view about science.	Students' notes from Lesson 1.1. Reference 50.	Surveying a range of viewpoints, then using these as a springboard for explaining a personal view.
Section 2 Thinking skills			
2.1 Reasons and points of view	Use of a simple framework to analyse arguments about 'aliens'.	References 39, 49 and 51.	Identification of premises and conclusions. Distinction between points of view and reasons.
2.2 Reasons and objections	Identification and discussion of argument and counter-argument in an article about euthanasia. Application to a personal viewpoint.	References 32 and 51. Part 2, Lesson 2.3 (The end of human life) of this course.	Argument and counter-argument as a means of persuasion.
2.3 Analysing the language of arguments	Identification of vague terms and emotive language in an argument about 'aliens'. Writing clear definitions and explanations.	References 38, 39, 49 and 51. Dictionaries.	The importance of defining and explaining key terms. The power of emotive language.

1 INTRODUCTION TO THINKING PHILOSOPHICALLY ABOUT SCIENCE

This section introduces the study of philosophy in relation to science.

Key topics and skills

In this section of the course, it is intended that students encounter:

- terms used to describe science (model, hypothesis, induction, etc.)
- accounts of the nature of science proposed by Popper and by Kuhn
- realist and relativist views of science
- identification of arguments for and against a point of view.

1.1 Processes of science

During this lesson students will engage in a series of games designed to amuse and also to illustrate aspects of the scientific process.

Aims

In this lesson students should:

- think about the nature of science and the sort of processes that scientists go through in carrying out a scientific investigation.

Student book pages 134–137

Lesson outline

What is philosophy? What is science?	(5 min)
Activity 1 Eleusis	(15 min)
Activity 2 Twenty questions	(10 min)
Processes of science	(10 min)

Resources and references

- Playing cards, one deck for each group of four to five students.

What is philosophy? What is science? (5 min)

A very brief introduction should emphasise that although this lesson is meant to be enjoyable, it does have a serious aspect to it and students should be prepared to make brief notes that will help them with later lessons.

Activity 1 Eleusis (15 min)

Eleusis is played by dealing ten playing cards to three or four people. A fourth (or fifth) person in the group does not have any cards. It is their task to make up a rule that determines how the cards are to be played, and it is the task of the other players to discover what the rule is. (The game is described in detail in the Student book.)

A round of Eleusis can take up to 5 minutes, so there might not be time to give everyone a chance to make up a rule. Allow enough time to summarise the ideas that can be drawn from the game afterwards.

Activity 2 Twenty questions (10 min)

The idea behind Twenty questions is that the 'experimenter' may ask up to 20 questions that can be answered 'yes' or 'no' in order to identify an object chosen by the rest of the group. At any time the experimenter is able to guess what the object is (based on the answers to the questions asked). If they have not correctly guessed after 20 questions, then they have lost.

Select one person from the class and send them outside while the rest select an object in the room that is reasonably obvious. Remind the class of the rules. After one game, select someone from the class who is reasonably flexible and send them out. Now agree with the class that you will not decide on an object, but answer each question randomly – the only proviso being that the answers have to be consistent with one another. This round will be harder and you may have to adjudicate on the consistency of answers. In the end, it should be possible for the group and the questioner to come to some agreement about what the object is!

Processes of science (10 min)

Summarise the lesson by pointing out the comparisons that can be drawn between science and the games.

Point to the similarity between the formulation of questions (in Twenty questions) and the design of experiments. In Eleusis, an 'experiment' is carried out by playing a card and seeing whether the outcome is as predicted. Just watching the game without being able to decide which cards are played is similar to the process of making observations in science (as in astronomy, for example).

It is worth discussing the role of hypotheses and models in both games, as explained in the Student book. It is also useful to discuss the term 'theory', which is used in science to mean an underlying framework of rules, often relating to a particular model. This is unlike common everyday usage where the term is often used to mean a guess.

It is quite possible in either game that the experimental information does not constrain the rule or object uniquely – in which case the players either guess or make a judgement based on what they know of the other people involved. Similarly in science, experimental results do not uniquely constrain the choice of theory.

You may wish to discuss the terms 'induction' and 'deduction'. Induction is the type of reasoning in which a generalisation is made on the basis of limited experience. Deduction means 'proof using logic'. If I observe 1000 white swans, I could form the hypothesis that 'all swans are white' using induction. The data provide support for this conclusion, though they do not prove it. I could, however, use deduction in testing the hypothesis: if all swans are white, I can deduce that every swan I see will be white. With deductive arguments, if the premises (the starting points) are true, the conclusion follows as a matter of logical necessity.

Further work

Students may be asked to write some brief notes on how each of the games illustrates different aspects of science. They should also write a paragraph giving their thoughts about what science is. If you are in a position to collect this from them, it will be instructive to return it to them in a few lessons' time so that they can reflect on how their views have developed.

1.2 Science and pseudo-science

Aims

In this lesson students should:

- compare and contrast scientific, pseudo-scientific and other activities
- clarify their views about what characterises a science.

Student book pages 138–138

Lesson outline

Science or pseudo-science?	(5 min)
Activity 3 Pseudo-science	(5 min)
Activity 4 Is it science?	(10 min)
Activity 5 Characterising science	(10 min)
Activity 6 A science decision tree	(10 min)

Resources and references

- A3 paper, pens and rulers.
- Reference 10 (see Table 2).

Science or pseudo-science? (5 min)

Explain to students that this lesson is about how we might distinguish science from activities that seem similar (like astrology) but that would not now be classed as genuinely scientific. Activities such as these are termed pseudo-science. Throughout this lesson, students can refer back to the work of Lesson 1.1, which illustrated aspects of how science is carried out.

For all the activities in this lesson, students could initially work in pairs or small groups and record their ideas on large sheets of paper for discussion with the whole class.

Activity 3 Pseudo-science (5 min)

First, students should think about why the distinction between science and pseudo-science matters. Three good reasons for making a distinction might be as follows.

- Money: much science is sponsored by government and industry. Is this money being used sensibly?
- Lifestyle: many decisions we make about our lives and health are on the basis of recommendations from 'experts'. Are these recommendations (e.g. concerning diet plans or food safety) based on genuine scientific research?

PART 4

CARRYING OUT A RESEARCH PROJECT

This part of the course is devoted to students' project work. Students taking the *Perspectives on Science* course in a single academic year should spend approximately one term researching a topic of their own choosing, writing a report on their research and giving an oral presentation on their work. It is envisaged that approximately half the timetabled class time will be devoted to structured activities supporting students' work and the other half will be available for students to work independently.

Table 1 summarises the lessons suggested for this part of the course. The first section suggests some introductory lessons and activities to help students get started on their projects. Sections 2 and 3 provide materials for structured lessons on the written report and oral presentation (respectively), probably involving the whole class, which can be used at various times during the research period. The order in which these sections are printed is *not* intended to be a teaching order; students need to develop oral presentation skills alongside working on their written reports, so the lessons need to be interspersed with one another. Finally, there are some photocopiable sheets (see Table 2). Some of these are linked to specific lesson activities while others contain information about resources; some of this information is general while some, depending on the topics chosen, might be relevant to individual students.

Table 1 Summary of lessons

Section 1 Introducing the Research project			
Lesson	Summary of activities	Resources and references	Key topics and skills
		For general resources for this part of the course see Student sheets 7–15.	
1.1 The *Perspectives on Science* Research project	Introduction to the research project. Discussion of research questions. Drafting research proposals.	Copies of Research proposal forms (available from Edexcel).	Formulating a research question. Writing a research proposal.
1.2 Planning the Research project	Producing an outline timetable for the Research project.	Copies of Sheet 1.	Planning and time management.
Section 2 Written report			
2.1 Introduction	Drafting an Introduction based on the research proposal.	Access to library and Internet. Copies of students' research proposals.	Writing clearly. Defining key terms.
2.2 Literature review	Researching and writing a mini-Literature review.	Access to library and Internet. Copies of Sheet 2.	Extracting and summarising information.
2.3 Good communication	Identification and discussion of factors affecting the quality of written communication.	Copies of Sheet 3 cut into cards.	Writing effectively. Critical review and editing.
2.4 All my own work	Discussion of plagiarism from an ethical and pragmatic viewpoint.	Copies of an 'essay' produced by cutting and pasting paragraphs from two or more students' recent work, or copies of Sheet 4.	Awareness of deliberate and accidental plagiarism. Awareness of why plagiarism is wrong.
2.5 Bibliography and footnotes	Writing footnotes and references to provide information about source material.	Examples of journals or books that include references to other sources (e.g. reference 2). Examples of books or journals that include footnotes. A selection of books and other printed resources, possibly with some relevance to students' Research projects. Internet access.	Recording references. Producing a bibliography. Use of footnotes.
2.6 Using web resources	Critical discussion of web resources.	Internet access.	Critical reading.
2.7 What do you think?	Development and clarification of a point of view relating to the Research project.	Copies of Sheet 5.	Oral communication. Analytical thinking.
2.8 Discussing discussions	Establishment of the purpose of the Discussion section. Using a template to plan the Discussion.	A selection of recent newspapers. Internet access to recent newspapers (e.g. reference 3). Copies of Sheet 6.	Presentation and analysis of arguments.

1 INTRODUCTION TO CARRYING OUT A RESEARCH PROJECT

This section introduces the study of philosophy in relation to science.

Key topics and skills

In this section of the course, it is intended that students encounter:

- formulating a research question
- writing a research proposal
- planning and time management.

1.1 The *Perspectives on Science* Research project

Aims

In this lesson students should:

- find out about the Research project they are to undertake
- discuss possible research questions
- draft research proposals.

Lesson outline

The *Perspectives on Science* Research project (20 min)
Activity 1 Writing a research proposal (20 min + homework)

Resources and references

- Copies of Research proposal forms (available from Edexcel).

Student book pages 186–188

The *Perspectives on Science* Research project (20 min)

By this stage of the course, students should already be aware that they are to carry out an individual Research project and this has probably been mentioned in several previous lessons. The Student book summarises the main features of the project and gives some general advice. Talk through this, and any additional information from the Specification for the Qualification, to ensure that students are fully aware of what they will need to do. In particular, students need to write a research proposal before the main period of project work and this must be submitted in time to meet an externally set deadline. Some more detailed information about the Research project (the written report and oral presentation) is given in the Student book for Lesson 1.2 of this section. You might want to discuss this with students before they start work on the research proposals.

Activity 1 Writing a research proposal (20 min + homework)

Writing the proposal is one of the key parts of the Research project, and is a demanding task both for the student and for the teacher-as-supervisor. It is unlikely that many (if any) students will write a good proposal at the first attempt. Be prepared to spend some time discussing ideas for proposals with the whole class and with individual students, both during this lesson and subsequently.

As set out in the Student book, a project is most likely to succeed if the research question:

- is interesting to the student
- relates to an area of science the student feels fairly confident of understanding
- provokes strong and varied opinions
- has ethical and philosophical dimensions
- is one where the student already has some ideas for where and how to find more information.

Even when a proposal satisfies all these criteria, it may still need some discussion and further refinement. Dangers to be aware of include the following.

Too ambitious

A student might be passionately interested in a large number of questions relating to a topic area.

For example, s/he might have strong views about the possible social and economic consequences of genetic modification as applied to crops, domestic animals and 'designer babies' and wish to explore all these and more in the project. Encourage such a student to focus on one main question in the first instance, suggesting that it can perhaps be broadened later on if time permits.

Too vague

A student might be interested in a general area but have little idea of how to turn this general interest into a research question. For instance, someone might want to do 'something about astronomy or cosmology'. Try to tease out some specific questions such as 'How did the discovery of galaxies in the early twentieth century alter people's perceptions of the universe?' or 'Should the search for extra-terrestrial intelligence be a priority for UK government-funded research?'.

Too 'way out'

There is nothing wrong with students choosing to research a highly unusual and original question provided it falls within one of the broad topic areas specified. But it is important to ascertain, as far as possible, whether there will be a suitable body of literature for them to consult, as well as discussing with them whether their suggested question does indeed lend itself to the sort of scientific, ethical and philosophical discussion required. Students who have genuine but unusual interests can be asked to provide evidence of literature resources before you agree to their proposals.

Too little scope for ethical and philosophical discussion

It might happen that a student has developed a keen interest in an area of science that might be more suited to a 'straight' piece of science or technology coursework, e.g. 'autotrophism in plants' or 'powered flight'. Such topics would in general be unsuitable for the *Perspectives* Research project as their investigation tends to focus on the scientific principles rather than on philosophical or ethical aspects. However, it might sometimes be possible to identify, in discussion with the student, a related topic that has more scope for the type of exploration required.

1.2 Planning the Research project

Aims

In this lesson students should:

- produce an outline timetable for their Research project.

Student book pages 188–192

Lesson outline

Research and writing	(15 min)
Oral presentation	(5 min)
Activity 2 Planning	(20 min)

Resources and references

- Copies of Sheet 1 (Table 1 from the Student book).

Research and writing (15 min)

This lesson sets the scene for students' work on their projects. It is important they have a clear idea of what is expected of them and how their lessons will be used. The following notes are mainly written for you as a teacher/assessor, but it is useful to bear them in mind when discussing the project timetable with students.

The second half of the course is when the majority of the work for the students' Research projects will be done. During this period, approximately half of the lesson time and most of the homework time will be given over to work on the Research projects. The remaining lesson time will be spent on a variety of formative exercises designed to equip students with the skills needed to conduct research and to strengthen the thinking skills they have begun to develop during the first half of the course.

It is expected that the teacher's role during this section of the course will mainly be as a facilitator. Instead of traditional teacher-led instruction, the focus should be on prompting students and giving direction to their research.

Challenges

Writing the Research project report requires students to take charge of their own learning and to assemble the materials and arguments to support their point of view. This is a difficult task for a number of reasons.

- Different students progress at different rates.
- Few have the time management skills to plan for themselves a large assignment.
- Students can head off down blind alleys.