

# What constitutes high-quality discussion in science? Research from the Perspectives on Science course

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**ABSTRACT** Perspectives on Science (POS) is a unique research-based post-16 course that addresses the history, philosophy and ethical aspects of science. Our central research question was to what extent is POS successful in promoting high-quality discussion in class and what factors influence this. Through questionnaires, interviews and observations of discussion episodes we were able to identify the most prominent characteristics: the instrumental role of the teacher, the introduction of conflict, and a balance between respect for rational argument and the advocacy of a position with passion.

## Introduction

Reforms to the science curriculum in the UK and other industrialised countries emphasise the importance of science in its relationship to other disciplinary contexts, and the ability to think and argue critically and to engage in productive democratic discussion (Millar and Osborne, 1998). These reforms have been implemented in contemporary science courses at high school/secondary school levels, such as the Science Education for Public Understanding Program (SEPUP) in the USA and Twenty First Century Science and Science in Society in the UK.

While these reforms reflect consensual changes to the science curriculum, they are far from straightforward to develop and implement. Discussion in courses focusing on the nature of science and socio-scientific issues have been reported as being equivocal in their success (Osborne, Duschl and Fairbrother, 2002). Contributory factors could be science teachers' lack of confidence in managing open-ended discussion, particularly on those scientific dilemmas, problems and issues that have no clear-cut answers (Bryce and Gray, 2004; Levinson and Turner, 2001) and that science teachers, on the whole, appear to favour a pedagogy that promotes certainty and a positivist way of thinking (Donnelly, 1999). Guiding open discussion is not only a challenge to science teachers; humanities teachers also find it difficult to implement (Rudduck, 1986) and

a review of the teaching of English in English schools indicated that '*in too many classes, discussion is dominated by the teacher and pupils have only limited opportunities for productive speaking and listening*' (Ofsted, 2005: 1).

## Perspectives on Science

The production and implementation of a new course aimed at 16- to 19-year-olds in the UK, Perspectives on Science (POS) (now an Extended Project), has embraced recent curriculum reforms and highlighted interdisciplinarity, enquiry and discussion as fundamental to the aims of the course, placing the learner at the centre of the knowledge construction process (Taylor and Swinbank, 2007).

In POS, the emphasis throughout is on the development of skills rather than the learning of factual content: '*The purpose of the course is to equip students to think critically about the profound and exciting historical, philosophical and ethical questions raised by science*' (Taylor and Swinbank, 2007: 41). Students spend the first half of the course learning relevant skills and vocabulary in the context of selected case studies where the course '*is designed to provide maximum opportunity for discussion and debate*' (Taylor and Swinbank, 2007: 41). Hence topics in the textbook *Perspectives on Science* (Swinbank and Taylor, 2007) contain some activities for reflection and critical thinking, followed by a stimulus for discussion (Box 1). In the second half, students

### BOX 1 A sample discussion point from the *Perspectives on Science* textbook

*'There is little doubt that the adoption of an "opt out" rather than an "opt in" system for organ donation would significantly increase (probably by a factor of more than two) the number of lives saved each year through organ donation. Discuss whether such an "opt out" system should be introduced into the UK. Jot down a list of bullet points in favour of such a system, and a list of points against.'* (Swinbank and Taylor, 2007: 102).

carry out individual research projects in which they investigate the 'story' behind a question with a scientific dimension, explore historical, ethical and philosophical aspects of that question in depth, and present the outcome of their research both orally and in writing. Ninety per cent of the marks are given for the essay and 10% for the oral presentation that also involves responding to questions from their peers and teachers. The key concepts of interdisciplinarity, critical thinking and discussion are thus firmly embedded in its design.

### Purpose of the research

Through its purpose and design, *Perspectives on Science* offers an opportunity to identify ways of approaching and enhancing discussion in an interdisciplinary science-based course. The aim of our research was to identify what and when high-quality discussion took place and the factors that promoted or inhibited it.

### Research design

We used a mixed method research design combining survey questionnaires, semi-structured interviews and classroom observations. The questionnaires were intended to yield a broad overview of teachers' and students' perspectives on the quality of class discussion. In the population cohort that we had access to, there was a 60% ( $n=261$ ) response rate for students and a 70% ( $n=14$ ) response rate for teachers.

The interviews elicited more detailed, considered and nuanced perspectives than those gathered from responses in the questionnaire and provided data sets for triangulation; the observations enabled us to assess the quality of class discussion for ourselves. For the semi-structured interviews and classroom observations, we selected four

POS centres, representing one-fifth of the number of centres registered for the examination. We conducted individual interviews with teachers and focus group interviews with students in each of the POS centres we visited. All participants were asked what they considered to be the features of a good-quality discussion and about the degree to which they thought their own class discussions possessed those features. Within this broad framework we allowed ourselves considerable freedom to tailor our questions to participants' responses and to follow up interesting issues and lines of thought as they presented themselves

As well as observing class discussions, we asked centres to make video recordings of class discussions when they occurred and send them to us. The advantage of this strategy was that students participating in discussion were not inhibited by the presence of a stranger in the room. Our observation transcripts, then, included both discussions we observed and recorded ourselves and discussions that were recorded and sent to us by centres.

### Factors promoting high-quality discussion

From a review of the literature on discussion (Bridges, 1979; Dawson *et al.*, 2009; Hand, 2008; Hess, 2009; Mercer and Littleton, 2007), we identified the following attributes of a high-quality discussion:

- deployment of sufficient knowledge to pursue an enquiry and to acquire relevant knowledge to address a question or form of enquiry;
- consistent use of rational argument in supporting claims;
- contributions from a range of participants without anyone feeling excluded;
- a critical approach and an openness about difference;
- respect between participants in helping to promote dialogue;
- participants' willingness to change their minds, together with the use of persuasive language.

From the research we carried out, the following factors are those we identified as being crucial in promoting the various criteria of high-quality discussion in POS. These are:

- the role of the teacher;
- the choice of discussion topic;
- classroom organisation;

- diversity and passionate commitment to viewpoints.

We will deal with each of these in turn.

### The role of the teacher

We were able to identify four different ways, often found combined in two or more ways, in which the teacher enabled good-quality discussion:

- as facilitator;
- as promoter of critical enquiry
- as developer of reasoning skills;
- as knowledge resource.

### Teacher as facilitator

Facilitating is an approach whereby the teacher sets up and frames a discussion and encourages participants to speak but makes little or no contribution to the content of the discussion. Teachers favouring this approach were alert to the need for sensitivity to students' differing levels of confidence, independence and skill in discussion, and that levels of participation would be likely to vary:

*At some point everyone will contribute. But it's going to be very variable and again I see it as a progression from each individual student that's starting off from a completely different position from another student. So I wouldn't necessarily be worried if they didn't all talk for the same amount of time with the same passion, because they are all different and it is very much a course about independence and the fact that they're developing their own skills from different points. (teacher)*

This approach was shared by other teachers, although some occasionally saw the need to prompt participation, particularly when progress in the discussion was lagging, as recognised by their students:

*if ... somebody actually wasn't talking then either Mr J or Mr D would ... just cut in and say 'What's your opinion?' but I think quite a lot of the time as well, people brought in other people's ideas that they had heard of earlier and then they were kind of forced into the argument a bit. (student)*

### Teacher as promoter of critical enquiry

In promoting critical enquiry, the teacher plays a more active role in the discussion, prompting students to think critically and justify their claims. In such a role, the teacher neither takes a wholly neutral stance nor necessarily exposes their

own views. The teacher is alert to the problem of unjustified assertions or beliefs, thereby preventing closure of the discussion through easy consensus. This can be evidenced by an interchange between a student and the teacher in a class discussion where the teacher refuses to allow the student to let a comment rest on a personal belief about abortion.

Teacher: *What about if the child was a product of rape? Would the mother's right outweigh the baby's right there, or would you disagree with that?*

Student: *I personally think it would, but it's a personal matter of what you believe in.*

Teacher: *Why do you think it would? What is it about the situation that you think it would?*

Student: *I guess it would depend on how the mother treats the child when it's born as well. It's not her fault, so it's not a choice that she's made.*

Before this exchange, the weight of opinion in the class has been leaning towards the view that the unborn child's right to life trumps the mother's right to choose. So when the student finds herself wanting to defend the mother's right to choose in the scenario suggested by the teacher, she is conscious of taking a position apparently at odds with those of her classmates. This may well be the reason for her attempt to insulate her opinion from criticism by classifying it as 'a personal matter of what you believe in'.

The teacher refuses to accept – or, more precisely, simply ignores – the student's attempt at reclassification. She continues to treat the opinion as the sort of thing for which the student should be able to produce reasons, and should be willing to give up if she cannot do so.

The justification of its being 'a personal matter' was also identified as one of the main obstacles to discussion but the ability of the teacher, or possibly another authoritative figure, to encourage reasoning that goes beyond the 'personal matter' opt-out is crucial to overcoming this obstacle. In a discussion in another school without the teacher, one of the students presents an argument against capital punishment. Student A has been trying to point out to the other four students in the group that views on capital punishment could not be made out of context and those in favour of capital punishment had to consider what it might be like if a member of their own family were to be judicially executed.

However, the move by Student B, 'It's just people's opinions', brings the discussion to an abrupt end, much to the evident annoyance of student A.

Student A: *If your dad killed someone, you'd still want him there. You wouldn't want him dead.*

Student B: *So? It's just people's opinions, isn't it?*

Student A: *It can't be different for everyone apart from your dad!*

Student B: [talking over student A] *This whole argument's useless. It's just people's opinions.*  
[long silence]

Student C: *So, shall we just ... end it there?*

Through our interviews with students and teachers we were able to discern two distinct ways in which preparation for discussion took place. The teachers recognised that discussion went beyond spontaneous talk and that (1) an understanding of what constituted a good argument and (2) an adequate background of knowledge were conducive to fruitful discussion. These two components could be realised through the process of discussion but these were elements that teachers were at pains to develop before discussions took place.

### Teacher as developer of reasoning skills

Students learn how arguments are grounded and the logical procedures by which claims can be made by studying philosophy. In the centres we visited, this explicit teaching of how to prepare an argument was in evidence, and in one centre in particular had been developed to a high degree. Students were encouraged to analyse arguments and texts:

*It's like a breakdown, there's a whole text you get from the newspaper and you take out certain words, you highlight certain words and you break them down then you start to reduce the argument to a core box so you dissolve all the paraphernalia of the text and you get what's actually there and it just makes it a lot easier, it's so good doing that. You get certain topics so his idea, his general beliefs and then what objections we have to that and then what arguments we have to that. It's a system that works really well to approach pretty much anything.* (student)

They also valued the intellectual tools that they had been given to test the validity of arguments in discussion:

*We've been given an ethical framework to base arguments around so we can come at it more objectively, we know different points of views. ... what I found particularly interesting in the first year which was how an argument is developed so we look at premises, at all that, so it was more about how to think about arguing.* (student)

Students noted a range of ways in which teachers sought to develop their reasoning skills. These included:

- introducing ethical frameworks for structuring an argument;
- systematically analysing texts as a basis for discussion;
- focusing explicitly on connecting claims with evidence and argument;
- acquiring a strong enough knowledge base to sustain a discussion.

### Teacher as knowledge resource

One of the purposes of discussion is to gain knowledge (Bridges, 1979) but students also need a knowledge base to get started and to ensure that information is accurate, although this knowledge base need not be very deep. Teachers were able to support students by giving them an appropriate knowledge background as and when needed. This could well be a distinct advantage in a course where the primary aim is skills based rather than knowledge based.

*... the students had sufficient facts ... to have a debate. That's a real skill in teaching. I've seen lessons (other than in POS) where the teacher saturates the students with facts, where the more facts they get the less able they are to have the discussion and make the value judgements and the less able they are to extract the information around the topic.* (teacher)

Occasionally, students introduced incorrect information into a discussion that, in one case, the teacher either failed to notice or chose to ignore, possibly because this would have impeded progress in an otherwise lucid and remarkably well-informed discussion on xenotransplantation. In the event, the student's incorrect information did not appear to have a material effect on the discussion's progress but a teacher might choose to rectify the information at the end rather than risk closing down a genuinely open discussion.

Students recognised the role of teachers in questioning the facts that they advanced and

how teachers helped them to look for relevant information to prepare for a discussion. All the students we spoke to valued the teachers as authoritative and reliable figures with the facility to distance themselves gently when there was any sign of the students becoming dependent.

Where we observed discussions without a teacher present, they had a tendency to drift, little use was made of relevant knowledge and, where students did begin to develop arguments or advance reasons in support of their opinions, the absence of an authoritative figure made it much less likely that their contributions were taken seriously. This is not to say that without a teacher present students do not have discussions driven by critical thinking and relevant knowledge; nevertheless, the involvement of a teacher, in one of the roles we have outlined, does appear to be a significant factor in the achievement of high-quality discussion. The presence of the teacher might be more important at the start of the course, followed by a gradual and sensitive distancing as students become more confident as discussants and more respectful of each other's points of view.

#### The choice of discussion topic

One striking feature of the discussions we observed is that all but one of them were explicitly focused on the ethics, as distinct from the history or philosophy, of science. The ethical issues we saw being discussed included xenotransplantation, organ donation, genetic engineering, abortion and capital punishment. These discussions had some notable common features that are likely to have contributed to the liveliness and high level of student participation:

- at least some students appeared to have pre-existing opinions on the issues;
- there was some diversity in these opinions;
- students seemed willing to engage in discussion about the issues in the absence of much relevant substantive scientific knowledge.

These observations suggest that issues in the ethics of science may be more conducive to high-quality discussion than issues in the history or philosophy of science, at least where discussion is attempted without extensive prior study of the issue in question. Ethical questions, because they tend to loom larger in the media and in everyday life than philosophical and historical questions, may be more familiar and accessible to students,

and therefore they are more likely to hold and be willing to express opinions on them. Indeed there is plenty of evidence that students do have a diversity of views on a range of bioethical issues (Hill, 1998; Macer, 2004). This is not, of course, to suggest that discussion of historical and philosophical topics should be avoided but rather that such discussions are likely to require more extensive instructional groundwork and more familiarity and comfort with the practice of discussion.

The one non-ethical discussion we observed was about a newspaper article reporting some research on the degree to which people's lives follow genetically predetermined paths. The article was intended by the teacher to prompt discussion of the philosophical problem of free will and determinism. In fact, students appeared reluctant to discuss this problem, even when given some fairly strong steers by the teacher, preferring to focus on questions about the methodology of the reported research. One possible explanation for this is that the philosophical issue was not one to which the students had previously given much thought, or not one they felt confident about discussing in the absence of relevant knowledge.

Problems in teaching philosophy raised broader questions because only a quarter of those teachers who returned questionnaires had taught courses relating to the philosophy of science before POS. Seven out of the ten teachers who felt that they needed extra professional development specifically mentioned philosophy as an area in which they needed to develop their knowledge and expertise. While teachers on POS might be adept at handling discussion on ethical issues, the expertise needed to scaffold the discussion to philosophical argumentation is generally lacking.

#### Classroom organisation

Both teachers and students mentioned a group size of about 12 as being optimal for allowing a wide-ranging exchange of views in which everyone has a chance to contribute. Some students also commented on the advantages of discussing in small groups of just three or four, noting that this gave them an opportunity to air their views freely and without inhibition:

*... some of the best discussions may not be in like a huge group but actually just between like two or three people where you can actually go deeper into what you're actually saying, what you actually understand ... (student)*

Small-group discussions, when organised by a teacher, had specific purposes that were designed to facilitate the narrative of the class discussion:

- locating misunderstandings;
- elucidating points of facts;
- in initiating a discussion, raising pertinent questions.

These strategies have much in common with good practice (Hogarth *et al.*, 2005). Often these groups formed spontaneously from larger group discussions and, while they had no managerial structure such as group leader or chair, achieved their purposes, as we found from interviews with teachers and students and from our own observations. This may well have been because students had previous practice in structured small-group discussions.

#### Diversity and passionate commitment to viewpoints

One factor identified by many of the teachers and students we spoke to as being highly conducive to good-quality discussion was diversity of views among students (Hogarth *et al.*, 2005). While it is possible, and sometimes desirable, to ensure that a diversity of views is represented in a discussion by asking students to defend views they do not in fact hold, it was generally felt by students of POS that genuine differences of opinion in a class helped enormously in generating worthwhile discussion.

In addition to the need for a diversity of student views, many participants thought the quality of class discussion was significantly enhanced by students holding their views strongly or passionately. One reason given for this was simply that discussions are more interesting and dynamic when animated by passion and persuasive language. Another was that students tend to be more ready and better able to advance arguments for positions that they feel strongly about.

Related to the idea that discussion is enhanced by passionately held views is the idea that it is enhanced by extreme ones. Some such connection is implied by the following student assessment of what makes for a good discussion:

*It sometimes makes it more interesting if you've got two people who are passionately on opposite sides of the argument, or someone who can argue passionately for one side or the other. Not just because it makes it a bit more forceful, but you can sort of then get wider ends of the spectrum and try and work out where you're going to fit in.* (student)

Passionately held views, this student plausibly suggests, tend to be located at the ends of spectra: extreme positions, perhaps, need more passion to sustain them than moderate ones. What this can do, he thinks, is stake out the disputed territory in a way that is helpful to the undecided in their efforts to 'work out where you're going to fit in'.

Diversity of views and passionately held and extreme student views were all present in the most sustained, coherent and argumentative of the discussions we observed. This particular discussion of xenotransplantation was driven by two powerful central figures, one passionately and unambiguously committed to the utilitarian view that xenotransplantation is entirely unobjectionable and will save lives, the other that it flouts the natural order of things. Although their voices were dominant, these two did not exclude or drown out other participants, and their contributions could be seen as staking out the ethical terrain in a way that allowed others to start working out where they stood.

Discussions in POS not only challenged students' ideas but influenced their opinions, which was reflected in the degree of openness among the students and their willingness to check credulity in their own intellectual assumptions:

*... using the animals testing, for example, I did that for my essay and like at first I was dead set against it but after like, I had to at one point argue for it in class and that did change my viewpoint but only because it made you think about other contributions.* (student)

*... when you start voicing your opinions early on it's quite nice at the end of the lesson you can pretty much be won around by everyone else and have a completely different opinion, I think.* (student)

#### Discussion

As a course where one of the primary purposes is to develop discussion skills, POS is distinct from many other courses on the school science curriculum since knowledge is brought in to support reflection and decision-making. There is less of an onus to teach substantive content and more to support argumentation. Many of the teachers on POS chose to initiate the course in their school because of this value and have commented on the difference and opportunities for exploration compared with standard science courses. A course that is specifically designed to promote discussion might have implications for other subjects.

Our research has sought to identify what criteria constitute high-quality discussion and the factors that promote such discussions in the context of POS. We have not theoretically justified the relationship between these factors and the criteria, and more research is needed in this area. Nonetheless, it is clear that teachers scaffold students' skill and knowledge both socially and procedurally in terms of group participation and the critical thinking skills needed to address controversial points. However, it appears that the level of discussion is limited to specific areas of ethics and that teachers need professional development in helping students to enhance their skills in deeper and more challenging philosophical argumentation.

Obstacles to discussion were identified throughout the research project and the factors

we identified were seen to overcome these obstacles. One such factor is the way in which a naïve relativism, anything goes or 'it's just my opinion' move can be challenged by teachers to open up the discussion and enhance critical thinking. Another similar move that has the possibility to enrich discussion but was often used as a blocking move was the 'this is what my religion tells me' approach that was seen as a source of comfort to some students but irritated others in stanching discussion. Again, the ability of a teacher to forestall closure, for example by helping to elucidate the distinction between belief and evidence, might have similar effects to the moves by teachers to encourage arguments to justify a point of view. Passionate commitment overall provoked thought and helped to challenge received opinions.

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