Comparing the effect of scientific and socio-scientific argumentation tasks: lessons from South Africa

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Do argumentation tasks allow students to demonstrate their full abilities? How is this influenced by teachers’ actions and students’ cultural background?

When a new curriculum was introduced in grades 10–12 (typically students aged 14–16) in South African schools in 2006, considerable emphasis was laid on developing students’ abilities as critical and creative thinkers. In biology, for example, they are required to ‘understand the nature of science and the influence of ethics and biases in science’ (Department of Education, 2004: 28). These requirements are similar to curriculum changes elsewhere, for instance the recent introduction of a strand called ‘How science works’ to key stage 4 (students aged 14–16) of the National Curriculum for England (DfES/QCA, 2004: 37). These changes represent a move from a content-oriented curriculum towards a focus on scientific literacy and ‘ideas about science’ (Goodrum, Hackling and Rennie, 2001) and are already having an impact on the design of assessments (Roberts and Gott, 2006). One major area of critical thinking is considered to be the ability to formulate an argument. Argumentation (the process of arguing) requires students to engage with data and evidence, to make claims based on these and to weigh the extent to which others’ claims can be substantiated (Erduran, Simon and Osborne, 2004).

Several formats of an argumentation task can be distinguished (see Box 1). Tasks may ask small groups to take different positions, that is, to defend a given position or to oppose a given claim. Such a task may lead to a whole-class debate. Alternatively, tasks may centre around different types of claim. The task’s argumentation claim may be scientific, socio-scientific (with possible ethical or political dimensions) or existential in nature. The type of evidence available to students to argue socio-scientific and existential claims may not be shared amongst students from different cultural backgrounds. Thirdly, argumentation tasks may be open-ended (what do you think is the reason for this phenomenon?) or closed (requiring students to select from a few given explanations of a phenomenon and provide argued reasons). Lastly, argumentation tasks may differ in the amount and the nature of evidence (numerical data in tables or graphs, text, pictures) that is provided explicitly with the task.

ABSTRACT
This article contrasts two types of argumentation lessons, one dealing with a socio-scientific topic and another with a pure scientific topic in the same school in Cape Town, South Africa. For each lesson we identify critical incidences – key moments in teaching either supporting or hindering successful argumentation among students. The analysis of dialogue sequences shows that there are common lesson features improving the level of argumentation. Differences emerge for both lessons in terms of the nature of argumentation that results. There is room for both types of argumentation task in science lessons. The features of teaching that might lead to successes in using both types are discussed.
Toulmin (1958) developed a typology of argument structure in normal discourse. In Toulmin’s model the ability to formulate a strong argument hinges on the effective use of evidence to support claims made and, at a more sophisticated level, to challenge the claims and supporting evidence made by others. Toulmin’s general scheme recognises that there should be a claim (an assertion or conclusion) based on data (evidence that can either be explicit information or views based on ethics or morals). In a strong argument the claim is supported by warrants (a reason for making the claim), in turn supported by backings (scientific models or laws). The claim may have a qualifier (limitation of the applicability of the claim), and can be challenged with a counter-claim (an alternative assertion) or a rebuttal (a reasoned rejection of claim, warrant or backing). These different components of an argument have been used to define different levels of sophistication for argument discourse in the classroom (Erduran et al., 2004).

Recently, research has been reported on the teaching of argumentation (Newton, Driver and Osborne, 1999) as part of supporting understanding in the major area of ideas about evidence. Osborne, Erduran and Simon (2004) developed and tested sets of pre-written lessons materials (the IDEAS pack) fostering argumentation for the National Curriculum in England. In addition, Simon, Erduran and Osborne (2006) report a typology of pedagogic strategies adopted by teachers when implementing argumentation lessons. The study reported here draws, in part, on tasks in the IDEAS pack.

**Purpose of research**

This article explores the nature of the discourse in student groups and of teacher scaffolding when engaging with two types of argumentation tasks. It compares and contrasts two types of argumentation lessons in two grade 10 biology classes in the same school in Cape Town, South Africa. The task in one lesson deals with a socio-scientific topic with evidence provided in the form of opinion pieces from newspapers. As such it provides for discussion of a controversial issue of the type described by Levinson (2006). The other task deals with a pure scientific topic and evidence was made available in the form of a set of short scientific statements. This task was drawn from the IDEAS pack (Osborne et al., 2004). In doing this we are looking for key features of teaching that seem to be successful in promoting effective argumentation among students.
The following research questions are addressed:

- What is the nature of the student interactions in argumentation classes for socio-scientific and scientific argumentation tasks respectively?
- What teaching interventions stimulate the use of higher levels of argumentation?

The school

Both biology lessons were taught at Arcadia High (not its real name), a well-resourced school similar to many schools in towns and cities in industrialised countries such as the UK. The students do not live in the school environment but are mostly boarders who have been selected from various previously disadvantaged schools around the Western Cape because of their abilities or aptitudes in science subjects. The school has a multicultural learning environment and most students learn in English (or Afrikaans) as their second language. The school was started to increase the percentage of students who choose to take science- or mathematics-based careers. The two qualified male science teachers who taught the lessons, Mr Van Rhyn and Mr Jacobs (not their real names), have 14 and 9 years of teaching experience respectively.

The lessons

Mr Van Rhyn taught a socio-scientific lesson of his own design. The purpose of the lesson was to stimulate argument among his students about Organ trafficking. Thirty students were seated in groups of four. He started by informing the class that the purpose of the lesson was to develop their argumentation skills. He probed their conceptions of what constituted a good argument. He then displayed a chart that depicted components of a good argument, such as drawing on reasons, evidence, facts and so forth. Readings, containing case studies of organ trafficking, were distributed to the groups to read and develop a role-play. Two groups presented. The groups were then asked to take part in an argument to list the pros and cons of organ trafficking. The teacher summarised group responses on the board. Students were then asked to reach consensus, in their respective groups, about whether they supported organ trafficking or not. Mr Van Rhyn facilitated a whole-class discussion in which groups were allowed to defend their positions.

Mr Jacobs taught a ‘scientific’ lesson. The purpose of the lesson was to stimulate argument around the classification of the single-celled organism, Euglena. The Euglena lesson was a highly structured one taken from the IDEAS pack (Osborne et al., 2004). The students (28) were seated in groups of four. Each group was issued with evidence cards containing characteristics applicable to Euglena. The students had to decide, as individuals, whether they thought Euglena is an animal, a plant or neither, by placing their evidence cards in the appropriate category. They shared their reasons for placements, which elicited discussion in the groups. Mr Jacobs recorded responses on the board and facilitated a whole-class discussion in which the groups could defend their positions.

Methodology

The two lessons were videotaped. Usually recordings were made where it seemed students were particularly engaged or where discourse was prolonged and sustained. At the same time as the recordings, field notes were made independently by two researchers to capture interesting teacher behaviours or actions. The framework for describing classroom interactions developed by Scott (1987) was used to organise the video-recordings and field notes to identify general features of the lessons. The first element of the framework, preparation for learning, describes the physical environment and the preparations made by the teacher to ensure that conditions for learning are as effective as possible. The second element, agreeing learning outcomes, accounts for ways in which the teacher helps students to appreciate the intentions of the lesson in terms of skills, content and concepts, and what students must do to demonstrate their achievement against the learning goals set for the lesson. The third element, construction of meaning, describes the main activities through which students construct new knowledge or understanding, whilst the fourth element, demonstrating new understanding, shows ways in which students declare their new learning, for example through group or individual presentations to the rest of the class. The final element of the framework, reviewing new learning, deals with metacognition, that is, examples of ways in which students reflected on their new learning and whether or not they attained the outcomes set for the lesson and their views on reasons for this. This final part feeds back to the first and second stages of the framework, thereby making it cyclic. Figure 1 shows how the two lessons, Organ trafficking (OT) and Euglena (E), have been mapped in terms of this framework.

The discourse in each lesson was analysed in terms of levels of argumentation according to
### Organ trafficking (OT)

1. **Preparation for learning**
   - desks moved for group work
   - students seated in groups of four facing each other
   - resources prepared and ready

2. **Agreeing learning outcomes**
   At two stages, before and after the role-plays (see 3)
   - characteristics of good arguments shown and described
   - roles and rules for group work described and set
   - context for discussion and its relevance described
   - desired outcomes of discussion set out

3. **Construction of meaning**
   Students read about OT then:
   **Part 1: Role plays about OT:**
   - students discuss and rehearse role-plays
   - groups perform role plays
   **Part 2: Argument (discussion in groups):**
   - groups discuss reasons for and against OT (10 mins)
   - each group summarises their reasoning

4. **Demonstrating (applying) new understanding**
   Group feedback and whole-class discussion:
   - each group reports reasons for and against OT
   - teacher summarises/lists reasoning from each group on the board
   - teacher invites others in the class to comment on reasons provided by each group
   - groups decide for or against OT (2 mins)

5. **Reviewing new learning**
   - students are invited to reflect on ways of learning in this lesson and how this differs from normal

### Critical incidents

1. **Preparation for learning**
   - desks moved for group work
   - students seated in groups of four facing each other
   - resources prepared and ready

2. **Agreeing learning outcomes**
   - clearly defined outcomes
   - teacher asks for list of ‘pros’ and ‘cons’

3. **Construction of meaning**
   - challenges where evidence cards are placed
   - teacher asks each group for a reasoned decision [first example of rebuttal (plant movement)]

4. **Demonstrating (applying) new understanding**
   - feedback from each group and class discussion
   - each group feeds back a reasoned choice

5. **Reviewing new learning**
   - summary of students’ contributions – emphasis on ownership of the learning process

### Euglena (E)

1. **Preparation for learning**
   - desks moved for group work
   - students seated in groups of four facing each other
   - resources prepared and ready

2. **Agreeing learning outcomes**
   - Purpose of lesson set out: ‘Euglena, where do you belong?’
   - Plant (P), Animal (A) or ‘other’ (O)
   - Justify the classification using the evidence provided

3. **Construction of meaning**
   - groups discuss cards and decide fit of evidence for P, A or O (8 mins)
   - teacher asks each group to decide if Euglena is P or A, and to record reasons (2 mins)

4. **Demonstrating (applying) new understanding**
   - feedback from each group and class discussion
   - each group feeds back a reasoned choice

5. **Reviewing new learning**
   - summary of students’ contributions – emphasis on ownership of the learning process

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**Figure 1** The structure of the *Organ trafficking* and *Euglena* lessons and critical incident analysis
a system devised by Erduran et al. (2004). Their assessment scheme is based on the extent to which different components of argumentation, as identified by Toulmin (1958), can be recognised as functional elements. The criteria for each of Erduran et al.’s levels of argumentation are set out in Table 1.

It can be seen that the higher levels of argumentation in Erduran et al.’s scheme (levels 3 and above) require rebuttals. At the highest levels (levels 4 and 5) there is an expectation that arguments will be more sustained or developed, with reasoned challenges based on more than one rebuttal or counterclaim. These levels of argumentation were applied to coherent sets of utterances during group discussions and whole-class reporting.

In the second stage of the analysis four researchers independently identified critical incidents that might support or constrain argumentation and might explain why the outcomes of each lesson showed the levels of argumentation ascribed in the previous stage. In this case, a critical incident was defined as any action, utterance or sequence of dialogue by the teacher or by students that could contribute to or constrain the successful outcomes of argumentation. The critical incidents in the two lessons were identified independently by four researchers, and discussed using a typology of teacher behaviours in argumentation in science lessons devised by Simon et al. (2006). These incidents (four in each lesson) are shown in the central column of Figure 1. Each incident has been linked to a specific point mapped against Scott’s (1987) organisational framework for each lesson.

Findings
Levels of argumentation
The levels of argumentation were found to be substantially different for each lesson. In the Organ trafficking (OT) lesson rebuttals hardly occurred, limiting the overall outcome to level 2. In the main group discussion (part 3 of the framework – construction of meaning) students were required, in their groups, to list the pros and cons of organ trafficking rather than to argue about a specific claim or to take up a particular position, thereby limiting opportunities for more developed argumentation at levels 3 and above.

Only one (weak) rebuttal (in part 4—demonstrating new understanding) was made by a student in response to the teacher exploring moral positions and possible clashes between religious beliefs and decisions on medical grounds. The dialogue below occurred during the whole-class plenary discussion that followed individual presentations from each discussion group. The episode was identified as critical incident 3 (OT3) for this lesson. Bold type denotes an emphasis in the voice of the teacher.

T: We now get into a moral issue about this [organ trafficking]. I think, eh, it’s a personal thing. How you feel about your own moral values and how you’ve been brought up will decide eventually what decision [about whether or not to donate a kidney] you will take.

S1: If they [medics] say your son needs a transplant, and you are a suitable donor, but it [having organs removed] is against your religion, you are ... you are ... going to think of your son first. Even though your religion says ... You are going to help your son. The first thing you think about is about helping your son rather than your religion which says he must die. This is what I think.

In the Euglena (E) lesson examples of arguments containing rebuttals were more frequent. The overall level of argumentation was judged to be at least at level 3 and in many cases closer to level 4 on Erduran et al.’s scale. As for the Organ trafficking lesson, arguments containing rebuttals were most noticeable in the plenary, whole-class, discussion (in part 4 of the lesson framework – demonstrating new understanding). In this part of the lesson the need

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to draw an overall conclusion about the nature of Euglena forced group members to provide support for their choices and rebut opposing views, as illustrated below. In this episode, two groups draw on two different sources of evidence (i.e. the data sheet provided and knowledge of environmental influences on growth of local plants). This was identified as critical incident 4 (E4) for this lesson.

T: You want to put another point to support that it [Euglena] is an animal?
S1: It says here [refers to a data sheet] that animals are sensitive to their environment, they have sensory characteristics. And the Euglena is temperature-sensitive, so that makes it an animal; it is sensitive to the environment.

S2 [different group]: On the topic of sensitivity to the environment: Protea seeds, they need heat to germinate. So that would make them temperature-sensitive. So I said it [Euglena] has more plant-like qualities, so it would be a plant. But I can surely move to a sort of a fusion of a plant and an animal.

Eight critical incidents (four in each lesson) were identified and agreed on as being key moments and actions underpinning or hindering successful argumentation. These are described below for each lesson. They are also shown in the central column of Figure 1.

**Critical Incidents in the Organ trafficking (OT) lesson**

**Critical incident 1 (OT1)**
The teacher spent a considerable portion of part 2 of the lesson (agreeing learning outcomes) explaining what constitutes a good argument. He also engaged the class in a sequence of questions to identify the purposes of argument:

T: What is arguing? What are the characteristics of arguing?

T [Addressing the whole class]: When is an argument valid? [The question was repeated in Afrikaans.]

S1: It’s say ... when your argument makes sense.

T: Yes ... when it makes sense.

S2: If it’s relevant to the topic and it’s what you think.

T: When will someone convince you their argument is correct?

S3: If you have facts or evidence.

T: And then, what is the purpose of an argument?

S3: To finalise something.

Later in this same part of the lesson the teacher identified a set of rules for group discussion, such as listening and taking it in turns to speak, and each group was given one minute to decide how the roles of chairperson, recorder, reporter and timekeeper would be allocated. These actions were considered as being helpful in guiding and facilitating purposeful and sustained argumentation of good quality. In view of later incidents, however, it is doubtful that they were fundamental in assuring good argumentation.

**Critical incident 2 (OT2)**
Immediately following the one minute allowed for groups to organise themselves for discussion (see above) the teacher said to the whole class:

T: Right, now every group must have views on both sides of the issue ... in support or not in support of the trafficking of organs.

At this point the teacher provided a sheet of paper for recording the reasons for and against organ trafficking. These actions, at this point, were considered to have constrained argumentation as students were merely required to list sets of warrants to pre-ordained claims, that is, that the trafficking of organs for transplant should or should not be allowed.

**Critical incident 3 (OT3)**
The weak rebuttal concerning the moral dilemma of deciding (against religious beliefs) as to whether or not to donate an organ (kidney) to a relative was discussed in the previous section on levels of argumentation. The incident arose from the teacher choosing to raise this as an issue, or playing devil’s advocate (Simon et al., 2006). In this case this was seen as being beneficial as it provided opportunities for students to engage in more personal reflections than had previously taken place and that were rare in group discussions.

**Critical incident 4 (OT4)**
Immediately following incident OT3 the teacher said to the whole class:

T: Now I want to get an idea of how you feel [about organ trafficking]. Should we sell [an organ] or should we not sell? So each group, you’ve got thirty seconds to quickly point out yes ... or no. Yes or no ... right? It’s a group decision ... quickly now! Democracy rules!

At this point in the lesson all groups of students were more noticeably engaged than at any other time. The noise level of voices was considerably higher and facial expressions of students were significantly more animated. For example, in one group, all
four students, two of whom had made little or no contribution during the main discussion activity, were visibly engaged, so much so that their talk continued for at least 30 seconds after the teacher had asked all groups to conclude the activity. Clearly the appeal by the teacher for decision making reaching a democratic (argued) and agreed position had promoted engaged debate that might have yielded higher levels of argumentation had it been allowed to continue.

**Critical incidents in the Euglena (E) lesson**

**Critical incident 1 (E1)**
In part 3 of the lesson the teacher had provided a set of evidence cards, each containing a statement relating to the structural features, life processes or actions of Euglena. Students’ discussions and arguments centred around whether a particular piece of evidence was helpful or not in supporting claims that Euglena might be a plant, an animal, either plant or animal or neither a plant nor an animal. At this particular critical incident the teacher challenged one group’s decision to place the evidence card reading ‘Euglena is a single cell’ into the column showing that it is neither a plant nor an animal.

**T:** Why is this [card] over here [in the column for neither a plant nor an animal] – ‘Euglena is a single cell’?

**S1:** [More than one student speaking]: ... It’s a single cell so ... not plant or animal ... so ...

**S2:** Some characteristics [referring to the full set of evidence cards] are for animal others plant ... um [indistinct other students’ voices seem to indicate agreement] ... like photosynthesis ... so it needs light.

**S3:** Ja ... and it’s light-sensitive [as an additional backing for Euglena synthesising and therefore being a plant].

**T:** Yes but when it talks about ‘light-sensitive’ ... it means it looks for where light is and it can detect light and move towards it [rather than light being required for photosynthesis].

In this incident the teacher challenges students’ warrants and explains some of the science behind evidence statements. These actions helped students make more effective use of evidence in their warrants and backings for claims about Euglena’s taxonomic status. Later in this part of the lesson the microphone picked up the first example of argumentation containing a rebuttal:

**S1:** I would say Euglena is part of Protozoa because here they say ‘others resembled animals because they move about by means of flagellate’. So I say that’s why it’s an animal because Protozoa is a sub-kingdom of Animalia.

**S2:** It’s a plant cell because it can photosynthesise. [She is challenging student 1.]

**S3:** A plant can’t move. Plants aren’t motile.

**S2:** A plant can move. Yes, a plant can move [smiling and nodding].

**S1:** See how that tree walks [smiling, sarcastic]. Plants aren’t motile. They don’t walk – That’s growth. That’s not movement. That’s growth.

**Critical incident 2 (E2)**
Following the group activity referred to above the teacher asked each group to reach a decision on Euglena as ‘plant or animal’:

**T:** Now ... the last two questions [on the students’ worksheet] say ..., after discussion with my group ... only your group ... I came to the conclusion that Euglena is ... And now what you need to do is you need to quickly report in your group what you individually selected what the Euglena is, and then you need to discuss in your group what your group thinks Euglena is.

Interestingly, the time set for this activity was very short (2 minutes as opposed to 8 minutes for the main discussion), as was the case for critical incident OT4 in the Organ trafficking lesson. Again, the amount of animated talk and facial expressions seen indicate that this activity stimulated a high degree of engagement.

**Critical incident 3 (E3)**
In part 4 of the lesson the teacher invites a student from each group to say whether they thought Euglena is a plant or an animal. Initially there were no responses and so the teacher deliberately took up a position (as devil’s advocate) claiming that all the class must have decided that Euglena was an animal. Some laughter ensued followed by this sequence of dialogue between the teacher and a student presenting his group’s decision:

**T:** Who believes Euglena to be a plant? ... Give me a reason.

**S1:** In the information given they [scientists] clearly describe the different types of micro-organisms that have the characteristics of plants and animals and then they describe ... um ... first the ones that are plant-like and that they photosynthesise, and then the ones that are animal-like ... they go on about using flagella ... and Protozoa are characterised as a sub-kingdom of Animalia – it’s an animal.
T: So give me a specific reason ... just why are you saying that yes Euglena ... you are an animal because ...

S1: It can move ... and it can absorb food from the environment.

The significant element of the teacher’s actions here, which makes this incident so critical in enabling argumentation, is the strong steer for the student to reason (i.e. provide warrants and backings) to support the claim that Euglena is an animal. The teacher asks for a ‘specific reason’ and scaffolds the student’s response through the use of the word ‘because’.

Critical incident 4 (E4)

As discussed in the previous section, the plenary reporting of group conclusions provided an opportunity for rebuttals. One group used the backing of temperature-sensitivity to support their claim that Euglena is an animal, based on learnt characteristics of animals. A second group used the same backing (temperature-sensitivity) to conclude that Euglena is a plant, based on knowledge about the need of Protea plant seeds for high temperature for germination. As a result of the exchange the latter group modified their claim to Euglena is ‘a sort of a fusion of a plant and an animal’, thus accommodating both previous claims. Unfortunately, the teacher did not explore this new claim any further, so the improvement in the argument may only have been clear to the reporting student. Nevertheless, whole-class discussion of argued claims by each group provides a platform for higher levels of argumentation.

Implications for practice

Though each of these lessons is based on a categorically different biological context and format of argumentation task, there are similar features that have a bearing on the relative success of argumentation. Firstly, both teachers invested a significant effort at the start of lessons to ensure that students were conversant with expectations, roles and rules for group work and that they were aware that sound argument requires claims based on data that have warrants and backings. Secondly, both teachers provided for argumentation and discussion in at least two phases of the lessons (as can be seen in Figure 1): in a group phase and in a plenary class discussion. Thirdly, both lessons contained episodes where higher levels of argumentation were about to occur but where very limited time for discussion constrained further development. Both teachers, in different ways, had set the scene for a diversity of claims. In the Organ trafficking lesson each group was asked to reach an agreed decision as to whether to support or oppose the trafficking of organs, based on an inventory of warrants and backing for and against. In the Euglena lesson a critical phase involved a task where group members wrote down individual decisions about Euglena’s taxonomic status to feed into a group decision. Both strategies to prepare an argumentation basis seem successful, as observations showed that the potential for heated debate was tangible and higher than in any other phase. Lastly, both teachers used techniques during whole-class plenary discussions to invite rebuttals, counterclaims or qualifiers from students. In the Organ trafficking lesson, for example, the teacher highlighted the decision-making process as one that is morally grounded. In the Euglena lesson the teacher responded to a hiatus in the lesson, where no responses were forthcoming, claiming that Euglena must be an animal. These strategies were successful in both lessons and have been identified in other research on argumentation in science classrooms (Simon et al., 2006). They refer to the first strategy (as seen in the Organ trafficking lesson) as ‘positioning’ and the second (as seen in the Euglena lesson) as ‘playing devil’s advocate’.

Despite the common features of the two lessons described above, the question remains as to why one lesson (Euglena) achieved an argumentation outcome (in terms of levels of argumentation) so much higher than the other (Organ trafficking). There are two plausible explanations: the more minor one is connected with teaching design; the other, much more major one, concerns the difference between arguments drawing on scientific evidence and centred around a set of causal claims, and those centred around a socio-scientific claim drawing on moral stances and beliefs.

In the Organ trafficking lesson a crucial limiting factor in the teaching design was the remit given to each group as the basis for group discussion (see critical incident OT2). Instead of a request to develop different claims (either in support of or against the trafficking of organs), students in each group were required to list a series of claims both for and against and then to submit these to the whole class. The style and presentation of the activity limited the opportunities for each group to reason using warranted claims. This is probably one of the reasons why a more heated exchange occurred when groups were finally asked to reach a decision (as described in critical incident OT3). At this point in the lesson this teacher’s relative inexperience at using group work and his lack of awareness of the need...
to provide social spaces for successful interactions as the basis for successful argumentation (see for example, Kumpulainen and Wray, 2002) were contributing factors. A more successful approach here might have been to allow time for a relatively free discussion about an open question, such as ‘Should organ trafficking be allowed?’ and then to follow this with a more closed discussion task focused around a number of different reasoned claims both in support and against trafficking. Such two-part tasks have been documented as being successful in other contexts for argument in biology, such as genetics (see for example, Jiménez-Alexandre, Rodríguez and Duschl, 2000). What seems crucial here is to allow enough time (and therefore mental space) for students to compare individually reasoned claims and then to engage in group discussion to reach a consensus (or majority) view. There is a note of caution here, as previous work (Scholtz et al., in press) suggests that a common feature of discussion groups in African contexts is for inclusive discourse that drives towards consensus, thus without the number of rebuttals, challenges and counterclaims that characterise argumentation from Toulmin’s perspective. This tendency towards consensus draws on the cultural traditions (known as ubuntu) of many African peoples.

Among the most striking differences between the two lessons are the sources and use of knowledge, beliefs and attitudes required and hence the nature of the reasoning that resulted. The Euglena lesson relies on a fairly simple design. What is required is to consider the status of various pieces of evidence (already provided) in supporting one of four opposing claims for the taxonomy of the organism. As such, the task could be said to represent classic scientific evidence-based argumentation where the evidence and knowledge base allows plentiful warrants and backings. Even where knowledge outside that included in the task was brought to the discussion, as was the case with the example of Protea and the sensitivity of its seeds to heat (see critical incident E4), this was easily integrated into the argument structure; indeed this incident was one of the main reasons (but not the only one) why this lesson was judged to be at a higher level. The Euglena lesson and the reasoning required fits comfortably with Toulmin’s model of argumentation.

On the other hand, the argumentation and reasoning required in deciding whether to allow organ trafficking or not is an entirely different matter. Here there are at least three aspects that affect reasoning: the scientific base, moral and ethical positions, and cultural standpoints including religious beliefs. Claims, warrants and backings that draw on the scientific base are also complex in this context and add to the demand. A number of biological concepts are relevant to the argument: efficacy of transplants for different organs (heart, kidney, liver); functioning of the immune system and tissue matching and rejection rates; the use of cloning for alternative sources for tissues and organs, etc. Added to these is an appreciation of the socio-economic aspects as often debated in health science policy (see also Zohar and Nemet, 2002; Levinson, 2006): availability of organs, relative cost-benefits, prioritisation on waiting lists for transplant surgery and so on. When it comes to the cultural, and especially the religious, aspects of the arguments in this context these would be complex in any cultural setting. This study took place in a school in South Africa that draws students from a wide variety of ethnic and religious groups. The mix of backgrounds, and therefore belief systems, that are drawn upon in these sorts of debates in this school is therefore very varied. Warrants made to support claims that are based on belief systems (particularly religious ones) are hard to evidence and therefore to back, at least in the sense that a scientist might use evidence. For example, one student might say, ‘I just cannot accept that any organ can be put into another person because my religion says it is wrong’. In such cases, Toulmin’s model of argument (Toulmin was a lawyer and used examples from jurisprudence) is harder to apply, and hence levels of argumentation based on his model are consequently limited for socio-scientific claims.

**Conclusion**

The findings pose a dilemma in that argumentation in pure science contexts could be seen by teachers as being easier and more successful than in the more fluid and less controllable climate of arguments about ethical or moral issues. There is clearly room for both types in science teaching. Indeed, the types of learning required by the How science works strand of the new key stage 4 programme in England will require teachers to have a broader understanding of how various types of argumentation task can be used in science classrooms. For the teacher, argument about controversial issues requires awareness of the underlying science and the various moral and ethical positions taken by students from often diverse cultural backgrounds. One suggestion that might allow discussion of the science (and scientific evidence base) and the issues (moral, ethical and religious perspectives) to take place and co-exist is...
to strip away the science to form a two-part debate: first the science and then the ethical issues involved (see Simon et al., 2006). We would like to post a note of caution here. Such courses of action could promote the view of science being divorced from its cultural and social roots. This is what has happened to science education in several developed countries where the evidence is that many students perceive science as a cold-hearted, anti-social enterprise stripped of its humanity. In these countries, students are turning away from science as shown by research of the ROSE project (Schreiner and Sjoberg, in press). In contrast, students in many developing countries (including South Africa) are better disposed towards science as an enterprise and as a subject to study. We do not wish to see the mistakes of divorcing school science from its role in everyday life repeated in the state education system in South Africa, and the teaching of argumentation skills provides opportunities to bridge the perceived gap. Finally, preserving the value of argumentation in socio-scientific contexts is very much in sympathy with the aims of democratic empowerment in South Africa.

References

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